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Comparative study of rodents and insectivores in natural and coffee forest habitats of Afalo Area, Gera district, Southwestern Ethiopia

Demelash Sime, Tadesse Habtamu and Tsegaye Gadisa

Abstract
The Comparative study on the diversity, distribution and abundance of rodents and insectivores in natural and coffee forest habitats of Afalo area of Gera district was conducted from August, 2014 to March, 2015. Two sites (coffee forest and natural forest) were identified and employed for the study purpose. Grids were established and representative sample sites were taken from randomly selected of each of the habitat types. Then, the species were sampled by setting traps on randomly selected grids. The specimens of the study animals were trapped by using snap traps and Sherman live traps and identified to the specie level. Skin and skull of some representative specimens were mounted and used for identification of animals in the laboratory. During the present study about 110 individuals were captured, among these, 5 species were rodents and 3 of them were shrews species. Of the total trapped species, *Lophuromys flavopunctatus* were the most abundant one 35(49.3%), followed by *Grammomys dolichuros*, and *Lophuromys chrysopus* 23(47.5%) and 16(29.7%) respectively. Rattus rattus, Mus musculus, *Crocidura flavescens*, *Crocidura fumosa* and *Crocidura bicolor* had 22.2%, 20.7%, 13.3%, 10.7% and 1.4% respectively. *Hystrix cristata* and *Paraxerus ochraceus* had the lowest relative abundance (1.4%) each. *Hystrix cristata* and *Paraxerus ochraceus* were recorded only from NF habitat. The species abundances were varies with habitats and seasons. There were significant differences in the abundance of rodent and insectivore among the seasons (x^2= 2.11, df =1, P<0.05). Diversity and abundance of species affected by increased habitat heterogeneity, open habitat, habitat disturbance, vegetation structure and seasonal availability of food and water. The highest abundance and species diversity of insectivore was recorded in natural forest (NF) habitat (H' =1.634). The species diversity, abundances and distribution of the study area were mainly affected by flora cover, rainfall distribution and human disturbances. Further assessment and evaluation will highly recommended on the comprehensive description of forest fauna and on the impacts of forest management practices on the diversity, distribution and abundance rodents and insectivores of the study site.

Keywords: abundance, distribution, diversity, Gera, rodents, insectivore, forest, Ethiopia

1. Introduction
1.1. Background of the study
Mammals those have less than 200gm body weight can be referred as Small mammals [1, 2]. As compared with other mammals, small mammals are the most successful species and consist of the highest proportion [3-5]. Moreover, they also account for almost half of the total mammal fauna in any given area [6]. Diverse types of interactions with other organisms, adaptability to diverse habitats and variation in the food habit of small mammals have been responsible for their success in such wide distribution pattern, globally. In Africa, small mammals are probably the most ubiquitous and numerous [7].

The diversity, abundance and distribution of rodents and shrews species can be affected by several biological and physical factors, including predator avoidance, competition within or with other species, and resource levels, especially the availability of food and water [8, 9]. The population dynamics of small mammals follow seasonality in relation to variations in rainfall and reach peaks towards the end of the rainy season when resources are plenty [10, 11]. In community dynamics of small mammals habitat selection is considered as an important factor because of their high potential for reproduction and ability of their invasion [12]. Generally, habitats with increased structural heterogeneity positively influence small mammal abundance and richness [13].

They play a significant role in natural communities including as a source of energy for predators and raptors [14] and acts as a good indicators of habitat disturbance [15].

They are also, useful tools in the study of elevational gradients, mainly because of their well-defined assemblages (in contrast to medium-sized and large mammals) along such gradients [16, 17].

Small mammals are good bio-indicators of environmental condition due to their rapid turnover rate [18], high biotic potential, ability to invade reclaimed areas and sensitivity to environmental disturbance [19]. They may potentially influence vegetation composition via selective foraging [20]. Small mammals diversity tends to be lower in open habitats, where cover providing food & resources [21] is reduced, leading to lower fecundity [22] as well as increased predation risk [23, 24].

A number of studies have been carried out on several aspects of small mammal communities in some parts of the Ethiopia. There are 58 forested areas in Ethiopia that have been given priority conservation status [25], but rodents and insectivore have been assessed in only some of these [26]. Most of the assessments have been confined to those forests in the central & southern highland areas [27]. None of these, assessed the small mammalian diversity of the tropical forest & rare for the coffee forest habitats [28]. Gera forest is one of the forests under protection, but less studied.

Coffee plantation has led to a loss of natural habitats and affected both the composition and diversity of small mammal species living in natural habitats [29]. Coffee plantations and extensive resettlement activities has leading to the destruction of natural habitats [30, 31]. From these points of view, the diversity of small mammalian species would be expected to be less diverse and more homogeneous in agricultural lands than in conservation land-uses because of the homogeneous vegetative structure.

Small mammal species richness was reported to be higher in structurally complex forests [32] and species composition and abundance is positively influenced by forest management and increased habitat heterogeneity [13]. In addition, activity of changing natural forest had negative effects on small mammal abundance due to decrease herbaceous understory on recently cut sites. Beside, [33] indicated that modified habitats including plantation forest and cultivation influenced rodent distribution due to availability and quality of food, shelter and rainfall. Therefore, this study aimed to assess the areas for their faunal diversity may contribute to the enrichment of the faunal list of the country. And this study also report faunal potential of the region has and the potential economic and social risks particularly associated with small mammals. In addition, to fulfill the gap on information on the small mammal fauna of the tropical forest, attempts to collect data on the diversity, distribution and relative abundance of small mammals between natural and managed tropical coffee forest habitat of the study area.

1.2. Statement of the problem

Small mammals play a fundamental role in ecosystem functioning as they constitute the prey base for many predators [14] and may potentially influence vegetation composition via selective foraging [20]. Small mammals have been used elsewhere as ecological indicators of the effects of forest management practices [34, 35]. Small mammals are also good bio-indicators of environmental condition, and habitats due to their rapid turnover rate, high biotic potential, ability to invade reclaimed areas and sensitivity to environmental disturbance [18, 19].

They also affect the structure, composition, and dynamics of ecosystems through natural processes such as pollination, seed dispersal and depredation, insectivore, and as food for predators [36-38].

