Tropical Ecology **53**(1): 15-24, 2012 ISSN 0564-3295
© International Society for Tropical Ecology
www.tropecol.com

Population density, biomass and habitat association of rodents and insectivores in Pawe area, northwestern Ethiopia

TILAHUN CHEKOL, AFEWORK BEKELE & M. BALAKRISHNAN*

Department of Biology, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia

Abstract: Abundance of rodents and insectivorous mammals was estimated in Pawe area of Ethiopia in natural forest, plantation, bushland, grassland and maize farms. Grids were randomly selected in each of the habitats, and small mammals were live-trapped during the wet and dry seasons. A total of 606 individuals (including recaptures) comprising 10 species of rodents and two species of insectivores were trapped. The rodents trapped were *Mastomys natalensis* (37.9 %), *Arvicanthis dembeensis* (28.8 %), *Stenocephalemys albipes* (9.2 %), *Mastomys erythroleucus* (7.5 %), *Arvicanthis niloticus* (4.5 %), *Acomys cahirinus* (3.6 %), *Tatera robusta* (2.6 %), *Lemniscomys striatus* (1.7 %), *Mus musculus* (0.9 %) and *Rattus rattus* (0.3 %). The two species of insectivores trapped were *Crocidura flavescens* (2.2 %) and *Crocidura fumosa* (0.8 %). *M. natalensis* was the most abundant and widely distributed species while *R. rattus* was the least abundant with limited distribution. Most of the rodents and insectivores were associated with the bushland habitat. More rodents were trapped during the wet season than during the dry season. The average trap success was 17.7 %. The population density ranged from 50 ha^{-1} in the plantation to 311 ha^{-1} in the bushland. Maize farm had the highest biomass of rodents and insectivores (23.9 kg ha^{-1}), followed by grassland (18.7 kg ha^{-1}) and bushland (18.0 kg ha^{-1}).

Resumen: Se estimó la abundancia de los mamíferos roedores e insectívoros en el área Pawe de Etiopía en bosque natural, plantación, matorral, pastizal y granjas de maíz. Se seleccionaron aleatoriamente cuadrículas en cada uno de los hábitats y los mamíferos pequeños fueron atrapados vivos durante las estaciones seca y lluviosa. Se capturaron en total 606 individuos (incluyendo recapturas), incluyendo 10 especies de roedores y dos especies de insectívoros. Los roedores capturados fueron *Mastomys natalensis* (37.9 %), *Arvicanthis dembeensis* (28.8 %), *Stenocephalemys albipes* (9.2 %), *Mastomys erythroleucus* (7.5 %), *Arvicanthis niloticus* (4.5 %), *Acomys cahirinus* (3.6 %), *Tatera robusta* (2.6 %), *Lemniscomys striatus* (1.7 %), *Mus musculus* (0.9 %) y *Rattus rattus* (0.3 %). Las dos especies capturadas de insectívoros fueron *Crocidura flavescens* (2.2 %) y *Crocidura fumosa* (0.8 %). *M. natalensis* fue la especie más abundante y ampliamente distribuida, mientras que R. rattus fue la menos abundante y más limitada en su distribución. La mayoría de los roedores e insectívoros estuvieron asociados con el hábitat de matorral. Se capturaron más roedores durante la época húmeda que durante la seca. El éxito promedio de captura fue 17.7 %. La densidad poblacional fluctuó de 50 ha^{-1} en la plantación a 311 ha^{-1} in el matorral. La granja de maíz tuvo la biomasa más alta de roedores y de insectívoros (23.9 kg ha^{-1}), seguida por el pastizal (18.7 kg ha^{-1}) y el matorral (18.0 kg ha^{-1}).

Resumo: A abundância de roedores e mamíferos insectívoros foi estimada na floresta natural, plantações, matas arbustivas, pastagens e fazendas de milho naárea de Pawena Etiópia. Em quadrículasseleccionados aleatoriamenteem cada um dos habitats,os pequenos mamíferos foram capturados vivos, durante as estações seca e húmida. De um total de 606 indivíduos capturados (incluindo recapturas), estavam representadas 10 espécies de roedores e duas espécies de insectívoros. Os roedores capturados foram *Mastomys natalensis* (37,9 %),

* *Corresponding Author*; e-mail: balak212@yahoo.com

Arvicanthis dembeensis (28,8 %), *Stenocephalemys albipes* (9,2 %), *Mastomys erythroleucus* (7,5 %), *Arvicanthisniloticus* (4,5 %), *Acomys cahirinus* (3,6 %), *Tatera robusta* (2,6 %), *Lemniscomys striatus* (1,7 %), *Mus musculus* (0,9 %) e *Rattusrattus* (0,3 %). As duas espécies insectívoras capturadasforam a *Crocidura flavescens* (2,2 %) e *Crocidura fumosa* (0,8 %). A *M. natalensisfoi* a espécie mais abundante e amplamente distribuída enquanto a R. rattus foi a menos abundante e com distribuição limitada. A maioria dos roedores e insectívoros foram associados com o habitat de mata arbustiva. Mais roedores foram capturados durante a estação chuvosa do que durante a estação seca. O sucesso médio de captura foi de 17,7 %. A densidade populacional variou de 50 ha^{-1} na plantação a 311 ha^{-1} na mata arbustiva. As fazendas de milho apresentaram a maior biomassa de roedores e insectívoros (23,9 kg ha^{-1}), seguido por pastagens (18,7 kg ha^{-1}) e mata arbustiva (18,0 kg ha^{-1}).

