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Population structure of rodents in Alage, Southern Ethiopia

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An ecological study on population structure of rodents was conducted in Alage, Southern Ethiopia. Sherman live traps were used to capture rodents in four habitats and trapping sessions. A total of 684 rodents that represented 11 species were captured. Regarding population size and density, *Mastomys natalensis* was the dominant species followed by *Arvicanthis dembeensis* while the least was observed in *Graphiurus murinus* in the study period. The highest biomass was recorded in *A. dembeensis* (6771.43 g/ha) followed by *M. natalensis* (6246.63 g/ha) and *M. erythroleucus* (3257.14 g/ha) while the least was recorded for *G. murinus* (10.2 g/ha) followed by *Mus musculus* (35.36 g/ha).The largest and lowest biomasses per habitat type were recorded for *M. natalensis* and *M. musculus*, respectively from bushland. There was variation in the population size, density and biomass among trapping sessions and habitats with the highest estimate in the second trapping session and bushland habitat type. All age groups were represented in the population with seasonal and age group variation. In conclusion, there was variation in population size, density and biomass of rodents among habitats and seasons. These population fluctuations might be mostly due to variation in rainfall, habitat heterogeneity, vegetation cover, reproductive patterns, quality and quantity of food and water.

Key words: Age, biomass, density, population, rodents

INTRODUCTION

Rodents, from mammals, constitute the largest order with more than 2,700 species and account for over 42% of all mammal species (Alpine et al., 2003; Singleton et al., 2003). Out of 2,700 species of rodents, 84 species have been recorded in Ethiopia, and of these 21% are endemic (Bekele, 1996a, b; Yalden et al., 1996). With their prolific nature of breeding, they represent a significant amount of biomass in different ecosystems. The abundance and distribution of small mammals could be affected by the nature and density of vegetation coverage (Bekele and Leirs, 1997; Datiko and Bekele, 2014). Thus, seasonal variation is an important factor regulating populations of rodents. Temperature, energy and nutrition are most important factors in determining reproduction potential, which influences population density of rodents (Magige and Senzota, 2006). Studies indicated that there could be seasonal, inter-annual and multi-annual fluctuations of rodent population structure (Leirs et al., 1996; Meserve et al., 1996).

Habitat structure, habitat selection, climatic condition,

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quality and quantity of food, fire and predation are the important factors that influence population fluctuations (Shurchfiesd, 1997; Shanker, 2001; Chekol et al., 2012). These fluctuations could be associated with the basic demographic processes such as reproduction, survival, mortality, emigration and immigration (Lima et al., 2001). Habitat heterogeneity as well as suitable vegetation coverage increases species richness, number and diversity by providing more niches, shelter and continuous supply of food that has been exploited by several species of rodents (Makundi et al., 2009; Addisu and Bekele, 2013).The quantity and quality of vegetation have been considered as prime factors that determined population size (Makundi et al., 2009).

Rodents naturally have high reproduction potential and ability to invade all habitats. This makes them to have great ecological and social values in this world. In spite of having high biodiversity of small mammals (Yalden and Largen, 1992; Bekele et al., *2003*), Ethiopia is among the least studied in terms of faunal diversity and documentation, their population ecology and population structure. Studies have indicated that population structure of the rodent community in many regions of Ethiopia are still poorly known. The same is true of rodents in Alage and its environs. Country wide studies on population structure of rodents in different habitats would be important to understand relationships between species and between rodents and the environment. Therefore, this study was proposed to carry out extended ecological surveys in this area to determine population structure of the rodents with the following specific objectives: 1) to evaluate the population density of rodents in different habitats; 2) to estimate the biomass of rodents in the study area; 3) to determine age as well as sex distribution of rodents in the area.

MATERIALS AND METHODS

Study area

An ecological survey of small mammals was carried out in Alage and its environs, Southern Ethiopia. It is located 215 km South of Addis Ababa along a Rift Valley bordering the two Rift Valley lakes, Abijata (10 km east) and Lake Shalla (8 km north). The area is located at 38°27' East longitudes and 7°36' North latitudes, with a range of altitude 1,580-1,650 m above sea level. It covers 4,200 hectare of land with an average altitude of 1,600 m above sea level. It receives bimodal rainfalls with mean annual rainfall of 860 mm. Temperature of the study area is known to fluctuate significantly; however, it mostly ranges between 16 and 29°C with mean daily temperature of 21°C.