So far, no comparative study of small mammal's composition, distribution, and abundance in the natural and tropical coffee forests habitats was conducted. This study therefore, attempted to assess the diversity of small mammals in two different habitats and identify the habitat that is less diverse on the composition of small mammals. With the result of the research the faunal potential of the region mentioned and factors affecting the composition, distribution and diversity of small mammals identified and recommended to be solved by concerned body.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study aims to compare the diversity, distribution and abundance of small mammals (rodents and insectivores) in natural and coffee forest habitats in Afalo area, Gera district, Southwestern Ethiopia.

1.3.2. Specific Objectives

To determine the diversity, distribution and abundance of rodents and insectivores in natural forest habitat of Afalo area.

To determine the diversity, distribution and abundance of rodents and insectivores in managed coffee forest habitat of Afalo area.

To compare the diversity and abundance of rodents and insectivores in the natural and coffee forest habitat of Afalo area.

To determine the impacts of managed coffee forest habitat of Afalo area on the diversity, distribution and abundance of rodents and insectivores.

1.4. Significance of Study

Small mammal species play key ecological roles in tropical forests. Small mammals are good bio-indicators of environmental condition due to their rapid turnover rate, high biotic potential, and sensitivity to environmental disturbance. They also provide food for predators. Therefore, study is essential to determine the diversity, distribution and abundance of species of small mammals among natural and coffee forest habitats to compare the diversity and abundance of small mammal's species in both habitat types & then the study also enrich faunal list of the country and fills the gap of faunal potential of the study area have. Hence, this study is planned to give stand line information on rodents and insectivore species in the study area for future study and provide information on the broad knowledge of these important mammals. And also forward the recommendation based on this research finding.

2. Material and Methods

2.1. Description of Study area

This study was conducted in Afalo area, Gera district, which located in the west direction of Jimma town, southwestern Ethiopia between 7°38'12.5''- 7°46'13''N & 36°17'04.6''-36°21' 0.5''E. The altitudinal ranges of Afalo area was 7°38' N, 36°13' E **[47]**. Gera district is 70km far from Jimma & 435km from Addis Ababa. Gera is located in the Eastern Afromontane biodiversity hotspot1, one of 34 hotspots in the world **[48]**. The district has areal size of 1,330 km^2 [49].

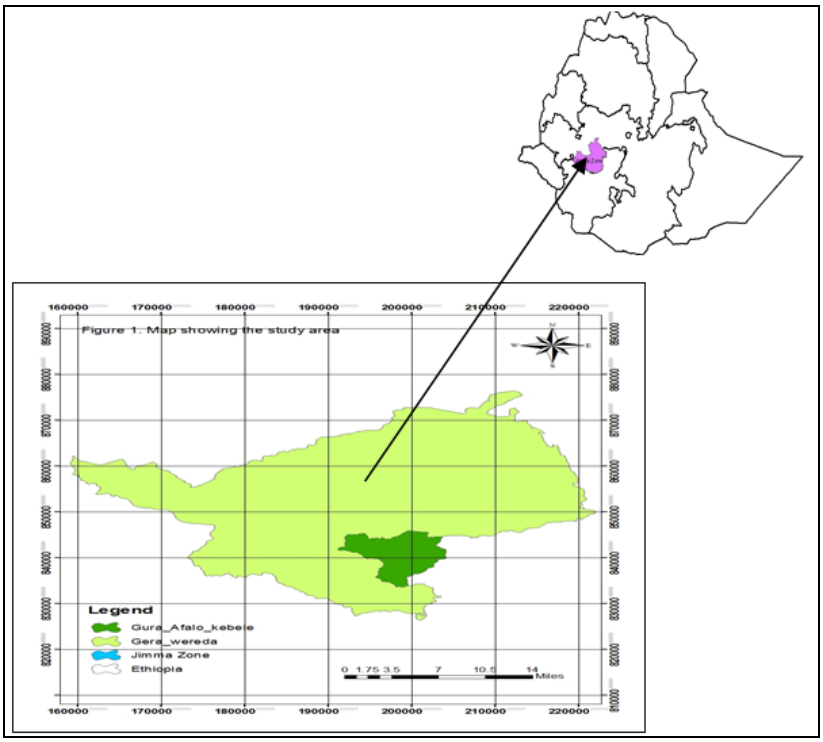

Fig 1: Map of the study area

The climate data for temperature and rainfall over the five years (2010-2014) for the study area was obtained from Jimma meteorology station. Differences in temperature throughout the year are small. According to the temperature data obtained from the Ethiopia Metrological Agency at Jimma station the mean maximum (Max) and minimum (Min) annual temperature of area ranged between 24.5 °C and 11.0 °C, respectively (Fig. 2).

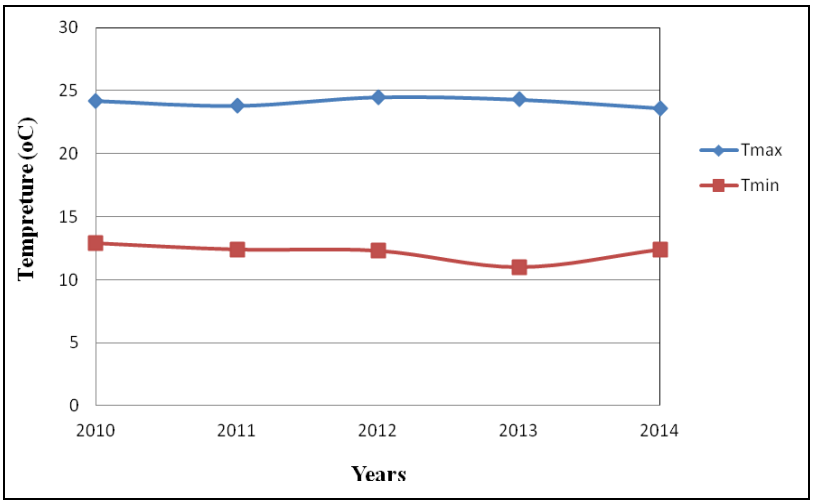

Fig 2: The mean annual Min and Max temperature of Gera Woreda (Afalo area) from 2010-2014 (National Meteorological Agency, Jimma Branch, 2015).

The rainfall distribution pattern of this area is bimodal, the highest rainfall between June and September and with low rainfall during March and April the (National Meteorology Agency, Jimma Branch, 2015). The total amount of annual rain fall in the study area varies between 1200mm and 1800mm (Fig.3) and the mean annual rainfall of the area is 1900mm.