Key words: Abundance, biomass, density, Pawe, small mammals, species composition.

Introduction

Small mammals form the highest proportion of mammals all over the world (Takele *et al.* 2011; Tsegay & Afework 2006; Workneh *et al.* 2006). Among them, the order Rodentia has more species (Buckle & Smith 1994; Feldhamer *et al.* 2007; Kingdon 1997; MacDonald 1984; Magige & Senzota 2006; Nowak 1999; Vaughan *et al.* 2000). Rodents account for more than 40 % of the mammalian species in the world with 21 living families, 443 genera and more than 2000 species (Danell & Aeve-Olsson 2002; Wilson & Reeder 1993). Diverse types of interactions with other organisms, adaptability to diverse habitats and variation in the food habit of rodents have been responsible for their success in such wide distribution pattern, globally. From the tropics to the polar region, rodent populations experience seasonal, inter-annual and multi-annual fluctuations (Leirs *et al.* 1996; Lima & Jaksic 1999; Meserve *et al.* 1996; Stenseth & Ims 1993). Such fluctuations are the results of the basic demographic processes such as reproduction, survival, mortality, emigration and immigration (Lima *et al.* 2001), which are also governed by the habitat structure and food supply (Boutin 1990). Reproduction is the most vital source of recruitment that influences population density of rodents (Leirs 1995).

There are 84 species of rodents recorded from Ethiopia, of which 15 (12 %) are endemic to the country (Afework 1996a; Afework & Leirs 1997; Hillman 1993; Yalden & Largen 1992). Many of the endemic mammals of Ethiopia are associated with high altitude moorland and grassland habitats (Yalden 1983). On the other hand, in the relatively western lowlands of the country, the vegetation is typically of savanna type, characterized by tall grasses or deciduous broad leaved plants (Yalden & Largen 1992), which support a range of species. The western lowlands of Ethiopia, lying to the west of the northern mountain and the south-western highlands extend from Tigrai in the north to Illubabor in the southwest. This area forms the Ethio-Sudanese border, which includes the low-lands of Benshangul Gumuz Regional State. The western lowlands are under-explored for faunal diversity due to inaccessibility and remoteness of the area. Accelerated human interactions in search of arable land and resettlement have been adversely affecting the natural habitats of this area. Therefore, the present investigation attempts to gather data on the species composition, distribution, population density, relative abundance, biomass and habitat association of rodents in Pawe area, Benshangul Gumuz Regional State in the north-western lowland of Ethiopia.

Material and methods

Study area

Pawe is a resettlement area in Benshangul Gumuz Regional State, northwest Ethiopia, located around 570 km from Addis Ababa, the capital city of Ethiopia. This area lies within the centre of the western lowland bordering Sudan on the west. It lies between 36º 15´E - 36º 34´E longitude and 11º 10´N - 11º 23´N latitude (Fig. 1). Before the arrival of the state-sponsored re-settlers in the 1980s, the area was inhabited by Gumuz people, who were dispersed and pushed to the periphery (Wolde-