Methods

Permanent 70 x 70 (4,900 m^2) live trapping grids were established in different habitat types. Grid 1 and 2 were randomly selected from natural habitats (acacia woodland and bushland), whereas grid 3 and 4 were selected from agricultural area (maize and wheat). Trapping was made in four sessions covering different seasons. The first session data gathering was carried out from end of August to the middle of September, and the second from end of September to October. The third session data assortment was conducted in December and the fourth from February to March. The first and second trapping sessions were conducted during and at late wet season whereas third and fourth sessions were during and at early dry season of the year.

In each trapping grid and session, 49 (7 x 7) Sherman live traps were set at 10 m intervals for three consecutive days. Traps were baited with peanut butter and crushed white onions and set between 05:00 and 6:30pm in the evening. Traps were covered with grasses and plant leaves to protect trapped animals against the strong heat and cold. A Capture-Mark-Recapture (CMR) method was employed by marking toe clipping and released at the point of capture.

Traps were checked twice a day: early morning and late afternoon. Trapped animals were removed from the trap, identified and recorded on grid and trap-station number. Then after, animals were weighed, toe-clipped for coding, sexed and aged (juvenile or young, sub-adult, adult), observed for sexual condition and released at the point of capture (Bekele, 1996a; Linzey and Kesner, 1997; Alpine et al., 2003). All the external attributes such as fur colour and texture, back colour of fore and hind foot, whisker and other physical features (size and shape) were also recorded. Sampled specimens were identified to the species level. For the specimen identification, museum specimens and taxonomic characters in Yalden and Largen (1992), Bekele (1996a) and Alpine et al. (2003) were used.

Data analysis

The raw data were stored and managed in excel spreadsheet. SPSS (version 15.0) statistical software was used to analyze the data. Population density was calculated for each habitat and trapping session by number of individuals of each species per hectare. Biomass is the mass of rodents in a specific area. Biomass was estimated using mean weight of each species multiplied by their density in each habitat and trapping sessions. Chi-square test was employed to evaluate the significant differences of different parameters.

RESULTS

A total of 684 individuals belonging to 11 species of rodents were captured by live-traps in a total of 2352 trap nights with 29.08% trap success from four trapping sessions. Trapped rodent species and their population size and weight range are indicated in Table 1. Regarding population size, *M. natalensis* comprised more than 32% of the total captures followed by *A. dembeensis* (23%), and *M. erythroleucus* (19%). The least population size was observed in *G. murinus* (0.2%) followed by *Rattus rattus* (0.9%) and *Mus musculus* (1.0%) in the study period. Body weights of the trapped rodent species were in the range of 5-155 g. The mean body weight of each trapped rodents' species is also indicated on Table 1. Population estimates of rodents in each trapping session are given in Figure 1. The variation in the population size was highly significant (χ^2=56.4, df=3, P<0.001) among trapping sessions. The second trapping session had the highest estimate followed by the third sessions while the first and fourth sessions showed the least population estimate.

Table 1. Population size, density and biomass of live-trapped rodent species in the study area.

Species followed by mean body weight	Population Size (%)	Weight range (g)	Density (no./ha)	Biomass (g/ha)
Mastomys natalensis (55.4 g)	221 (32.3)	15-108	112.75	6246.63
Arvicanthis dembeensis (84 g)	158 (23.1)	20-150	80.61	6771.43
Mastomys erythroleucus (48 g)	133 (19.4)	15-95	67.86	3257.14
Tatera robusta (96.3 g)	57 (8.3)	25-130	29.08	2800.56
Mus mahomet (10.6 g)	33 (4.8)	5-18	16.84	178.47
Pelomys harrin gtoni (87.8 g)	25 (3.7)	37-129	12.76	1119.9
Lophuromys flavopunctatus (60.7 g)	24 (3.5)	12-99	12.24	743.26
Stenocephalemys albipes (62.6 g)	19 (2.8)	30-87	9.96	606.84
Mus musculus (9.9 g)	7 (1.0)	7-13	3.57	35.36
Rattus rattus (104.8 g)	6 (0.9)	38-155	3.06	320.82
Graphiurus murinus (20 g)	1 (0.2)	20	0.51	10.2
Total (63.28 g)	684 (100%)	5-155	348.98	22083.4