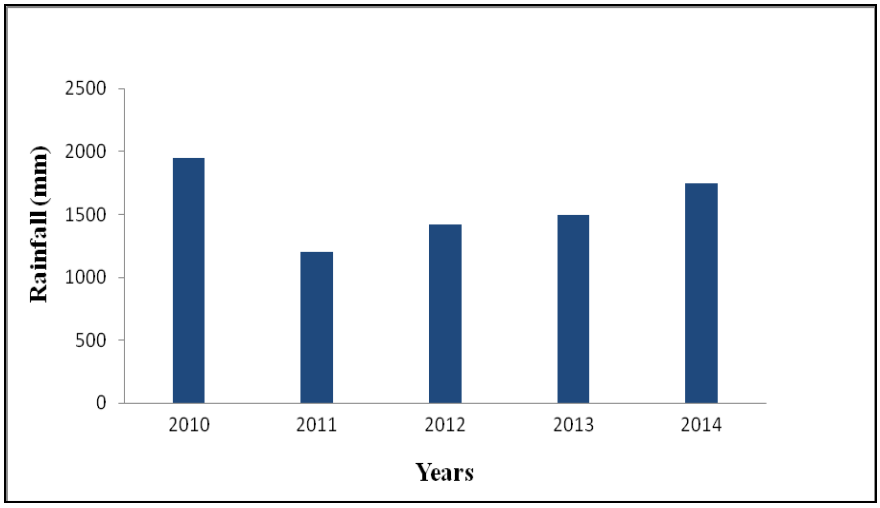

Fig 3: Mean annual rainfall of Gera District area from 2010-2014 (National Meteorology Agency, Jimma Branch, 2015).

The area has different topographical features, namely; Lowland (<1,500 m), Mid-highland (1,500-2,000 m), and highland >2,000m [50]. The elevation in the district ranges between 1,500 m and 3000m [50]. According to [49, 51], 50% of the land is covered by natural forest and the southern parts of the districts cover the most dense forests and experience extended crop-production, where the altitude reaches above 2000 m. Belete-Gera National Forest Priority Area is found there in Gera district. Concerning the type of the soil, it is dominated by red-dish clay and forest soil in the gentle slopes and grey-vertic soil type in the lowlands [51].

The area has an estimated total population of 115,307 inhabitants, of which 95.9% live in rural areas subsisting on mixed agriculture [51]. The area is mainly known by farming, cattle rearing, harvesting coffee, wild honey collection and honey production land use patterns.

One of the habitats identified for the study was natural forest, locally named as Gera Forest, which is found under the protection of Belete-Gera National Forest Priority. Natural forests are the dominant vegetation covers of the district [51]. Due to this favorable climate, Gera has 113,514 ha of forest [52]. Slightly more than half of the district is covered by forest and the extent of forest cover has been reduced over the past few decades [49]. Most of this forest belongs to a state-owned enterprise, the Oromia Forest and Wildlife Enterprise. Private companies and farmers, however, own a significant proportion of the forest. This forest is categorized under Afromontane rainforest type [53].

The forest generally forms a good canopy cover with a number of undergrowth plant species. Based on the vegetation type, the study area was classified in to two major habitat types as follows: Natural forest and Coffee forest (Fig. 4 & Fig. 5) respectively. Dominant tree species of the study area are trees such as*: Albizia gummifera, Bersema abyssinica, Cordia africana, Croton macrostachyus, Urtica simensis, Domboya torrid, Ekebegia capensis, Ficus sycomorus, Coffee arabica, Ficus vasta, Podocarpus falcatus, and others* [54].

2.2. Materials

Materials used during the present study were Sherman live-traps (16x6.5x5.5 cm), bait, Dissecting kit, Camera, Face masks, Spring balance, Zip lock plastic bag, GPS unit, Clipboard, Data forms, Pencils, Gloves, Calipers, Scale, Ruler, Head torches, the Kingdon field guide book.

2.3. Methods

2.3.1 Preliminary Survey

Preliminary survey was conducted in early August, 2014, to determine the different habitat types that suite for the purpose. Based on the presence or absence of coffee plantations, study area was classified into natural forest (NF) and coffee forest (CF). Furthermore, information on the different vegetation types, their area extent and distance between them (as a buffer area), geographic position of the study area, altitudinal ranges, temperature and rainfall data were also assessed.

2.3.2 Grid Design and Sampling

Trapping was conducted from August, 2014 to March, 2015 in Afalo area. In the selected habitats, eight permanent trapping grids, each of 30 m x 30 m (900m^2) four from each habitat types) were established to gather information on live-trapped specimens, the grids comprised of 3 parallel lines 10 m apart, with a trapping station in each line, resulting in 16 trapping stations. Three rows placed by 10m were established on each grid, for the trapping purpose. On each trapping stations one Sherman live trap was used. The grids were used during both the wet and dry seasons. Peanut butter mixed with corn flour was used as bait. The traps were covered by hay and plant leaves during the dry season to minimize temperature changes and to avoid from sight of baboons. This also provided protection for the trapped animals against the strong heat. Traps were set between 06:00 and 07:30 am, in the morning and checked for diurnal catch between (16:30-18:00 hr), the same day. Traps were checked for nocturnal catches and removed between (06:30 - 09:00 hr), for 4 consecutive days. Traps were baited the first day and as necessary re-baited the following day. Each grid was trapped for 4 consecutive days per seasons for the wet (between August through October, 2014) and dry (December and February, 2015) seasons. Each grid was trapped for 4 consecutive days. Each habitat was sampled for about 256 trap nights for season.

After collecting the necessary data, all live trapped animals were released at spot they were trapped. Eight Snap traps were used and placed 200 m away from permanent grids for voucher specimen preparation purpose. Specimens from the snap traps were mounted and used as voucher specimens for confirmation of species identification. The standard procedure [55] was used to mount voucher specimens.

Sexual conditions of males were assessed via examination of scrotal and abdominal testes [56], while for female's conditions including perforate or imperforate vagina, pregnancy and lactating [55]. Age of the trapped specimen was categorized adults, sub-adults and young on the basis of size, body weight, pelage colour (which is usually grey in young) [41].
Species identification was carried out based on the taxonomic characteristics listed in [6, 42, 46, 55, 57]. Additionally, when species identification was difficult in the field; the mounted skins and skulls were compared with the specimens available in the Zoological Natural History Museum of Addis Ababa University.