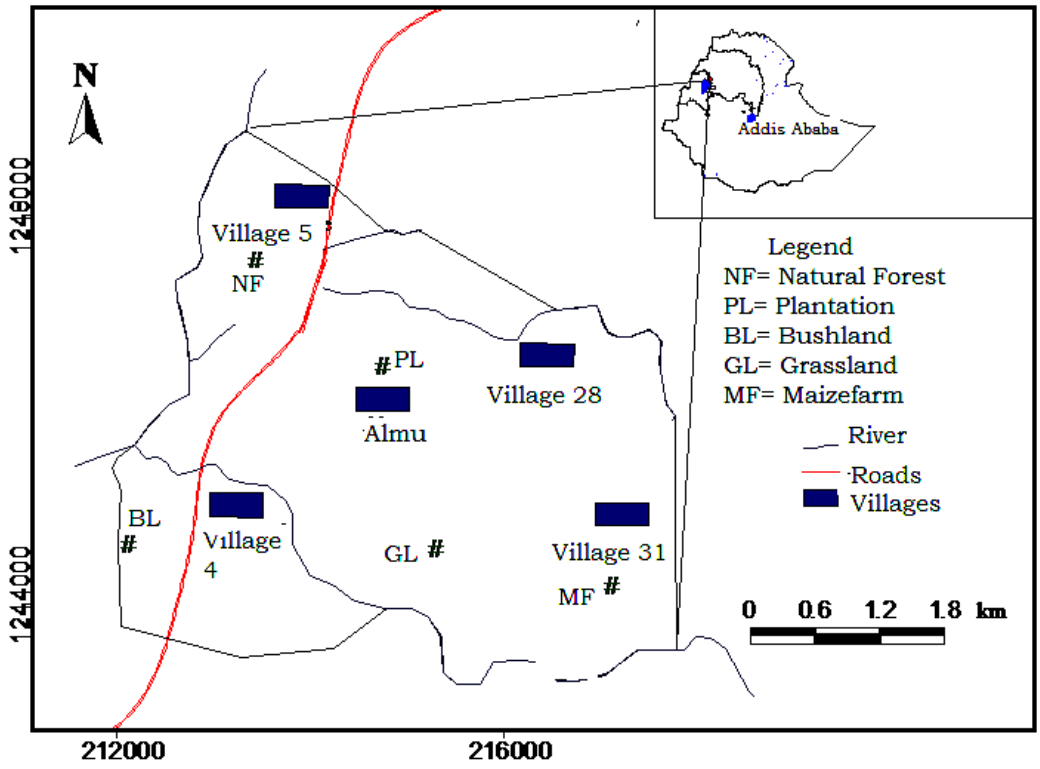

Fig. 1. Location map of the study area with Ethiopia in inset. (# = grids).

selassie 2002). The re-settlers inhabit the lowland area at an altitude range of 1000 - 1200 m asl, which is now called Pawe.

Based on the vegetation type, five sample sites were identified in the central part of Pawe area around Almu. These were natural forest (NF), plantation (PL), bushland (BL), grassland (GL) and farmland (maize farm, Mf). Live-trapping grids, each of 4900 m² in extent were established one in each habitat type, marked and numbered as 1, 2, 3, 4 and 5, respectively. These grids were used during both the wet and dry seasons.

Trapping

In each grid, 49 Sherman live-traps, measuring 7.5 × 8.5 × 23.5 cm were set at 10 m distance between trap stations. The traps were baited with peanut butter and checked twice a day, in the morning (07:00 - 08:00 h) and late in the afternoon (17:00 - 18:00 h). Traps were set for three consecutive nights, giving trapping effort of 147 trap nights per grid. Trapped animals were transferred into a pre-weighed polythene bag and weighed to the nearest gram. They were marked by toe-clipping and released at the point of capture after recording the location of capture, weight, species, sex and approximate age (juvenile, sub-adult, adult) based on the visibility of nipples (visible or not), vaginal condition (perforated or non-perforated) and testes (abdominal or scrotal). Population density of each of the live-trapped species was estimated for both the wet and dry seasons by estimating the number of individuals of each species per hectare. Biomass of each species per hectare was estimated by multiplying the density of the species (per ha) by its mean body weight.

SPSS software version 15.0 and Chi-square test were used for analysis of the data.

Results

A total of 606 captures of rodents and shrews were made using live-traps. Among them, 519 were new captures and 87 were recaptures. There were 500 individuals of 10 species of rodents, and 19 individuals of two species of shrews. Among the 10 species of rodents, 197 (38.0 %) were *M. natalensis*, 147 (28.3 %) *A. dembeensis*, 45 (8.7 %) *S. albipes*, 38 (7.3 %) *M. erythroleucus*, 24 (4.8 %) *A. nilotocus*, 20 (3.9 %) *A. cahirinus*, 14 (2.7 %) *T. robusta*, 7 (1.3 %) *L. striatus*, 6 (1.2 %) *M. musculus* and 2 (0.4 %) were *R. rattus*. Among the two

Table 1. Abundance of rodents and insectivores live-trapped from different habitat types (Figures in brackets give relative abundance of trapping from each habitat type).

Species	Habitat-wise abundance					Total
	NF	PL	BL	GL	Mf	
Mastomys natalensis	39(19.8)	16(8.1)	54(27.4)	43(21.8)	45(22.9)	197
Arvicanthis dembeensis	-	-	45(30.6)	67(45.6)	35(23.8)	147
Stenocephlemys albipes	37(82.2)	4(8.9)	4(8.9)	-	-	45
Mastomys erythroleucus	1(2.6)	2(5.2)	16(42.1)	-	19(50)	38
Arvicanthis niloticus	-	-	10(41.7)	13(54.2)	1(4.1)	24
Acomys cahirinus	-	-	3(15)	15(75)	2(10)	20
Tatera robusta	-	-	7(50)	6(42.9)	1(7.1)	14
Lemniscomys striatus	-	-	7(100)	-	-	7
Mus musculus	-	-	2(33.3)	4(66.6)	-	6
Rattus rattus	-	-	-	-	2(100)	2
Crocidura flavescens	9(64.3)	3(21.4)	2(14.3)	-	-	14
Crocidura fumosa	1(20)	-	4(80)	-	-	5

NF = Natural forest, PL = Plantation, BL = Bushland, GL = Grassland, Mf = Maize farm (- indicates no capture).

species of shrews trapped, 14 (2.7 %) were *C. flavescens* and 5 (0.9 %) were *C. fumosa*. *M. natalensis* was the dominant (38.0 %) species trapped,