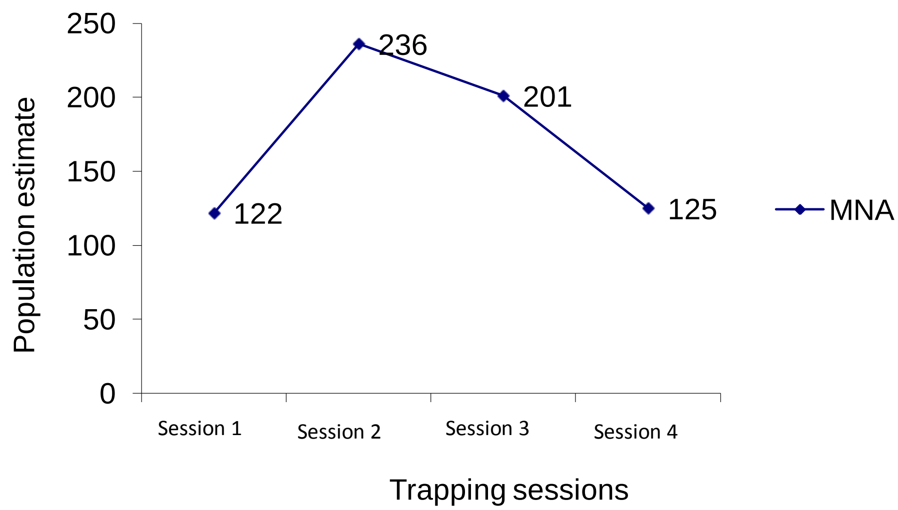

Figure 1. Population estimation of rodents in four trapping sessions.

Population density

The total density of trapped rodents in the study area was estimated to be 348.98 individuals/ha (Table 1). The highest overall population density was recorded in *M. natalensis* (112.75/ha) followed by *A. dembeensis* (80.61/ha) and *M. erythroleucus* (67.86/ha) while *G. murinus* (0.51/ha) followed by *R. rattus* (3.06/ha) and *M. musculus* (3.57/ha) were comprised the lowest population density (Table 1).

The population densities of rodents in different habitats during different seasons are given in Table 2. The density of rodents was more in bushland followed by acacia woodland during both seasons whereas the lowest density was recorded for wheat and maize farm during dry season. The highest population densities of *M. natalensis*, *A. dembeensis, M. erythroleucus* and *T. robusta* were recorded in bushland whereas the lowest was in wheat farm during dry season. There was no record for *T. robusta* in maize farm. The lowest and the highest density of *M. mahomet* was recorded in bushland during wet and dry season, respectively, but not recorded in acacia woodland. *Pelomys harringtoni* had more density in bushland and the least in wheat farm during dry and wet season, respectively; but not recorded in acacia woodland and wheat farm in the dry period. *Lophuromys flavopunctatus* was recorded only in bushland with more density in wet season. Highest population density of *S. albipes*, *M. musculus* and *R. rattus* was observed in bushland, wheat farm and maize farm, respectively during wet season. Among the trapped rodent species in the present survey, the population

Table 2. Number of individuals and population density (individuals per hectare) of rodents in different habitats during different seasons (density in parenthesis).

Species followed by mean body weight	Bushland		*Acacia* woodland		Maize farm		Wheat farm	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
M. natalensis (55.4 g)	56 (114.3)	78 (159.2)	29 (59.2)	19 (38.8)	13 (26.5)	3 (6.1)	20 (40.8)	2 (4.1)
A. dembeensis (84 g)	21 (42.8)	36 (73.5)	24 (49)	33 (67.3)	17 (34.7)	8 (16.3)	17 (34.7)	3 (6.1)
M. erythroleucus (48 g)	21 (42.8)	37 (75.5)	28 (57.1)	23 (46.9)	7 (14.3)	2 (4.1)	14 (28.6)	1 (2.0)
T. robusta (96.3 g)	10 (20.4)	19 (38.8)	8 (16.3)	10 (20.4)	0	0	8 (16.3)	2 (4.1)
M. mahomet (10.6 g)	1 (2.0)	15 (30.6)	0	0	5 (10.2)	3 (6.1)	7 (14.3)	2 (4.1)
P. harrin gtoni (87.8 g)	5 (10.2)	8 (16.3)	4 (8.2)	0	5 (10.2)	2 (4.1)	1 (2.0)	0
L. flavopunctatus (60.7 g)	14 (28.6)	10 (20.4)	0	0	0	0	0	0
S. albipes (62.6 g)	9 (18.4)	5 (10.2)	0	0	4 (8.2)	1 (2.0)	0	0
M. musculus (9.9 g)	0	1 (2.0)	0	0	2 (4.1)	0	4 (8.2)	0
R. rattus (104.8 g)	0	2 (4.1)	0	0	4 (8.2)	0	0	0
G. murinus (20 g)	0	0	0	1 (2.0)	0	0	0	0
Subtotal	137 (279.6)	211 (430.6)	93 (189.8)	86 (175.5)	57 (116.3)	19 (38.8)	71 (144.9)	10 (20.4)
Overall	SBL=348 (710.2)		AWL=179 (365.3)		MF=76 (155.1)		WF=81 (165.3)	

BL= bushland; AWL= acacia woodland; MF= maize farm; WF= wheat farm.