2.3.3 Data Analysis Method
Species diversity of trapped small mammals were calculated using the Shannon-Weaver index of diversity, H'= - ∑PilnPi where Pi is the proportion of the i^{th} species in the habitat and *ln* is the natural logarithm [58]. H' is influenced both by number of species as well as by the evenness with which mammals are distributed with those species.
Trap Success was calculated to expressed the total number of animal trapped per total trap-nights (a trap-night = 1 trap set for 1 night) according to [59]. Thus,
Ts= Nc x 100/Tn, Where: *Ts* = trap-success, *Nc* = total number of captures, *Tn* = total number of trap-nights.
Abundance was used estimated as the total number of individuals captured per total capture according to [60]. Thus,

$$\text{Abundance} = \frac{\text{Total number of individuals captured}}{\text{Total number of captured}}$$

Simpson similarity index (SI) was computed to assess the similarity between two habitats with reference to the composition of species. SI= 2C/I+II. Where:
SI= Simpson's similarity index, C= the number of common species to both habitats, I= the number of species in habitat one, II= the number of species in both habitats [61].
For the statistical computations, SPSS version 16.0 computer software program was used and Chi-square test was used to compute significance of variation for each parameter used. Level of significance was determined using Chi square test at 5% level of significance.

3. Results
3.1. Species composition
During this study, a total of 110 individuals of small mammals were trapped in 512 trap nights. Ten species of small mammals (rodents and insectivores) belonging to two orders (Rodentia and Insectivora) and four families (Muridae, Hystricidae, Sciuridae and Soricidae), were identified both at dry and wet seasons. The captured rodents and insectivores are in the table. Out of the total trapped small mammals, 96(87.3%) individuals represented seven species of rodents and 14(12.7%) individuals represented three species of shrews (Table 1).

Table 1: Small mammals species identified in study area.

Order	Family	Common Name	Scientific Name
Rodentia	Muridae	Yellow spotted brush-furred rat	*Lophuromys flavopunctatus*
	Muridae	Woodland thicket rat	*Grammomys dolichuros*
	Muridae	Ethiop. Forest Brush-furred rat	*Lophuromys chrysopus*
	Muridae	Common rat	*Rattus rattus*
	Muridae	Common mouse	*Mus musculus*
	Hystricidae	Crested porcupine	**Hystrix cristata*
	Sciuridae	Striped squirrel	**Paraxerus ochraceus*
Insectivora	Soricidae	Greater musk shrew	*Crocidura flavescens*
	>	Smoky white-toothed shrew	*Crocidura fumosa*
	>		*Crocidura bicolor*

Key: **(***) The visual species (= not trapped)

3.2. Relative abundance of small mammal species
Lophuromys flavopunctatus was high in number with (n= 35) individuals 49.2% of the total. This was followed by *Grammomys dolichuros*, and *Lophuromys chrysopus* with 23(49.5%) and 13(29.7%) respectively. *Rattus rattus, Mus musculus, Crocidura flavescens* and *Crocidura fumosa* had 22.2%, 20.7%, 13.3%, and 10.7% respectively. The least abundant species was *Crocidura bicolor* with 1.4%. Rodents such as *Hystrix cristata* and *Paraxerus ochraceus* were observed in the study area (Table 2). *Grammomys dolichuros, Lophuromys chrysopus, Rattus rattus, Mus musculus, Crocidura flavescens and Crocidura fumosa* were widely dispersed species and recorded from both habitat types. However, *L. flavopunctatus, Crocidura bicolor, Hystrix cristata* and *Paraxerus ochraceus* were present only in one habitat (Table 2). *L. flavopunctatus* species had high numbers as compared to other species in natural forest habitats.

Table 2: Species composition, number of individuals and the relative abundance of each species captured in both habitats during dry and wet seasons.

Number of individuals trapped during the wet and dry seasons in both habitats					
Species	**NF**		**CF**		**Relative abundance**
	WET	**DRY**	**WET**	**DRY**	
L. flavopunctatus	20(28.16)	15(21.12)	_	_	35(49.3%)
Grammomys dolichuros	4(5.6)	4(5.6)	9(23.0)	6(15.3)	23(49.5%)
Lophuromys chrysopus	7(9.85)	5(7.04)	3(7.69)	2(5.12)	17(29.7%)
Rattus rattus	3(4.22)	_	3(7.69)	4(10.25)	10(22.2%)
Mus musculus	1(1.40)	1(1.40)	4(10.25)	3(7.69)	9(20.7%)
Crocidura flavescens	3(4.22)	1(1.40)	2(5.12)	1(2.56)	7(13.3%)

Crocidura fumosa	3(4.22)	1(1.40)	2(5.12)	_	6(10.7%)
Crocidura bicolor	1(1.40)	_	_	_	1(1.4%)
**Hystrix cristata*	1(1.40)	_	_	_	1(1.4%)
**Paraxerus ochraceus*	1(1.40)	_	_	_	1(1.4%)
Total	44(39.9%)	27(24.5%)	23(20.9%)	16(14.5%)	110

Keys*:* (-) = indicates the absence, (*) =Visualized species, **NF**= natural forest, **CF**= coffee forest.

In the present study a total of 71(64.6%) individuals were trapped from natural forest habitat. *L. flavopunctatus* (49.29%) was the most abundant rodent species in the NF habitat followed by *Grammomys dolichuros* (11.2%). For the coffee forest habitat, the most abundant was *Grammomys dolichuros* (38.4%).

Between the habitats, the relative abundance of the trapped species was significant for *L. flavopunctatus* (χ^2 =49.16, df =1, P<0.05), *G. dolichuros* (χ^2 =17.06, df =1, P<0.05), *L. chrysopus* (χ^2 =11.73, df=1, P<0.05) and *R. rattus* (χ^2 =9.00, df=1, p<0.05). The overall difference in abundance of small mammals among the two habitats of the study area was significant at (χ^2 =84.06, df =1, P<0.05) (Table 3).

Lophuromys flavopunctatus species vary between habitat and season, show significance difference at (χ^2 =28.8, df=1, P<0.05) (Table 3). The abundance of *Grammomys dolichuros* species vary between season in a CF, which statistically also shows significance difference at (χ^2=10.37, df=1, P<0.05). However, its abundance didn't vary in NF habitat during wet and dry season (χ^2 =8.0, df=1, P>0.05) (Table 3). This is true for *species Mus musculus.*

More species and individuals were trapped from the natural forest, and hence the highest diversity index (H'= 1.634) than the coffee forest and the difference was significant (χ^2 =2.11, df=1, P<0.05) (Table 3).

Table 3: Number of Species (N), Abundance, Evenness (J) and Diversity indices (H') for small mammal species in different habitats types.