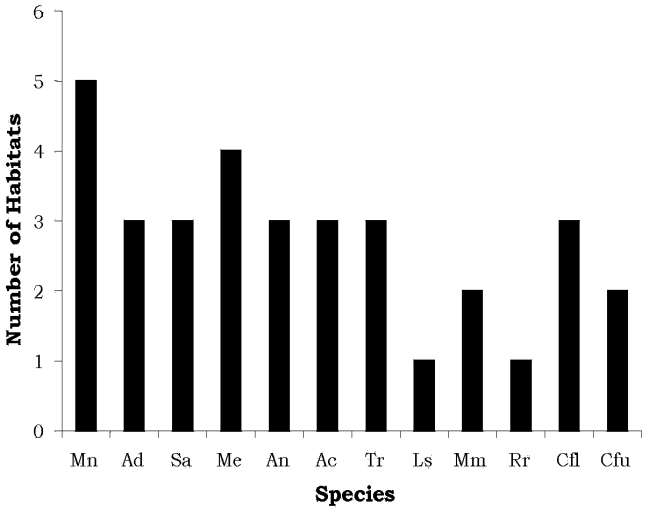

Fig. 2. Number of habitats in which each of the species of rodents and insectivores was trapped during the present study period. (Mn = *Mastomys natalensis*, Ad = *Arvicanthis dembeensis*, Sa = *Stenocephlemys albipes,* Me = *Mastomys erythroleucus*, An = *Arvicanthis niloticus*, Ac = *Acomys cahirinus*, Tr = *Tatera robusta*, Lm = *Lemniscomys striatus*, Mm = *Mus musculus*, Rr = *Rattus rattus*, Cfl = *Crocidura flavescens,* Cfu = *Crocidura fumosa).*

followed by *A. dembeensis* (28 %). *R. rattus* was the least in abundance (0.4 %) among the live-trapped small mammals (Table 1).

Variation in species composition and their abundance was observed from habitat to habitat. *M. natalensis* was the most widely distributed species. It occurred in all the habitat types studied. The other widely distributed species was *M. erythroleucus*. This species was trapped from all habitats other than grasslands. However, its abundance was relatively less in the area. Five species of rodents, viz., *A. dembeensis, S. albipes, A. niloticus, A. cahirinus* and *T. robusta* were recorded from three different habitats. Among these species, *A. dembeensis* was the second most abundant (147). The least distributed species of rodents were *L. striatus* and *R. rattus*, which were restricted only to bushland and maize farm, respectively. Insectivore, *C. flavescens* was trapped from natural forest, plantation and bushland, whereas *C. fumosa* was trapped only from natural forest and bushland. The number of habitats in which each species was trapped is shown in Fig. 2. Among the 12 species of small mammals trapped, bushland had the highest diversity with 11 species, whereas plantation had the least diversity with only four species. *R. rattus* was the only rodent not recorded from bushland in this study area. There was a significant difference in the number of species recorded from different habitat types ($\chi^2 = 4.4$, df = 4, $P < 0.05$).

Table 2. Population densities (individuals ha^{-1}) and biomass (g ha^{-1}) of rodents and insectivores in the study area.

Season	Species followed by mean body weight (g)	Density followed by biomass (g ha^{-1}) in brackets					
		NF	PL	BL	GL	Mf	Total
Wet	*M. natalensis,* 64.1	49(3140)	18(1153)	69(4422)	61(3910)	69(4422)	266
	A. dembeensis, 77.1	0	0	57(4394)	97(7478)	51(3932)	205
	S. albipes, 50.3	51(2565)	8(402)	8(402)	0	0	67
	M. erythroleucus, 52.8	0	0	16(844)	0	28(12034)	44
	A. niloticus, 61.2	0	0	10(612)	14(856)	2(122)	26
	A. cahirinus, 36.1	0	0	2(72.2)	8(489)	4(144)	14
	T. robusta, 52.0	0	0	8(416)	6(312)	2(104)	16
	L. striatus, 41.6	0	0	6(249)	0	0	6
	C. fluvescence, 18.6	12(223)	4(74)	4(74)	0	0	20
	C. fumosa, 17.4	2(34)	0	4(69)	0	0	6
Sub-total		(5964)	(1630)	(11488)	(13047)	(20656)	
Dry	*M. natalensis,* 52.3	30(1569)	14(732)	41(2144)	26(1359)	22(1150)	133
	A. dembeensis, 65.2	0	0	34(2216)	38(247)	20(1304)	92
	S. albipes, 46.7	24(1120)	0	0	0	0	24
	M. erythroleucus, 47.3	2(94)	4(189)	16(758)	0	10(473)	32
	A. niloticus, 57.8	0	0	10(758)	12(693)	0	22
	A. cahirinus, 34.3	0	0	4(137)	22(754)	0	26
	T. robusta, 49.7	0	0	6(298)	6(298)	0	12
	L. striatus, 37.5	0	0	8(300)	0	0	8
	M. musculus, 27.9	0	0	4(112)	8(223)	0	12
	R. rattus, 71.9	0	0	0	0	4(287)	4
	C. fluvescence, 13.1	6(78)	2(26)	0	0	0	8
	C. fumosa, 11.6	0	0	4(46)	0	0	4
Sub-total		(2768)	(947)	(6591)	(5806)	(3215)	

(NF = Natural forest, PL = Plantation, BL = Bushland, GL = Grassland, Mf = Maize farm).