Table 1. Biomass (g/ ha) of rodents in different habitat types (figures in parenthesis are mean weight of species in each habitat).

Species	Habitats			
	Bushland	Acacia woodland	Maize farm	Wheat farm
M. natalensis	15302.33 (55.95 g)	4794.16 (48.94 g)	2043.56 (62.59 g)	2831.42 (60.32 g)
A. dembeensis	9856.96 (84.74 g)	9289.32 (79.86 g)	4141.29 (81.17 g)	3782.99 (97.55 g)
M. erythroleucus	5619.02 (47.47 g)	4819.94 (46.31 g)	838.96 (45.67 g)	1742.63 (56.93 g)
T. robusta	5538.66 (93.59 g)	3446.37 (93.83 g)	0 (0)	2218.57 (108.7 g)
M. mohamet	369.27 (11.31 g)	0 (0)	167.38 (10.25 g)	175.62 (9.56 g)
P. harringtoni	2114.17 (79.69 g)	773.16 (94.75 g)	1431 (100.14 g)	163.2 (80 g)
L. flavopunctatus	2974.79 (60.71 g)	0 (0)	0 (0)	0 (0)
S. albipes	1893.91 (66.29 g)	0 (0)	534.48 (52.4 g)	0 (0)
M. musculus	20.4 (10 g)	0 (0)	40.8 (10 g)	79.56 (9.75 g)
R. rattus	418.2 (102.5 g)	0 (0)	864.96 (106 g)	0 (0)
G. murinus	0 (0)	40.98 (20 g)	0 (0)	0 (0)
Total biomass	44075.3 (62.06 g)	23164.1 (63.4g)	10024.2 (64.6g)	11068.9 (67g)

density of *G. murinus* was the least when compared to other species in the study period.

Biomass estimation

The total mean biomass of rodents in the study area was 22083.4 g/ha. The highest biomass was recorded in *A. dembeensis* (6771.43g/ha) followed by *M. natalensis* (6246.63 g/ha) and *M. erythroleucus* (3257.14 g/ha) while *G. murinus* (10.2 g/ha) followed by *M. musculus* (35.36 g/ha) comprised the lowest biomass in the present study (Table 1).

Population biomass of rodents was highest in bushland and lowest in maize farm (Table 3). The largest and lowest biomasses per habitat type were recorded for *M. natalensis* (15302.33 g/ha) and *M. musculus* (20.4 g/ha), respectively from bushland. Biomass of rodents was highest in trapping session 2 and lowest in trapping session 4.The highest and the least biomass per trapping session were recorded for *A. dembeensis* and *M. musculus*, respectively in all trapping sessions except in trapping session 1 where *M. natalensis* had the highest biomass (Table 4). The biomass of rodents during the wet season (12566.6 g/ha) was greater than during the dry season (9521.3 g/ha).

Age distribution and sex ratio

Composition of different age groups of trapped rodent communities between seasons is given in Table 5. All

Table 2. Biomass (g/ ha) of rodents in different trapping sessions (figures in parenthesis are mean weight of species in each trapping session).

Species	Trappin g Session			
	Session 1	Session 2	Session 3	Session 4
M. natalensis	1250.64 (57.29 g)	2380.32 (61.38 g)	1403.55 (43.67 g)	1232.36 (60.38 g)
A. dembeensis	1202.53 (90.62 g)	2472.81 (91.45 g)	1719.4 (66.08 g)	1474.41 (96.18 g)
M. erythroleucus	632.4 (62 g)	1214.28 (47.6 g)	666 (37.29 g)	742.51 (51.96 g)
T. robusta	659.43 (107.75 g)	752.77 (105.43 g)	898.11 (88.05 g)	489.58 (87.27 g)
M. mohamet	15.3 (10 g)	52.02 (10.2 g)	67.82 (10.23 g)	42.84 (12 g)
P. harringtoni	167.79 (82.25 g)	608.4 (108.45 g)	343.74 (67.4 g)	0 (0)
L. flavopunctatus	248.39 (60.88 g)	239.69 (78.33 g)	90.27 (44.25 g)	164.72 (53.83 g)
S. albipes	198.9 (78 g)	241.74 (59.25 g)	68.85 (45 g)	97.42 (63.67 g)
M. musculus	3.57 (7 g)	26.52 (10.4 g)	5.1 (10 g)	0 (0)
R. rattus	59.16 (116 g)	157.08 (102.67 g)	0 (0)	104.55 (102.5 g)
G. murinus	0 (0)	0 (0)	10.2 (20 g)	0 (0)
Total Biomass	4415 (70.93 g)	8151.6 (67.7 g)	5273.2 (51.42 g)	4248.1 (66.6 g)