Habitat types	No of Species	Abundance	J	H'
NF	10	71	0.512	1.634
CF	6	39	0.823	1.597

The calculated similarity index (SI) for the similarity of species between the two habitats was 0.75 indicating that about 75% of the species were common for both habitats.

3.3. Trap success

The average trap success in the study area in 512 trap nights was 21.48% but vary between habitats and seasons. For the natural forest, the success was 27.7% but 15.2% for the coffee forest. The trap success of small mammals was highest during the wet season than the dry. The success was highest for NF (17.2%) during the wet and least for CF during the dry season (6.6%). Success variation between seasons were significant (χ^2 = 8.96, df =1, P<0.05) (Table 4).

Table 4: Trap success of rodents and insectivores species at different seasons in both habitat types (each 256 trap nights per season).

Habitat types	Season	Captures	Trap nights	Trap success (%)	Mean %
Natural forest	Wet	44	256	17.2	27.7%
	Dry	27	256	10.5	
Coffee forest	Wet	23	256	8.6	15.2%
	Dry	16	256	6.6	

3.4. Sex ratio distribution

More male individuals were trapped than females during the present study. More male of species *L. flavopunctatus*, and *L. chrysopus* were trapped during the wet season than the dry. Single female individual of species *C. bicolor* was trapped from NF during wet season (Table 5).

Table 5. Seasonal variation and sex distribution of small mammals during wet and dry seasons.

Species	Sex distribution along the seasons and habitats							
	Coffee Forest habitat				Natural Forest (NF) habitat			
	Wet season		Dry season		Wet season		Dry season	
	M	F	M	F	M	F	M	F
L. flavopunctatus	–	–	–	–	15	5	3	12
G. dolichuros	5	4	4	2	3	1	2	2
L. chrysopus	2	1	1	1	4	3	3	2
Rattus rattus	2	1	3	1	2	1	-	-
Mus musculus	3	1	1	2	1	-	1	-
C. flavescens	-	1	1	1	2	1	-	1
C. fumosa	1	1	_	_	1	2	1	-
C. bicolor	_	_	_	_	_	1	_	_
**Hystrix cristata*		_		_		1	-	
**Paraxerus ochraceus*		_		_		1	-	
Total	13	9	10	7	28	16	10	17

Key: M- Male**, F-** Female,

3.5. Age distribution

Animals from all age groups were trapped during this study. However, adult animals accounted most (43.6%), followed by sub-adult (34.5%) and less young (20.9%).

Table 6. Age groups distribution of captured small mammals during study.

Species	Total Catch	Age groups					
		Dry season			Wet season		
		A	Sa	Y	A	Sa	Y
L. flavopunctatus	35	5	7	4	8	5	6
G. dolichuros	23	4	2	1	7	6	3
L. chrysopus	16	4	3	1	3	4	1
Rattus rattus	10	2	1	1	3	-	3
Mus musculus	9	1	1	1	2	3	1
C. flavescens	7	2	1	1	1	2	_
C. fumosa	6	2	-	-	2	2	-
C. bicolor	1	_	-	-	-	1	-
Total	110	20	15	9	28	23	14

Keys: A-adult, Sa- sub-adult, and Y-young, C- Crocidura, L- *Lophuromys*

Majority of species e.g. *G. dolichuros, R. rattus, Mus musculus, C. flavescens, C. fumosa* and *C.bicolor* were trapped nocturnally. However, *L. chrysopus* were trapped diurnal. Yet again, *L. flavopunctatus* was trapped both at night and day time.

4. Discussion

Several studies in Ethiopia documented small mammal's characteristic to the major ecology and specific habitats. Comparative studies on the diversity and habitat preference of small mammals among habitats were limited [28, 43]. However, comparative studies on the diversity of small mammals between intact tropical forest and the adjacent coffee forest habitat were rare. This was essential to document the characteristic fauna for each and those shared between the habitats. The generated data also serves to reveal the impact of forest management on the faunal diversity and abundance.

The present study revealed the presence of 10 species of small mammals in Afalo area. The recorded species were not unique and are common to reported fauna from related habitats in the country. The recorded diversity, however, was relatively less as compared to most other areas elsewhere in the country [28, 43, 62]. The present survey involves small areas sampled to represent the two habitats, however, the sampled rodents and insectivores provide good insight for the resident fauna of the area.

The diversity, abundance and habitat preference of small mammals are largely determined by the availability of resource and vegetation cover. The diversity of small mammal was relatively higher in natural forest than in the coffee forest. [33] reported similar finding for similar habitat in Tepi, Ethiopia. The abundance and diversity of small mammals in forest habitat depend mainly on the nature, habitat heterogeneity, and density of vegetation, for food and shelter [45].

In the present study, most species were common to both habitats, but few were specific. For instance, *G. dolichuros, L. chrysopus, Rattus rattus, Mus musculus, C. flavescens* and *C. fumosa* species were common for both habitats. On the other hand *L. flavopunctatus* and *C. bicolor* were recorded only from NF. Also, two rodent species were observed in NF only. This is in agreement with the finding of [63], distribution of small mammals over an area is not uniform and species are more abundant in some habitats than others. According to [64], habitat complexity, food and cover availability are key factors influencing the overall distribution of small mammals species.

In the present study, the lowest composition and abundance of small mammals was recorded in coffee forest. This might be due to homogeneous vegetation that is dominated by few species of trees and the underground habitat is open or has less cover resulting in shortage of cover, food. [65] shown that the change from natural forest to plantation caused decline in both total number of individuals and species composition. Clearance of ground cover during the wet season and the intensive human activity to harvest coffee beans in the early dry season seem affected the diversity and abundance of some species. Similar finding was reported by [28] for small mammalian fauna in coffee forests around Jimma area. In addition, [33] was also recorded the lowest abundance of species from coffee plantation habitat. According to [66], habitat selection of different species of small mammals is mainly dependent on the vegetation of the habitat.

During the present study, it was observed that, some species were more abundant than others in both habitats. For instance, *L. flavopunctatus, G. dolichurus* and *L. chrysopus* were more numerous in natural forest than in coffee forests. *L. flavopunctatus* (31.8%) was the most widely distributed species as compared with others and followed by *G. dolichurus. L. flavopunctatus* is one of the most widespread and numerous rodents in the moister areas of East Africa, inhabiting a range of different habitats with a preference for montane habitats [67, 68] stated that this species occurred from lowland forests at about 500m asl to afro-alpine, reaching well above 4200m and extending into ericaceous habitats and montane moorlands. Similarly, it was also the most abundant rodent species in the present study area, but only from natural forest habitat.