The total number of individuals trapped from bushland (154) was higher than those trapped from other habitat types. The number of individuals trapped from grassland, maize farm, natural forest and plantation were 148, 105, 87 and 25, respectively. The overall abundance of rodents and insectivores trapped from different habitats was significantly different ($\chi^2 = 106.8$, df = 4, $P < 0.01$). *L. striatus*, *C. fumosa* and *T. robusta* showed close association with the bushland. *A. dembeensis*, *A. niloticus* and *A. cahirinus* were more associated with the grassland. *M. erythroleucus*, *M. natalensis* and *R. rattus* were more in the maize farm. On the other hand, *S. albipes* and *C. flavescens* showed their association with the natural forest (Table 1).

Variation in trap success between different habitats was statistically significant ($\chi^2 = 18.8$, df = 4, $P < 0.01$). Trap success ranged from 1.3 % during the first session of the dry season in the plantation to 41.4 % during the second session of the wet season in the bushland. The average trap success during wet and dry seasons was 22.5 % and 12.7 %, respectively. The average trap success in the study area was 17.7 %. Among the trapped individuals, 274 (52.8 %) were adults, 112 (21.6 %) sub-adults and 133 (25.6 %) juveniles. More juveniles were trapped during the wet season compared to dry season ($\chi^2 = 54$, df = 1, $P < 0.01$). The number of juveniles was more than the sub-

Table 3. Abundance of rodents and insectivores trapped during different seasons (I = 1st trapping session, II = 2nd trapping session, III = total for both the sessions).

Species	Abundance					
	Wet season			Dry season		
	I	II	III	I	II	III
Mastomys natalensis	47	84	131	42	24	66
Arvicanthis dembeensis	38	63	101	32	14	46
Stenocephlemys albipes	11	22	33	5	7	12
Mastomys rythroleucus	8	14	22	9	7	16
Arvicanthis niloticus	4	9	13	8	3	11
Acomys cahirinus	6	1	7	8	5	13
Tatera robusta	0	8	8	4	2	6
Lemniscomys striatus	0	3	3	2	2	4
Mus musculus	-	-	-	3	3	6
Rattus rattus	0	0	0	2	0	2
Crocidura flavescens	4	6	10	3	1	4
Crocidura fumosa	0	3	3	1	1	2
Total			331		188	

adults during the wet season and *vice - versa*. The overall age distribution between adults, sub-adults and juveniles was statistically significant (χ^2 = 87.8, df = 2, $P < 0.01$).

Population densities of rodents and insectivores in different habitats during different seasons are given in Table 2. The density of *M. natalensis* ranged from 32 ha^{-1} in the plantation to 110 ha^{-1} in the bushland. The lowest density of *A. dembeensis* was recorded in the maize farm (71 ha^{-1}), whereas the highest density of the species was recorded in the grassland (135 ha^{-1}). There was no record of this species in the natural forest and the plantation. The density of *S. albipes* ranged from 8 ha^{-1} in the bushland and the plantation to 75 ha^{-1} in the natural forest with no records in other habitats. *M. erythroleucus* had a density of 38 ha^{-1} in maize farm, 32 ha^{-1} in the bushland, 4 ha^{-1} in plantation, 2 ha^{-1} in natural forest with no record in the grassland. The density of *C. flavescens* was 18 ha^{-1} in the natural forest, followed by 6 ha^{-1} in the plantation and 4 ha^{-1} in the bushland. There was no record of this species in the grassland and the maize farm. Highest density of *A. niloticus, A. cahirinus* and *M. musculus* was observed in the grassland and the highest density of *T. robusta, L. striatus* and *C. fumosa* was observed in the bushland. High cumulative density of rodents and insectivores for the wet and dry seasons was recorded in the bushland (311 ha^{-1}), followed by the grassland (298 ha^{-1}), the maize farm (212 ha^{-1}) and the natural forest (176 ha^{-1}). The lowest density was recorded in the plantation area (50 ha^{-1}) during the entire study period.

The data on biomass of rodents and insectivores in different habitats during wet and dry seasons is also given in Table 2. Biomass of each species declined during the dry season. The maize farm had a maximum biomass of rodents and insectivores (20.65 kg ha^{-1}), followed by grassland (13.04 kg ha^{-1}), bushland (11.55 kg ha^{-1}), natural forest (5.66 kg ha^{-1}) and plantation (1.63 kg ha^{-1}) during the wet season. During the dry season, the highest biomass was estimated in the bushland (6.59 kg ha^{-1}), followed by grassland (5.80 kg ha^{-1}), maize farm (3.22 kg ha^{-1}), natural forest (2.76 kg ha^{-1}) and plantation (0.95 kg ha^{-1}).

