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SPECIES COMPOSITION, HABITAT ASSOCIATION AND RELATIVE ABUNDANCE OF SMALL MAMMALS IN BORENA SAYINT NATIONAL PARK, SOUTH WOLLO, ETHIOPIA

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ABSTRACT: Small mammals are ecological regulators in natural habitats. During the present investigation, species composition, distribution and relative abundance of small mammals were studied in Denkoro Forest, South Wollo, and Ethiopia from 2011 to 2012. In this investigation, Capture-Mark-Recapture (CMR) method was used. Data were collected during the wet and dry seasons by using Sherman live-traps (7.6× 8.9 × 22.9 cm. size) and snap-traps, and the traps were randomly laid at different trap sites of the habitats. The area of each live-trap grid was 70 ×70 m. Each of the grids consisted of seven lines, 10 m apart, with a trap station at every 10 m. A total of 49 Sherman traps was set in each grid, for 3 consecutive days. Ten species of small mammals belonging to rodents and insectivores were recorded from the study area. Additional two rodent species (*Hystrix cristata* and *Trachyoryctes splendens*)were sighted, but not captured. The small mammals trapped were *Lophuromys flavopunctatus* (35.7%), *Otomys typus* (28.5%), *Stenocephalemys griseicauda* (14.6%), *Arvicanthis dembeensis* (9.1%), *Crocidura flavescens* (5.9%), *Stenocephalemys albipes* (1.9%), *Crocidura fumosa* (1.4%), *Desmomys harringtoni* (0.8%), *Mus Mahomet* (0.6%) and *Dendromus lovati* (0.3%). Population abundance and species composition of small mammals varied from habitat to habitat and from season to season. *Lophuromys flavopunctatus* and *O. typus* were the most widely distributed and abundant species, whereas *S. albipes*, *C. fumosa* (in the forest), *D. harringtoni*, *D. lovati* and *M. mahomet* (in the farmland) were restricted species. Seasonal variation and availability of food resulted in variation in abundance and distribution of small mammals from habitat to habitat. Disturbance of small mammals by plant trampling and cutting should be stopped since small mammals are a source of diet to the endemic Ethiopia wolf and other carnivores.

Keywords/ phrases: Denkoro forest, habitat association, insectivores, rodents, species composition

INTRODUCTION

Mammals are diverse group of vertebrates and range in size from whales to mice (Afework Bekele and Yalden, 2013). Small mammals form a major proportion of the mammalian fauna, and among them, rodents comprise approximately 43% with 29 living families, 443 genera and about 2004 species (Vaughan *et al*., 2000; Danell and Aava-Olsson, 2003). Rodents show considerable diversity in morphology, habitat utilization, behaviour, and life history strategies (Sewnet Mengistu and Afework Bekele, 2003). In Ethiopia, the small mammal fauna is particularly diverse. So far, 84 species of rodents have been recorded from Ethiopia, of which 21% is endemic (Afework Bekele and Yalden, 2013). Among the nine families of rodents that occur in Ethiopia, the family Muridae comprises 57 species (84%) and 93% of the total endemic rodents. In general, 50% of the Ethiopian endemic mammals are rodents (Afework Bekele and Corti, 1997). This is mainly determined by the topographical diversity and related characteristics of the country. Distribution and reproductive patterns of rodents generally follow seasonality in relation to variations in rainfall and peaks at the end of the rainy season when resources are plenty (Workneh Gebresilassie *et al*., 2004). As a result, the nature and density of vegetation determine the abundance and distribution of small mammals. Rodent density in a given area correlates with the availability of food resources (Cole and Batzli, 1979; Workneh Gebresilassie *et al*., 2006). In this area, no more studies regarding small mammals species composition, habitat association and abundance. Hence, the findings would enable to fill the gaps in area of small mammals. Additionally the findings would enable to determine the prey status of Ethiopian wolf in the area. Since, small mammals are the main source of food for the Ethiopian wolf.

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THE STUDY AREA AND METHODS

Study area

The present study was carried out in the Amhara Regional State, South Wollo Zone, located between two Woredas of Debersina and Densa. It is located about 596 km north of Addis Ababa and 196 km from Dessie via Mekaneselam. Geographically, Denkoro Forest is bounded by $10^{o}50'$ 25''–10^{o} 54' 27'' N latitudes and 38^{o} 40' 41''–038^{o} 53'' 39' E longitudes (Figure 1).