The soft-furred rat, *L. flavopunctatus*, was one of the most common rodents in the moister areas of East Africa, inhabiting a wide range of montane and highland habitats [39]. In Ethiopia, it is essentially a species of the plateau with distribution records between 1500-4000m [42]. In the present study, two species of the genus were recorded, *L. flavopunctatus* from the natural forest and *L. chrysopus* from the coffee forest and in both areas, they were the most trapped rodents. The species showed extremely high local variation [39]. Such behavior of the animal was also reported elsewhere [28], where several related assemblage was sympatrically recorded from small extent of area. During the present study, however, only single species was recorded from a habitat. This finding may reveal the other behavior of the species, i. e. competitive exclusion.

Mus musculus has a wide distribution in Ethiopia. [44] described the occurrence habitat between 1510 and 3000 m asl. In the present study, it occurred at an altitudinal range between 1200 and 1300 m asl. It was recorded mainly from coffee forest (CF) as a major pest with few only from natural forest (NF).

Crocidura flavescens is a very large shrew with flat brain case and likely to be confused with *Suncus murinus*. It is, however, a very variable species in both size and color, and there are some suggestions that both characters are influenced by altitude. This shrew is one of the most common and widespread in Ethiopia, where it ranges from approximately 1000-3000m asl. It was thought to be a typical forest species [57]. It was recorded in different parts of Ethiopia including Addis Ababa, Chilalo Mountains, Debre Markos and west shore of Lake Tana. Furthermore, [44] also observed the species in Bale Mountains National Park, below the tree line, and in association with clearings and within the forest. Similarly, in the present study it was trapped in the natural forest and coffee forest and accounted for only 6.4% from the total catches.

Crocidura fumosa is essentially a montane shrew with thick fur usually showing little contrast between the grey brown dorsum and silvery grey ventral. It has been recorded in Ethiopia at an altitude of 1750- 3900m [57]. At the present study, few specimens were captured from both habitats. This is within the reported altitudinal range of the species. The species was comprised 5.5% abundant of the total number. *Crocidura bicolor* were trapped only from NF habitat only in single season. *Hystrix cristata* and *Paraxerus ochraceus* were highly expected from both habitats but not observed in CF during the present survey.

During the present study, there was variation in abundance of small mammals between seasons. Seasonality might cause the dynamic changes which occur in the habitats such as cover and food availability as noted by [40]. More individuals were recorded during the wet season than during the dry season. The abundance of small mammals in the wet and dry seasons was 64 and 46, respectively. Unlike the present record, most studies on small mammals reported the abundance of individuals during the dry season (e.g. [41, 43]). This is comparable with finding of [69] who has recorded more individual during wet season. However, this is disagreement with the findings of [27, 41, 70], who recorded more individuals during the dry season in their respective study areas. Trap success during the wet season was relatively high, and more from the natural habitat. This is in agreement with finding of [69, 71] have recorded similar results from different habitats. However, from the characteristics of managed coffee farm, farmers clear the floor of coffee forest that may remove food and covers, the resource very critical for small mammals.

The variation in trap success among different habitat types was significant in the present study area. The overall trap success in the present study was 21.48%. The highest trap success (27.7%) was recorded during the wet season in the NF habitat. The least trap success (15.2%) was recorded in coffee plantation during the dry season. The present trap success was low as compared to the study by [41] who recorded with trap success of 36.8% from Alatish National Park and [72] who recorded 44.1% from Chilalo Galama Mountain range. The difference in trap success might be due to the effects of habitat factors as the habitats vary in vegetation composition and cover. However, the present trap success was highest as compared to the study by, [71] obtained 15.8% from Arditsy Forest, [27] recorded 17.6% from Arbaminch Forest and Farmlands.

Sexual conditions of female looks like perforate or imperforate vagina, pregnancy and lactating **[55]**, while for male's were assessed via examination of scrotal and abdominal testes [56].

According to the present results, ages class of captured individuals varied from species to species and among seasons as given in (Table 6). Adult rodents accounted for the highest proportion. The capture rate of young was more during wet season than the dry season. This could possibly be associated with the effect of rainfall. Young are non-violent individuals, less weight, grayer than adult. Sub-adult are violent and fully grown where as adult show mature size, large pelage in male (scrotal or abdominal) and females may lactating, suckling nipples, or imperforate vagina according to [55].

Out of the 110 individuals of rodents and insectivores captured, male comprised 61 (55.5%) and females 49 (44.5%). This is in agreement with the findings of [69, 73] who have recorded higher number of males.

5. Conclusion and Recommendations

The present study identified and documented 10 small mammalian species from Afalo area. Some of the species are common to both habitats and few were unique for forest habitat. As the sampled areas were limited in size, in relation to the large extent of tropical forest, the documented diversity could be underestimated. However, the study gives bird's eye view about the characteristic small mammalian fauna of the area. The study revealed that, more species with relatively large number were recorded from natural forest. This brief survey also showed the impact of forest management on the diversity and abundance of small mammals. Most of the species documented from the area were not unique but largely reported from many areas in the country and most are reputed to have large ecological ranges across the country.

Based on the results of the study;

- Detailed small mammals faunal assessment involving several sites from each habitat is recommended to gain detailed account of the tropical forest fauna of the area and to evaluate the impacts of different level forest management on the diversity and abundance of small mammals.
- I recommend including shade trees, maintaining high amounts of canopy cover, and retaining lower strata vegetation within the coffee farms.
- I also recommend preserving or reestablishing forested areas surrounded within the coffee landscape to enhance small mammal diversity.

6. Conflict of Interests

The authors have not declared any conflict of interests.

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8. References

1. Juokaitis R, Baranauskas K. Diversity of small mammals in the northwestern Lithuania. Acta Zool. Lithua 2001;11:343-348.
2. Hashim M, Mahgoub S. Abundance, habitat preference and distribution of small mammals in Dinder National Park, Sudan. Afr. J Ecol 2007;46**:**452-455.