Among the 519 individuals trapped, 331 (63.8 %) were during the wet season and 188 (36.2 %) during the dry season (Table 3). The number of individuals trapped during the wet season was significantly higher than those trapped during the

dry season ($\chi^2 = 39.4$, df = 1, $P < 0.01$). The seasonal abundance of *M. natalensis, A. dembeensis* and *S. albipes* was statistically significant ($\chi^2 = 21.4$, df = 1, $P < 0.01$; $\chi^2 = 20.5$, df = 1, $P < 0.01$ and $\chi^2 = 9.8$, df = 1, $P < 0.01$, respectively). However, seasonal abundance of *L. striatus*, *A. niloticus, T. robusta* and *C. fumosa* was not statistically different ($\chi^2 = 0.28$, df = 1, $P > 0.01$; $\chi^2 = 0.16$, df = 1, $P > 0.01$; $\chi^2 = 0.24$, df = 1, $P > 0.01$ and $\chi^2 = 0.20$, df = 1, $P > 0.01$, respectively). During the wet season, 10 species of small mammals were trapped, whereas, during the dry season, 12 species were trapped. The overall difference in the number of species trapped between the two seasons was not statistically significant ($\chi^2 = 0.18$, df = 1, $P > 0.05$). During the wet season, more individuals (92) were trapped from the grassland, followed by the bushland (91), the maize farm (77) and the natural forest (56). However, during the dry season, more individuals were trapped from the bushland (63), followed by the grassland (56), the natural forest (31) and the maize farm (28). The lowest number of individuals trapped was from the plantation. There were seasonal variations in the number of individuals trapped from the natural forest, bushland, grassland and maize farm ($\chi^2 = 7.2$, df = 1, $P < 0.05$; $\chi^2 = 5.09$, df = 1, $P < 0.05$; $\chi^2 = 8.7$, df = 1, $P < 0.05$ and $\chi^2 = 22.6$, df = 1, $P < 0.05$, respectively), but the variation was insignificant in the plantation ($\chi^2 = 1$, df = 1, $P > 0.05$).

Discussion

During the present study, 12 species of small mammals were trapped and four additional species of small mammals were observed in the study area. These include 14 species of rodents and two insectivores. Almost similar representation of rodents and insectivores have been recorded from different parts of Ethiopia. For instance, Yalden (1988) recorded 14 species of rodents and five species of insectivores in the Bale Mountains National Park. Afework (1996b) recorded 12 species of rodents in the Menagesha State Forest and Demeke *et al.* (2007) recorded 12 species of rodents and two species of insectivores in Arbaminch forest and farmland. However, Tadesse & Afework (2008) recorded 29 species of rodents and insectivores in Alatish Proposed National Park, northwestern Ethiopia. High level of human encroachment (re-settlement), extensive fire during the dry season and intensive grazing by livestock might have influenced the abundance of species of rodents and insectivores in the present study area.

In the present study area, *M. natalensis* was the most abundant and widely distributed species of rodent. This species was trapped from all the five habitats with altitudinal range of 1000 - 1200 m asl. Its abundance was very high in the farmland and the bushland. Yalden *et al.* (1976) reported that it has wide distribution in different parts of Ethiopia in altitudinal ranges of 500 - 2900 m asl. Demeke *et al.* (2007) also stated that *M. natalensis* was the most abundant rodent species in farmlands and bushlands in Arbaminch area of southern Ethiopia. According to Afework & Leirs (1997) and Magige & Senzota (2006), this is the most abundant and widely distributed rodent species in areas with high human interactions.

The unstriped grass rat, *A. dembeensis* was recorded as the second most abundant species in the present study area. It occurred in the grassland, the bushland and in the maize farm. It was also one of the major rodent pests of maize in the area. Capanna *et al.* (1996) also stated that *A. dembeensis* is a lowland species commonly seen in areas of altitudinal ranges between sea level and 2200 m asl. It is the most common species of rodent in the African savannah habitat (Ducroz *et al.* 1997). *S. albipes,* the third most abundant species in the present study area is the most widely distributed species in forest habitats in altitudinal ranges between 800 - 4000 m asl (Fadda & Corti 2000; Yalden & Largen 1992). Afework (1996a) also reported that *S. albipes* prefers dense forests that are progressively shrinking. This species was the most abundant in the natural forest habitat in the present study area. However, the extent of natural forest in the present study area is highly reduced by human encroachment. *M. erythroleucus* is an important murid pest of maize in East Africa (Odhiambo *et al.* 2005). It is recorded as the fourth most abundant species in the present study area. This species was trapped from all habitat types except grassland. The highest abundance of this species was recorded in the maize farm. Yalden *et al.* (1976) reported that *C. fumosa* was confined to altitudinal ranges of 1750 - 3900 m asl in Ethiopia. It was considered as a moorland species (Yalden 1988). However, there was a recent record of this species from altitude range < 1000 m (Tadesse & Afework 2008). In the present study area, it was trapped from the bushland at an altitude of 1170 m asl. This is within the reported altitudinal range of the species.

The bushland habitat had the highest number of individuals and species of rodents. Out of the 12

trapped small mammal species, all except *R. rattus* were present in this habitat. This might be due to the heterogeneous nature of the vegetation composition for food and shelter. Further, moisture content of the soil and moderate temperature in the habitat might also favour small mammals to prefer such habitat. Kotler (1984) also noted that such habitats with enough ground cover provide sufficient food and reduce predation risk, which in turn would enhance the richness and diversity of habitats. More complex habitats contain more niches, which will be exploited by diverse animals including rodents (Rozenzwig & Winakur 1969). The plantation habitat had the lowest species composition and abundance. Only 25 individuals of four species were trapped from this habitat during the present investigation. The homogenous vegetation dominated by few species of tall trees in the plantation has resulted in less habitat heterogeneity and microhabitat diversity. The ground cover was also less in this habitat, leading to shortage of food and shelter. This is consistent with the findings of Happold & Happold (1987) that the change from natural forest to plantation caused decline in both total number of individuals and species composition.