Denkoro forest was originally recognized and proposed to be protected during the reign of Emperor Zera-Yakob (1428−1462). It was legally recognized as an important biodiversity area or priority forest area in 1952 during Emperor Haile Selassie (PaDPA, 1999). The protection of the forest continued during the military regime as a State Forest. Denkoro Forest has a wide range of altitude, and therefore, embraces three climatic zones, 'Woinadega'(midland), 'Dega' (highland) and 'Wurch' (Afroalpine) (PaDPA, 1999). The distribution of rainfall in the area is characterized by a bimodal pattern. The long rainy season is from June to the end of September, while the short rainy season is from mid-January to April. Periodical records of temperature extend from 20^{o}C to 25^{o}C during the dry season and from 10^{o}C to 15^{o}C during the wet season. Denkoro Forest Priority Area represents rich biodiversity with high number of endemic species and attractive biophysical features (Keiner, 2002). Even though the forest is small in size with an area of 720 ha, it has higher species diversity due to the characteristics of moist evergreen forest (Abate Ayalew *et al*., 2006). The study area, in general encompasses three vegetation zones such as Afro-alpine belt, sub-afro-alpine belt and Afro-montane belt.

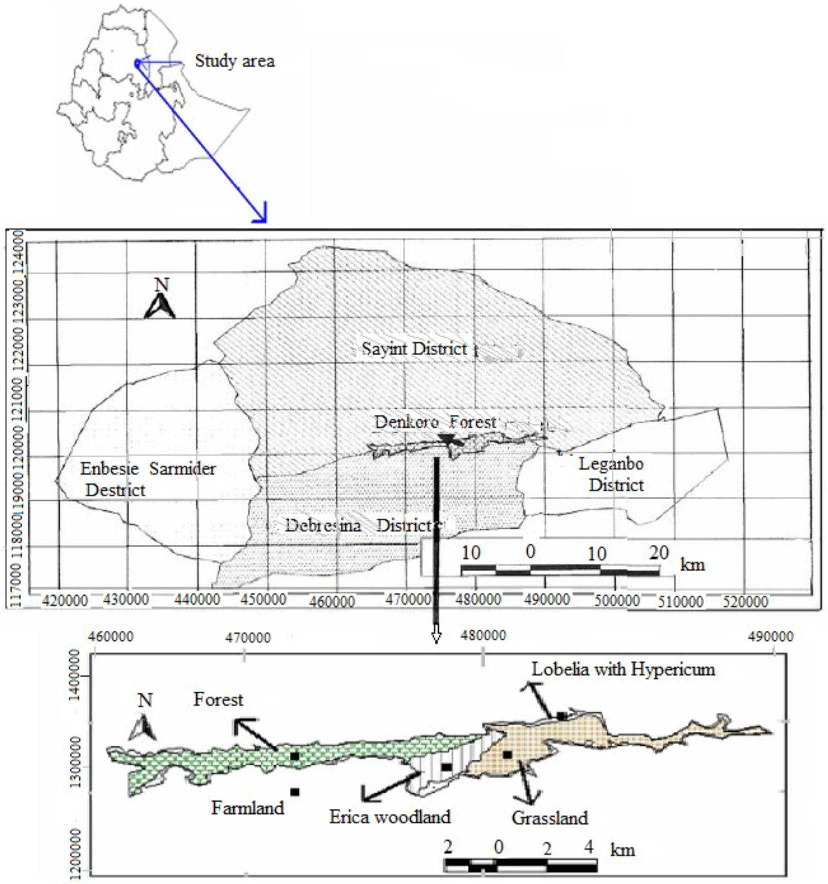

Figure 1. Map of the study area showing the position of grids

Methods

Data were collected during the wet and dry seasons by using Sherman live-traps (7.6× 8.9 × 22.9 cm. size) and snap-traps, and the traps were randomly laid at different trap sites of the habitats such as afro-alpine, afro-montane, grassland, *Erica* moorland. For live-trapping, five grids were randomly identified to represent different vegetation zones such as *Erica* moorland, grassland and forest. The area of each live-trap grid was 70 ×70 m. Each of the grids consisted of seven lines, 10 m apart, with a trap station at every 10 m. A total of 49 Sherman traps was set in each grid, for 3 consecutive days. Snap-traps (n=25) were set at an interval of 20 m at a distance of 200 m away from live-trapping sites for 3 consecutive days, in each site. Peanut butter mixed with wheat or barely scraps were used as bait. The grid was checked twice a day from 07:00 to 09:00h and 16:00 to 18:00h., respectively. Trapped animals were marked by toe clipping and released after recording the location of capture, weight, species identification code, sex and reproductive status (Happold and Happold, 1991; Clausnitzer *et al*., 2003). Weight was recorded by a Pesola spring balance. Each species was identified as juvenile, sub-adult, or adult based on weight and pelage colour. Sexual condition of males was noted based on the relative size and position of testes, whether it is scrotal or inguinal. For females, the condition of vagina was noted as perforated or non-perforated, size of nipples, and lactating or not. Species were identified using morphological characters, activity patterns and referenced specimens of the Zoological Museum of Addis Ababa University. The data were analysed by using SPSS 17.0 software for Windows Evaluation Version. Chi-square tests were used to compute distribution, relative abundance and habitat association of small mammals between dry and wet seasons. Wet and dry seasons were independent variables to run the data and to determine dependant variables such as abundance and habitat association of small mammals in different study periods.