3. Gadisa T, Bekele A. Population dynamics of pest rodents of Bilalo area, Arsi, Ethiopia. Ethio J Biol Sci 2006;5:63-74.
4. Gebresilassie W, Bekele A, Gurja B, Balakrishnan M. Home range and reproduction of rodents in Maynugus irrigation field, northern Ethiopia. Ethiop J Sci 2006;29:57-62.
5. Takele S, Bekele A, Belay G, Balakrishnan M. A comparison of rodent and insectivore communities between sugarcane plantation and natural habitat in Ethiopia. Trop Ecol 2011;52:61-68.
6. Kingdon J. The Kingdon Field guide to African Mammals. Harcourt Brace & Company, London 1997.
7. Skinner JD, Chimimba CT. The Mammals of the Southern African Sub region (3rd Ed).Cambridge: Cambridge University Press 2005, 874.
8. Willig R, Kaufman M, Stevens D. Latitudinal gradients of biodiversity: pattern, process, scale and synthesis. Annu. Rev. Ecol. Evol. Syst. 2003;34:273-309.
9. Kelt A, Meserve L, Nabors K, Forister L, Gutie RR. Foraging ecology of small mammals in semiarid Chile: the interplay of biotic and abiotic effects. Ecology 2004;85:383-397.
10. Feliciano BR, Fernandez FS, Freitas DD, Figueiredo ML. Population dynamics of small rodents in grassland between fragments of Atlantic Forest in southeastern Brazil. Mamm. Biol 2002;67:304-314.
11. Mssawe AW, Rwamugira W, Leirs H, Makundi RH, Mulungu LS. Do farming practices influence population dynamics of rodents? A case study of the multimammate field rats, *Mastomys natalensis*, in Tanzania. Afr. J Ecol. 2006;45:293-301.
12. Shanker K. The role of competition and habitat in structuring small mammal communities in a tropical montane ecosystem in southern India. J Zool. Lond 2001;253:15-24.
13. Tews J, Brose U, Grimm V, Tielborger K, Wichmann MC, Schwager M *et al*. Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. J Biogeography 2004;31:79-92.
14. Schmidt NM, Hubertz H, Olsen H. Diet of Kestrels *Falco tinnunculus* on grazed coastal meadows. Dansk Ornitol. Foren. Tidsskr 2002;96:171-175.
15. Solari S, Rodriguez J, Vivar E, Velazco M. A framework for assessment and monitoring of small mammals in a lowland tropical forest. Environ. Monit. Assess 2002;76**:**89-104.
16. Lomolino MV. Elevational gradients of species-density: historical and prospective views. Glob. Ecol. Biogeogr. Lett 2001;10:3-13.
17. Mena J, Vazquez-Dominquez E. Species turnover on elevational gradients in small rodents. Glob Eco. Biogeo. 2005;14:539-547.
18. Happold D. Age structure of a population of Pryomys tullbergi (Muridae, Rodentia) in Nigerian Rainforest. Review Ecology 1979;33:253-274.
19. Malcom JR, Ray JC. The influence of timber extraction routes on central African small-mammal communities, Forest Structure and Tree Diversity. Conser Biol 2000;14:1623-1638.
20. Brown JH, Heske EJ. Control of a desert grassland transition by a keystone rodent guide. Science 1990;250:1705-1707.
21. Silva M, Hartling L, Opps SB. Small mammals in agricultural landscapes of Prince Edward Island (Canada): effects of habitat characteristics at three spatial scales. Biol. Conser 2005;126:556 568.
22. Grant WE, Birney EC, French NR, Swift DM. Structure and productivity of grassland small mammal communities related to grazing-induced changes in vegetation cover. J Mammal 1982;63:248-260.
23. Kotler B. Patch use by gerbils in a risky environment: manipulating food and safety to test four models. *Oikos*, 1997;78:274-282.
24. Andreassen HP, Ims RA. The effects of experimental habitat destruction & patch isolation on space use & fitness parameters in female root vole, Microtus oeconomus. J Anim. Ecol 1998;67:941-952.
25. Kidane L, Bekele T, Nemomissa S. Vegetation composition in Hugumbirda-Gratkhassu National Forest Priority Areas, south Tigray. Ethiopian J Sci 2010;2:27-48.
26. Senbeta F, Teketay D. Diversity, Community types & population structure of woody plants in Kimphee Forest, a virgin Nature Reserve in Southern Ethiopia. Ethiopian J Biol. Sci 2003;2:169-187.
27. Datiko D, Bekele A, Belay G. Species composition, distribution and habitat association of rodents from Arbaminch forest and farmlands, Ethiopia. Afr. J Ecol 2007;45:651-657.
28. Habtamu T, Bekele A. Species composition, relative abundance and habitat association of small mammals along the altitudinal gradient of Jiren Mountain, Jimma, Ethiopia. Afr J Ecol 2012;51:37-46.
29. Peter B. Experimental treatment control studies of ecologically based rodent management in Africa: balancing conservation and pest management. S. Afr. J Wildl. Res 2012;39:51-61.
30. Fitzgibbon CD. Small mammals in farm woodlands: the effects of habitat, isolation, and surrounding land-use patterns. J App. Ecol 1997;34**:**530-539.
31. Mekuria K. Forest conversion – soil degradation – farmers' perception nexus: Implications for sustainable land use in the southwest of Ethiopia. Ecology and Development Series No. 2005, 26.
32. Sullivan TP, Sullivan DS. Influence of variable retention harvests on forest ecosystems. II. Diversity and population dynamics of small mammals. J Appl. Ecol 2001;38:1234-1252.
33. Bayessa D. Species composition, distribution, abundance and habitat association of rodents in forest and farmlands around Tepi, SW. Ethiopia. MSc Thesis, Addis Ababa University, Ethiopia 2010, 79
34. Pearce J, Venier L. Small mammals as bio-indicators of sustainable boreal forest management. Forest Ecology and Management 2005;208:153-175.
35. Kaminski JA, Davis ML, Kelly M. Disturbance effects on small mammal species in a managed Appalachian forest. Am. Midl. Nat. 2007;157:385-397
36. Mangan S, Adler G. Seasonal dispersal of arbuscular mycorrhizal fungi by spiny rats in a Neotropical forest. Oecologia 2002;131:587-597.
37. Naranjo ME, Rengifo C, Soriano PJ. Effect of ingestion by bats and birds on seed germination of *Stenocereus griseus* and *Subpilocereus repandus* (Cactaceae). J Trop. Ecol 2003;19:19-25.