The density of small mammals in the present study area varied from habitat to habitat. The lowest density was estimated from the plantation habitat, whereas the highest density was recorded from the bushland. The density of small mammals per hectare observed in the present study was comparable to earlier results of Happold (1974), who estimated rodent population density in western Nigeria as 16 - 106 ha^{-1} and Delany & Kansieriimubanga (1970), who recorded 160 ha^{-1}. The density of small mammals in the present study area showed a range of 2 - 110 ha^{-1}.

Most rodent species showed a significant decrease in the body weight during the dry season. This seasonal reduction in biomass might be correlated with the shortage of food, which was limited in quantity and quality during the dry season. Taylor & Green (1976) have also stated that weight of small mammals decreased during the dry season. Food availability and quality are important for attaining weight and in determining fertility rate of small mammals.

More individuals were recorded during the wet season than during the dry season. This is not in agreement with the findings of Demeke *et al.* (2007), Happold & Happold (1991), Taddesse & Afework (2008) and who have recorded more individuals during the dry season in their respective study areas. Various factors such as weather conditions, quality and abundance of food, fire and predation would contribute for population fluctuations of small mammals, especially in areas with intensive human interactions. In the present study area, fire, deforestation and grazing were major factors for the reduction of rodent population during the dry season. Among the five habitats, the highest trap success was in the bushland. This might be due to habitat heterogeneity, sufficient cover and food availability. The lowest trap success recorded in the plantation might be due to lack of habitat heterogeneity, absence of ground cover and sufficient food. The higher trap success during the wet season might be associated with the influence of rainfall. During the wet season, rainfall facilitates the growth of ground cover and exerts influence on food availability, which in turn enhances breeding of rodents. It is evident from the greater abundance of juveniles during wet season.

Acknowledgements

We acknowledge the Department of Biology, Addis Ababa University for facilities and for financial support received for this research work. We are also thankful to Mr. Ketema Amberbir for his help in the Zoological Natural History Museum for identification of specimens. The staff members of the Pawe Agricultural Research Centre and the Woreda Agriculture and Rural Development are thanked for their support in the field.

References

Afework, B. 1996a. Population dynamics of the Ethiopian endemic rodent, *Praomys albipes* in the Menagesha State Forest. *Journal of Zoology* **238**: 1-12.

Afework, B. 1996b. Rodents of Menagesha State Forest, Ethiopia with an emphasis on the endemic *Praomys albipes* (Rüppell 1842). *Tropical Zoology* **9**: 201-212.

Afework, B. & H. Leirs. 1997. Population ecology of rodents of maize fields and grasslands in central Ethiopia. *Belgian Journal of Zoology* **127**: 39-48.

Boutin, S. 1990. Food supplementation experiment with terrestrial vertebrates : Patterns, problems and features. *Canadian Journal of Zoology* **68**: 103-120.

Buckle, P. A. & H. R. Smith**.** 1994. *Rodent Pest and Their Control*. CAB International, Wallingford.

Capanna, E., B. Afework, M. Capula, R. Castiglia, M. V.

Civitelli, J. T. C. I. Codjia, M. Corti & C. Fadda. 1996. A multidisciplinary approach to the systematics of the genus *Arvicanthis* Lesson, 1842 (Rodentia, Muridae). *Mammalia* **60:** 677-696.

Danell, K. & B. Aave-Olsson. 2002. Endemic mammalian genera: are they really unique? *Journal of Biogeography* **29**: 457-464.

Delany, J. & K. Kansieriimubanga. 1970. Observations on the ecology of rodents from small arable plot near Kampala, Uganda. *Revue de Zoologie et de Botanique Africaines* **81:** 417-427.

Demeke, D., B. Afework & B. Gurja. 2007. Species composition, distribution and habitat association of rodents from Arbaminch forest and farm land, Ethiopia. *African Journal of Ecology* **45**: 651-657.

Ducroz, J. F., L. Granjon & P. Chevret. 1997. Characterization of two distinct species of *Arvicanthis* (Rodentia, Muridae) in West Africa : cytogenetic, molecular and reproductive evidence. *Journal of Zoology* **241**: 709-723.

Fadda, C. & M. Corti. 2000. Three dimensional morphometric study of the Ethiopian *Myomys-Stenocephalemys* complex (Murinae, Rodentia). *Hystrix* **10**: 131-143.

Feldhamer, G. A., L. C. Drickamer, S. H. Vessey & F. Joseph. 2007. *Mammalogy* : *Adaptation, Diversity and Ecology*. 3rd edn. The Johns Hopkins University Press, Baltimore.

Happold, D. C. 1974. The small rodents of the forest-savanna farmland association near Ibadan, Nigeria with observations on reproductive biology. *Revue de Zoologie et de Botanique Africaines* **88:** 814-834.

Happold, D. C. D. & M. Happold. 1987. Small mammals in pine plantations and natural habitats on Zomba plateau, Malawi. *Journal of Applied Ecology* **24**: 353-367.