RESULTS

Species composition

A total of 871 individuals of small mammals were trapped during 4440 trap nights. These comprised eight species of rodents and two species of insectivores (shrews). From the total number of small mammals trapped, 808 (92.8%) were rodents and 63 (7.2%) were shrews. The abundance eight species of rodents trapped were *Lophuromys flavopunctatus* Thomas, 1888 (35.7%), *Otomys typus* Heuglin, 1877 (28.5%), *Stenocephalemys griseicauda* Petter, 1972 (14.6%), *Arvicanthis dembeensis* Rüppell, 1842 (10.3%), *Stenocephalemys albipes* Rüppell,1842 (1.9%), *Desmomys harringtoni* Thomas, 1903 (0.8%), *Mus mahomet* Rhoads, 1896 (0.6%) and *Dendromus lovati* De Winton, 1899 (0.3%). Insectivores were *Crocidura flavescens* I. Geoffroy, 1827 (5.9%) and *Crocidura fumosa* Thomas, 1904 (1.4%) (Table 1). Among the insectivores, *C. fumosa* was highly restricted in the forest habitat. *C. flavescens* was present in open grassland, *Erica* moorland, and *Lobelia* with *Hypericum* sp. habitats. In addition, *Tachyoryctes splendens* Rüppell, 1836 and *Hystrix cristata* Linnaeus, 1758 were also observed in the study area (Table 1)

Table 1. Species composition of small mammals trapped from different habitats in Denkoro Forest (* observed, not trapped)

Species	Total capture	Relative abundance
Lophuromys flavopunctatus	311	35.7
Otomys typus	248	28.5
Stenocephalemys griseicauda	127	14.6
Arvicanthis dembeensis	90	10.3
Stenocephalemys albipes	18	1.9
Desmomys harringtoni	7	0.8
Mus mahomet	4	0.6
Dendromus lovati	3	0.3
Crocidura flavescens	52	5.9
Crocidura fumosa	11	1.4
*Tachyoryctes splendens**	*	*
*Hystrix cristata**	*	*
Total 12	871	100

Distribution of rodents and insectivores in different habitat types

Rodents and insectivores were not uniformly distributed in all habitat types, and variation in species and population number of rodents and insectivores was observed from habitat to habitat. *Lophuromys flavopunctatus* is the most widely distributed species in the study area. The population size was also very high. The other widely distributed species was *O. typus,* and it occurred in all habitats. However, its population was less than that of *L. flavopunctatus.* The less distributed species in the study site were *S. albipes* and *C. fumosa.* These were highly restricted in the montane forest habitat type. *Desmomys harringtoni*, *D. lovati* and *M. mahomet* were also less distributed species, which were confined to the farmland habitat of Denkoro Forest (Table 2).

Table 2. Habitat-wise capture of rodents and insectivores in different habitat types in the study area

Species	Individuals trapped from different habitats					
	OGL	ML	LH	MF	FL	Total catch
L. flavopuncta	42(36.5)	35(30.4)	29(25.2)	-	9(7.8)	115
O. typus	78(26.2)	12(4.0)	125(41.9)	67(22.5)	16(5.4)	298
S. griseicauda	60(83.3)	-	-	-	12(16.7)	72
A.dembeensis	41(18.1)	36(15.9)	129 (56.8)	14(6.2)	7(3.1)	227
S. albipes	-	-	-	15 (100)	-	15
D.harringtoni	-	-	-	-	6(100)	6
D.lovati	-	-	-	-	2(100)	2
M.mahomet	-	-	-	-	4(100)	4
C.flavescens	31(65.9)	5 (10.6)	11(23.4)	-	-	47
C.fumosa	-	-	-	7(100)	-	7
Total 10	252	86	294	103	56	793

OGL= open grassland, ML= moorland, LH=Lobelia with *Hypericum*, MF= montane forest, FL= farmland; figures in brackets show percentage.