38. Napolitano C, Bennett M, Johnson WE, Brien SJ, Marquet PA, Barría I *et al*. Ecological and biogeographical inferences on two sympatric and enigmatic Andean cat species using genetic identification of faecal samples. Molecular Ecology 2008;17:678-690.
39. Clausnitzer V, Kityo R. Altitudinal distribution of rodents (Muridae and Gliridae) on Mtn. Elgon, Uganda, *Trop. Zool*. 2001;14:95-118.
40. Oguge N. Diet, seasonal abundance and microhabitats of *Praomys* (*Mastomys*) *natalensis* (Rodentia: Muridae) and other small rodents in Kenyan sub-humid grassland community. Afr. J Ecol. 1995;33:211-225.
41. Habtamu T, Bekele A. Habitat association of insectivores and rodents of Alatish National Park, northwestern Ethiopia. Trop Ecol. 2008;49:1-11.
42. Yalden DW, Largen MJ. "The endemic mammals of Ethiopia," Mammal Review 1992;22(3):115-150.
43. Datiko D, Bekele A. Species composition and abundance of small mammals in Chebera-Churchura National Park, Ethiopia. Afr. J Ecol. 2012;5(6):95-102.
44. Yalden DW. Small mammals in the Harenna Forest, Ethiopia: Bale Mountains National Park. SINET: Ethiop. J Sci 1988;11:41-53.
45. Gebresilassie W, Bekele A, Gurja B, Balakrishnan M. Microhabitat choice and diet of rodents in Maynugus Irrigation Field, Northern Ethiopia. Afr J Ecol. 2004;42:315-321.
46. Nowak RM. Walker's: Mammals of the World, 6th edn. John Hopkins University Press, Baltimore and London 1999 837-865.
47. De Beenhouwer M. Effects of habitat fragmentation and coffee cultivation on the epiphytic orchids in Ethiopian Afromontane forests. Dissertations presented in fulfillment of the requirements for the degree of master in biology. Systematic and Ecology Section 2011, 34-69.
48. Schmitt C, Denich M, Sebsebe D, Friis I, Boehmer H. Floristic diversity in fragmented Afromontane rainforests: Altitudinal variation and conservation importance. Appl. Veg. Sci 2010;13:291-304.
49. Hylander K, Nemomissa S, Delrue J, Enkosa W. Effects of coffee management on deforestation rates and forest integrity. Conservation Biology 2013;27(5):1031-1040.
50. Gemechu T, Borjeson L, Senbeta F, Hylander K. Balancing ecosystem services and disservices: smallholder farmers' use and management of forest and trees in an agricultural landscape in southwestern Ethiopia. Ecology and Society 2014;19(1):30.
51. CSA. Summary and Statistical Report of the 2007, Population & Housing Results Population Size by Age & Sex. FDRE Population Census Commission. UNFPA, Addis Ababa 2008, 56-78.
52. Cheng S, Hiwatashi Y, Imai H, Naito M, Numata T. Deforestation and degradation of natural resources in Ethiopia: Forest management implications from a case study in the Belete-Gera Forest. J For Res 1998;3**:**199-204.
53. Friis I. Forests and forest trees of northeast tropical Africa. Kew Bulletin Additional Series. HMSO, London 1992, 15.
54. Hundera K. Traditional forest management practices in Jimma zone, Ethiopia. Ethiopian J Sci and Educ 2007; 2(2)**:**1-11.
55. Alpine KP, Brown PR, Jacob J, Krebs CJ, Singleton GR. Field Methods for Rodent Studies in Asia and the Indo Pacific. BPA Printing group. Malborne 2003.
56. Ghobrial IL, Hodieb KS. Seasonal variations in the breeding of the Nile rat. J Mammal 1982;46**:**319-333.
57. Yalden DW, Largen MJ, Kock D. Catalogue of the mammals of Ethiopia. Insectivora and Rodentia. Italian Journal of Zoology 1976;8(1):1-118.
58. Shannon GE, Weaver W. The Mathematical Theory of Communication. University of Illinois Press, Chicago 1949.
59. Ofori B, Attuquayefio D, Owusu E. Aspects of the ecology of the Tullberg's Soft-Furred Mouse (*Praomys tullbergi*: Thomas 1894) in mount, Afadjato, Ghana. J Exp. Biol. and Agri. Sci 2013;1(5)**:**2320-8694.
60. Brown J On the relationship between abundance & distribution of species. Am. Nat 1984;124:255-279.
61. Magurran AE. Measuring biological diversity. Blackwell Publishing; Oxford, United Kingdom 2004, 256.
62. Kassa D, Bekele A. Species composition, abundance, distribution and habitat association of rodents of Wondo Genet, Ethiopia. SINET: Ethiop. J Sci 2008;31:141-146.
63. Morris DW. Ecological scale and habitat use. J Ecol. 1987;68:362-369.
64. Avenant N, Cavallini P. Correlating rodent community structure with ecological integrity, Tussen-die-Riviere Nature Reserve, Free State Province. South Afri. Integr. Zool 2008;**2**:212-219.
65. Happold D, Happold M. Reproduction, growth and development of a West African Forest Mouse, *Praomys tullbergi* (Thomas). Mammalia 1987;42(1):74-95.
66. Iyawe JG. Distribution of small rodents and shrews in a lowland rain forest zone of Nigeria, with observations on their reproductive biology. Afr. J Ecol. 1988;26:189-195.
67. Clausnitzer V, Chrchfield S, Hutterer R. Habitat occurrence and feeding ecology of *Crocidura montis* and *L. flavopunctatus* on Mt. Elgon, Uganda. Afr. J Ecol. 2003;41:1-8.
68. Misonne X. African and Indo Australian Muridae. Evolutionary trend. Ann. Mus. Roy. Afr. Center 1969;8:12-19.
69. Chekol T, Bekele A, Balakrishnan M. Population density, biomass and habitat association of rodents and insectivores in Pawe area, northwestern Ethiopia. Inter. Soc. Trop. Ecol. 2012;53(1):15-24.
70. Happold D, Happold M. An ecological study of small rodents in the thicket-clump savanna of Lengwe National Park, Malawi. Journal of Zoology 1991;223:527-542.
71. Bantihun G, Bekele A. Population structure of small mammals with different seasons and habitats in Arditsy Forest, Awi Zone, Ethiopia. Intern. J Biodiv and Cons. 2015;7(8):378-387.
72. Kasso M, Bekele A, Graham H. Species composition, abundance and habitat association of rodents and insectivores from Chilalo-Galama Mountain range, Arsi, Ethiopia. Afr. J Ecol 2010;48:1105-1114.
73. Smith MH, Gardner RH, Gentry JB, Kaufman DW, O'Farrell MJ. Density estimations of small mammal populations. In: Small Mammals: Their Productivity and Population Dynamics (Golley, F. B., Petrusewicz, K. and Ryszkowski. L. eds). Cambridge University Press, Cambridge 1975, 25-53.