Happold, D. C. D. & M. Happold. 1991. An ecological study of small rodents in the thicket-clump savanna of Lengwe National Park, Malawi. *Journal of Zoology* **223**: 527-542.

Hillman, J. C. 1993. *Ethiopia: Compendium of Wildlife Conservation Information. Vol. 1 Wildlife Conservation Areas*. New York Zoological Society and Ethiopian Wildlife Conservation Organization, Addis Ababa.

Kingdon, J. 1997. *The Kingdon Field Guide to African Mammals*. Academic Press, London.

Kotler, B. P. 1984. Predation risk and the structure of desert rodent communities**.** *Journal of Ecology* **65:** 689-701.

Leirs, H. 1995. *Population Ecology* of *Mastomys natalensis* (Smith 1834). *Implications for Rodent Control in Africa*. Belgian Administration for Development Cooperation, Brussels.

Leirs, H., R. Verhagen, W. Verheyen, P. Mwanjabe & T. Mbise. 1996. Forecasting rodent outbreaks in Africa: an ecological basis for *Mastomys* control in Tanzania. *Journal of Applied Ecology* **33:** 937-943.

Lima, M. & F. M. Jaksic. 1999. Survival, recruitment and immigration processes in four subpopulations of the leaf eared mouse in semiarid Chile. *Oikos* **85**: 343-355.

Lima, M., R. Julliard, N. C. Stenseth & F. M. Jaksic. 2001. Demographic dynamics of a neotropical small rodent (*Phyllotis darwini*): Feedback structure, predation and climate. *Journal of Animal Ecology* **70**: 761-775.

MacDonald, D. 1984. *The Encyclopedia of Mammals*. Vol. 2. Academic Press Ltd., London.

Magige, F. & R. Senzota. 2006. Abundance and diversity of rodents at the human-wildlife interface in Western Serengeti, Tanzania. *African Journal of Ecology* **44:** 371-378.

Meserve, P. L., J. R. Gutiérrez, J. A. Yunger, L. C. Contreras & F. M. Jaksic. 1996. Role of biotic interactions in a small mammal assemblage in semi-arid Chile. *Ecology* **77**: 133-148.

Nowak, R. M**.** 1999. *Walker's Mammals of the World*. Vol. II. 6th edn. The John Hopkins University Press, Baltimore.

Odhiambo, R., R. Makundi, H. Leirs & R. Verhagen. 2005. Community structure and seasonal abundance of rodents of maize farms in southwestern Tanzania. *Belgian Journal of Zoology* **135**: 113-118.

Rozenzwig, M. L. & J. Winakur. 1969. Population ecology of desert communities: habitats and environmental complexity. *Ecology* **50**: 558-572.

Stenseth, N. C. & R. A. Ims. 1993. *The Biology of Lemmings*. Academic Press, London.

Tadesse, H. & B. Afework. 2008. Habitat association of insectivores and rodents of Alatish Proposed National Park, northwestern Ethiopia. *Tropical Ecology* **49**: 1-11.

Takele, S., B. Afework, B. Gurja & M. Balakrishnan. 2011. A comparison of rodent and insectivore communities between sugarcane plantation and natural habitat in Ethiopia. *Tropical Ecology* **52**: 61-68.

Taylor, K. D. & G. Green. 1976. The influence of rainfall on diet and reproduction in four African rodent species. *Journal of Zoology* **180**: 367-389.

Tsegay, G. & B. Afework. 2006. Population dynamics of pest rodents of Bilalo area, Arsi, Ethiopia. *Ethiopian Journal of Biological Sciences* **9**: 63-74.

Vaughan, A. T., M. J. Ryan & N. Czaplewaki. 2000. *Mammalogy*. Saunders College Publishing. 4th edn. New York.

Wilson, D. E. & R. Reeder. 1993. *Mammal Species of the*

World : A Taxonomic and Geographic Reference. Smithsonian Institution Press, Washington, D.C.

Woldeselassi, A. 2002. *Gumuz and Highland Resettlers. Differing Strategies of Livelihood and Ethnic Relations in Metekel Northwestern Ethiopia*. Ph. D. Dissertation, University of Göttingan, Göttingan.

Workeneh, G., B. Afework, B. Gurja & M. Balakrishnan. 2006. Home range and reproduction of rodents in Maynugus irrigation field, northern Ethiopia. *SINET*: *Ethiopian Journal of Science* **29**: 57-62.

Yalden, D. W. 1983. The extent of high ground in Ethiopia compared to the rest of Africa. *SINET*: *Ethiopian Journal of Science* **6**: 35-38.

Yalden, D. W. 1988. Small mammals of the Bale Mountains, Ethiopia. *African Journal of Ecology* **26**: 282-294.

Yalden, D. W., M. J. Largen & D. Kock. 1976. Catalogue of the mammals of Ethiopia, insectivores and rodentia. *Monitore Zoologico Italiano (NS) Supplemento* **8**: 1-118.

Yalden, D. W. & M. J. Largen. 1992. The endemic mammals of Ethiopia. *Mammal Review* **22**: 115-150.

(Received on 28.04.2010 and accepted after revisions, on 29.12.2010)