Seasonal variation

Lophuromys flavopunctatus, *S. griseicauda*, *C. flavescens*, and *C. fumosa* were abundant during the wet season, whereas *D. harringtoni*, *D. lovati* and *M. mahomet* were recorded only during the dry season. Trapping of *A. dembeensis* was more at the end of the wet season and the beginning of the dry season (Table 3). There were significant difference in the abundance of *S. griseicauda* (χ^2 = 69.5, df= 2, p < 0.001), *L. flavopunctatus* (χ^2 = 34.8,df = 2, p < 0.001), *A. dembeensis* (χ^2 =38.9, df = 2, p< 0.001), *O. typus* (χ^2 = 22.2, df= 2, p <0.001), *S. albipes* (χ^2 =2.3, df = 2, p < 0.05) *M. mahomet* (χ^2 = 1.0, df = 2, p < 0.05), *C. flavescens* (χ^2 = 22.9, df = 2, p < 0.001) and *C. fumosa* (χ^2 = 1.3, df= 2, p < 0.05) between wet and dry seasons. However, the abundance of *S. albipes* andD*P. harringtoni* showed no significant difference between wet and dry seasons (χ^2= 0.7, df = 2, p > 0.05, χ^2 = 0.3, df= 2, p > 0.05). The relative abundance of small mammals between wet and dry seasons was 64.4% and 35.6%, respectively, and the difference was statistically significant (χ^2 =7.8, p<0.05).

Table 3. Seasonal variation in the abundance of live-trapped small mammals (M=male; F=female)

Species	Wet season capture August/October		Dry season capture December/ February		Total capture	
	M	F	M	F	M	F
Stenocephalemys griseicauda	50	41	13	11	63	52
Lophuromys flavopunctatus	113	103	35	47	148	150
Arvicanthis dembeensis	19	21	15	17	34	38
Otomys typus	48	57	51	71	99	128
Stenocephalemys albipes	4	3	2	6	6	9
Desmomys harringtoni	-	-	3	4	3	4
Dendromus lovati	-	-	2	-	2	-
Mus mahomet	-	-	3	1	3	1
Crocidura flavescens	20	25	-	2	20	27
Crocidura fumosa	3	4	-	-	3	4
Total 10	257	254	124	158	381	412

Age structure and sex ratio

Out of the total of 793 individuals live-trapped small mammals, juveniles comprised 100 (19.9%), sub-adults 70 (13.9%) and adults 333 (66.2%) individuals during the wet season (Table 4). However, juveniles comprised 52 (17.9%), sub-adults 23(7.9%) and adults 215(74.2%) during the dry season. The difference in the total capture of juveniles during the two seasons varied significantly (χ^2 = 22.3, df = 2, p<0.001). In addition, the difference in total capture of both sub-adults and adults was also statistically significant (χ^2=31.8, df= 2, p < 0.001, χ^2=109.1, df= 2, p < 0.001, respectively). Out of the total trapped individuals, males comprised 381 (48.1%) and females 412 (51.9%). During the wet season, there were 257 males and 254 females, whereas during the dry season, 124 males and 158 females in the total capture. Hence, the sex ratio of trapped individuals was not significantly different (χ^2 0.16, df= 2, p > 0.05).

Table 4. Age structure and sex ratio of small mammals

Month /seasons	Age structure						
	Juveniles		Sub-adult		Adult		Total
	M	F	M	F	M	F	
August/September (1st wet season)	26	34	17	27	66	87	257
December (1st dry season)	13	19	9	6	60	73	180
October (2 nd wet season)	18	22	14	12	70	110	246
February (2nd dry season)	14	6	5	3	37	45	110
Total	71	81	45	48	233	315	793

Density and biomass

The highest small mammal biomass was revealed in *Lobelia rhynchopetalum* mixed with *Hypericum* sp. grid, followed by open grassland (Table 5). *O. typus* constituted the highest proportion of biomass in all grids. The small mammal biomass varied between grids and between trapping sessions. In *Lobelia rhynchopetalum* mixed with *Hypericum* sp. grid, the maximum biomass recorded per hectare was 9,744 g during the second trapping session (wet season) and the minimum was 40 g/ha during the third session (dry season). The minimum small mammal biomass was obtained from the wheat grid. In the wheat grid, the maximum biomass recorded per hectare was 784.8 g and the minimum was 60.2 g/ha in the same (fourth) trapping session. The biomass of small mammal in relation to seasonal variation in *S. griseicauda* and *L. flavopunctatus* was significantly different between wet and dry season (χ^2 = 2.0, df= 2, p <0.05, χ^2 = 1.6, df= 2, p < 0.05, respectively).

Table 5. Number and biomass (g ha^{-1}) of small mammals captured at different trapping sessions

Sess -ion	Grid	S.g Mbw=68.3 n=233	L.f, Mbw=59, n=611	A.d Mbw=83 n=146	O.t Mbw= 116 n=463	S.a Mbw= 48 n=30	P.h Mbw =58 n=12	D.l Mbw =25 n=4	M.m Mbw =30 n=8	C.fl Mbw=3 0, n=95	C.f Mbw =20 n=14
1	1	55(3756)	86(5082.6	8(669)	8(928)	0	0	0	0	39(799	0
	2	37(2527)	14(827.4)	0	6(696)	0	0	0	0	4(82)	0
	3	29(1980)	16(6855.6	0	47(5452	0	0	0	0	12(246)	0
	4	0	29(1713.9	0	2(232)	6(288)	0	0	0	0	0
	5	4(273.2)	10(591)	6(502.2	4(464)	0	0	0	0	0	0
2	1	22(1502)16	59(3486)	65(5440)	29(3364)	0	0	0	0	22(451)	0
	2	(1092)14(9	8(472.8)	0	18(2088)	0	0	0	0	8(164)	0
	3	56.2	76(4491.6)	0	84(9744)	0	0	0	0	6(123)	0
	4	0	35(2063.5)	0	10(1160)	8(384)	0	0	0	0	
	5	8(546.4)	8(472.8)	2(167.4)	6(696.0)	0	0	0	0	0	6(132) 0
3	1	6(409.6)14(	24(1418.4)	20(1674)	22(2552)	0	0	0	0	0	0
	2	965.2	0	0	33(3828)	0	0	0	0	0	0
	3	10(683)	49(2895.9)	0	82(9512)	0	0	0	0	4(40)	0
	4	0	31(1832.1)	0	8(928)	12(576)	0	0	0	0	0
	5	2(136.6)	10(591)	10(837)	2(232)	0	8(464)	4(100	6(180	0	0
4	1	8(546.4)	14(827.4)	31(2594)	31(3596)	0	0	0	0	0	0
	2	4(273.2)	6(354.6)	0	20(2320)	0	0	0	0	0	0
	3	4(273.2)	20(1182)	0	37(4292)	0	0	0	0	0	0
	4	0	12(709.2)	0	6(696)	4(192)	0	0	0	0	0
	5	0	4(236.4)	4(334.8)	8(928)	0	4(232)	0	2(60.2)	0	0
	Tota1	233 15,913.9	611 (36,110.1)	146 (12,220)	463 (53,708)	30 (1,440)	12 (696)	4 (100)	8 (240.8)	95 1905.5	14 305

Grid 1= open grassland, Grid 2= moorland, Grid 3 = *Lobelia* with *Hypericum*, Grid 4 = montane forest, Grid 5 = farmland; *S.g.=Stenocephalemys griseicauda*, L.f.=*Lophuromys flavopunctatus*, *A.d.=Arvicanthis dembeensis*, *O.t.=Otomys typus*, *S.a.=Stenocephalemys albipes*, *P.h.=Pelomys harringtoni*, *D.l.=Dendromus lovati*, M.m.=*Mus Mahomet*, *C.fl.=Crocidura flavescens*, *C.f.=Crocidura fumosa* (Figures in parentheses show biomass, Sessions 1 and 2 are wet season, and Sessions 3 and 4 are dry season).

Trap success

Number of captures and trapping success varied among habitat types (Table 6). Capture rates significantly differed between habitats (χ^2 =47.8, df= 2, p < 0.001). The highest catch was recorded from *Lobelia rhynchopetalum* mixed with *Hypericum* sp. habitat (294), followed by open grassland (252). The lowest capture was from farmland (56)(Table 6).

Table 6. Trap success of small mammals from different habitat types in the study area

Habitats	Altitude (m)	Total capture	Trap nights	% Trap success
Open grassland	3293 m asl	252	588	42.9
Moorland	3413 m asl	88	588	14.9
Lobelia with Hypericum	3490 m asl	294	588	50.0
Montane forest	3114 m asl	103	588	17.5
Farmland	2848 m asl	56	588	9.5

The maximum trap success was recorded in *Lobelia rhynchopetalum* mixed with *Hypericum* grid (50%) and the minimum was from farmland (9.5%). The trap success from different habitats varied between seasons. More individuals were recorded from open grassland and *Lobelia rhynchopetalum* mixed with *Hypericum* habitats during the wet season and the least was from the farmland during the dry season (Table 7). The trap success between habitats (OGL, ML, LH, MF and FL) during different seasons was significantly different (χ^2= 39.6,df=2, p < 0.001, χ^2 = 4.4, df=2, p< 0.01).

Table 7. Trap nights, total capture and trap success during the wet and dry seasons in different habitats

Habitat types	Grid with altitude	Seasons	Sessions	Trap nights	Total capture	Trap success (%)
OGL	G1	Wet	1	147	91	61.9
	(3293 m)	Dry	3	147	36	24.5
		Wet	2	147	97	65.9
		Dry	4	147	28	19.0
ML	G2	Wet	1	147	30	20.4
	(3413 m)	Dry	3	147	20	13.6
		Wet	2	147	25	17.0
		Dry	4	147	13	8.8
LH	G3	Wet	1	147	97	65.9
	(3490 m)	Dry	2	147	65	44.2
		Wet	3	147	86	58.5
		Dry	4	147	46	31.3
MF	G4	Wet	1	147	28	19.0
	(3114 m)	Dry	2	147	32	21.8
		Wet	3	147	34	23.1
		Dry	4	147	9	6.1
FL	G5	Wet	1	147	8	5.4
	(2848 m)	Dry	2	147	26	17.7
		Wet	3	147	16	10.9
		Dry	4	147	6	4.1

(OGL = open grassland, ML= moorland, LH = *Lobelia* with *Hypericum*, MF=montane forest, FL= farmland).

DISCUSSION

In the present study area, ten species of small mammals were captured and two additional species were observed. Similarly Duckworth *et al*. (1993) had reported the same numbers of rodent and insectivore species around Arbaminch Forest Area. In addition, Bekele Tsegaye (1999) recorded nine species of rodents from Entoto area, Afework Bekele (1996b) recorded twelve species of rodents from Menagesh State Forest and Yalden (1988) recorded seven species of rodents from the Bale Mountains National Park.

In the present study area, distribution of rodents and insectivores were unevenly distributed; some species were restricted only to a particular habitat type while others did not. Inline with this, Merritt *et al*. (2001) had stated that the distribution of small mammals over an area is not uniform as species are more abundant in some habitats than others. The distribution of some species of small mammals restricted in some habitat types and may not be found others might be related to habitat preference of the species. Similarly, Yalden and Largen (1992) and Clausnitzer and Kityo (2001) had reported that the variations in distribution of small mammals over an area is usually associated with ecological requirement of each species.

Age distribution in a population of most species of rodents and insectivores is directly related to seasonality in reproduction (Yalden, 1988). When reproduction of a species is seasonal, age groups are expected to occur in the population in specific season. In the present study, during the wet season, more juveniles were recorded next to adults. Sub-adults were less in number compared to the juveniles. However, during the dry season, there was a decrease in the abundance of all age groups of small mammals in the present study area. Even for the most abundant species, *L. flavopunctatus* and *O. typus*, juveniles were rarely recorded during the dry season. This might be associated with giving low litter size. In the dry season the availability of food is very low as a result no more pregnant females that going to give juveniles. In addition, predators who rarely depend on small mammals in the wet season entirely depend on during the dry season because of this the number of most abundant small mammal species got decrease.

In the present study, the sex ratio of trapped small mammals did not vary significantly based on seasonal changes. However, in some cases, the number of females increased as the number of captured rodents and insectivores increased. Such increase of females would result in the increase of reproductively active females, and subsequently increase of the population. The increment of females than the males in the present study area might be related with males is highly mobile, or dispersal as a result they spent much time and energy for fighting with others and exposed to predators and other factors.

The mean trap success in the present study was 26.9%. Similar studies in different parts of Ethiopia have also shown variations in trap success. Afework Bekele (1996b) recorded a mean trap success of 9.1% in the Menagesha State Forest. Yalden (1988) obtained 18.7% mean trap success from Harenna Forest, Happold and Happold (1991) recorded a trap success of 33% from Lengwe National Park, Malawi and Bekele Tsegaye (1999) has recorded 62.8% average trap success from Entoto Natural Park, Ethiopia. During the present study, the highest overall trap success was recorded from open grassland and *Lobelia* mixed with *Hypericum* habitat (65.9%), whereas the lowest was from farmland (4.1%). In general, the present study showed trap success to be high during the wet season than during the dry season. This was highly related to the population dynamics between seasons. During the wet season, the population increased probably due to increased availability of food. At the same time, during this period, burrows were filled with water. As a result, animals were forced to hide in grass, and enhance the chance to enter the traps enabling to increase trap success during the wet season. Low trap success was recorded during the dry season. This could be due to low population density as the population in the dry season was affected by shortage of food supply in the habitat in addition to the presence of high number of avian predators. Furthermore, during the dry season due to excessive solar radiation, trap success was affected as most small mammals prefer to hide in their burrows for a long period to avoid harsh environmental conditions.

Density of small mammals in the present study varied from habitat to habitat. The overall density of small mammals recorded habitat-wise throughout the trapping sessions varied significantly. The lowest density was estimated from the wheat farm (112/ha). Whereas the highest density was from *Lobelia* mixed with *Hypericum* habitat type (590/ha). The density of small mammals per hectare in the present study showed a range of 2−116/ha. Happold and Happold (1989) estimated the density of small mammals in montane area of Malawi from 3−17/ha, Mena *et al*. (2011) found densities of 236–361/ha in the lowland forest of Congo and Caro (2001) estimated population densities in out side African National Park as 16–106/ha. In general, a comparison of population density of small mammals is difficult as it depends of a variety of factors such as topographical features, weather patterns and habitat characteristics, which vary from place to place. Afework Bekele (1996a) remarked that a comparison of the density and biomass of small mammals in different areas is difficult due to the variations of habitats and weights of different species of small mammals, in addition to underestimation of the available numbers. The present study has revealed that the biomass of rodents and insectivores significantly decreased during the dry season. This might be related to the availability of food, which is restricted both quantity and quality during the dry season. Merritt *et al*. (2001) and Conde and Rocha (2006) have stated that weight of small mammals decreased more during the dry season than during the wet season due to limited availability of food during the dry season. The quality of food and its availability are important in determining the fertility rate of small mammals. This also evident from the less number of embryos recorded during the dry season.

The mean biomass of small mammals of all trapping occasions was 11,791.4 g/ha for *Lobelia* with *Hypericum* habitat type, followed by 8,002.9 g/ha for open grassland habitat. The lowest biomass estimated was 1,567 g/ha for wheat farm. The highest and the lowest average biomass estimates were obtained during the second trapping session in the *Lobelia* mixed with *Hypericum* habitat type and during the fourth trapping session (post-harvesting) in the wheat farm, respectively. Manyingerew Shenkut *et al*. (2006) revealed that variation in the biomass recorded during different trapping sessions was associated with the fluctuation in population number. Similarly, in the present study, the biomass of small mammals varied from one grid to another in different trapping occasions. The present study has also revealed that the trap success significantly varied between habitats and seasons.

CONCLUSION AND RECOMMENDATIONS

Ecologically, small mammals have a significant impact on the environment as grazers, seedeaters, insectivores, as prey for some carnivores and a source of human diet. Furthermore, they are important pests of agriculture in the field, and are vectors of disease. In the present study; distribution, habitat association and relative abundance of small mammals were varied from habitat to habitat and season to season. Variations in the abundance of small mammals in different habitats show the key role of ground vegetation from season to season. In addition, density of small mammals varied within different habitats and seasons. This is related to the variation in rainfall between seasons. High trap success in wet season than dry season was associated with high population growth as a result of more birth than death in wet season. Based on the information obtained from the present study, the following recommendations are suggested:

- Avoid disturbance of small mammals by plant trampling and cutting. They are the main source of diet to the endemic Ethiopia wolf and other carnivores.
- Construct alternative roads out of the national park and the daily traders should be stopped so that trampling of *Festuca*, undergrowth and small mammals disturbance could be minimized.

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