Table 3. Age distribution and sex ratio of live-trapped rodents (numbers in parenthesis are percentage).

Age groups	Sex		Season		Total
	Male	Female	Wet	Dry	
Young	56	63	40 (33.6)	79 (66.4)	119 (17.4)
Sub-adult	51	52	47 (45.6)	56 (54.4)	103 (15.1)
Adult	220	242	271 (58.7)	191 (41.3)	462 (67.5)
Total	327	357	358 (52.3)	326 (47.7)	684 (100)

age groups were represented in the population of trapped rodents during both dry and wet seasons. From the total 684 individuals captured, adults comprised 67.5%, sub adult 15.1% and young 17.4%. Age distribution was significantly varied (χ^2=26.0, df =2, P < 0.001) among seasons. More young individuals were captured during the dry seasons compared to wet season (χ^2=12.8, df =1, P <0.001). The number of adult individuals was higher than young and sub adult individuals in both seasons. Adults distribution among seasons in the present study was significantly different (χ^2=13.9, df =1, P< 0.001). From the total rodents captured, males comprised 327 (47.8%) and females 357 (52.2%). The sex ratio between seasons (46.4: 53.6% for the wet and 49.4:50.6% for the dry season) was not significantly different (χ^2=0.6, df =1, P>0.05).

DISCUSSION

In the present survey, *M. natalensis* was recorded as the most dominant species and its population size and density was very high. Similarly, different reports affirmed that *M. natalensis* was the dominant species in different parts of Ethiopia (Yalden et al., 1976; Datiko et al., 2007; Tadesse and Bekele, 2008; Chekol et al., 2012; Datiko and Bekele, 2014). Moreover, Mulungu et al. (2013) also showed that *M. natalensis* is the most dominant rodent in Tanzania. This might be due to high reproductive success and large litter size.

A. dembeensis was the second most dominant species with its population size and density with variable status in different habitats. This finding is in agreement with other reports elsewhere and in different parts of Ethiopia (Bekele and Leirs, 1997; Capula et al., 1997; Bekele et al., 2003; Gebresilassie et al., 2006; Chekol et al., 2012). This may be due to vegetation cover and grass loving nature of the rodent. Since this species is active during the day time, it requires more vegetation cover to protect itself from predators.

Mastomys erythroleucus was the third abundant rodent in the present study. It was comparatively common in *Acacia* woodland. This is in accordance with the findings of other researchers in different parts of Ethiopia (Bekele and Leirs, 1997; Bekele et al., 2003). *M. mahomet* and *M. musculus* were found in the three habitat types that include natural and farm habitats and exploited at altitudinal range between 1,590 and 1,635 m above sea level. This was not in line with the description of Bates (1988) that reported their occurrence exclusively in urban and villages. However, this is consistent with other reports (Yalden, 1988a; Bekele and Leirs, 1997; Bekele et al., 2003; Gebresilassie et al., 2004). The least population size was observed in *G. murinus* only found in *acacia* woodland followed by *R. rattus* in the present study. *Lophuromys flavopunctatus* was recorded only in bushland with more density in wet season. This might be due to habitat specificity nature of these species (Makundi et al., 2009).

In the present study, there was variation in the population size, density and biomass among trapping sessions and habitats with the highest estimate in the second trapping session and bushland habitat type. These population fluctuations might be mostly attributed to variation in weather conditions, reproductive patterns, vegetation cover, food and water. This is supported by different researchers (Fernandez et al., 1996; Makundi et al., 2005; Gebresilassie et al., 2006; Makundi et al., 2009; Chekol et al., 2012; Mulungu et al., 2013; Datiko and Bekele, 2014). Although there was high rainfall that affects availability of food, water and vegetation covers, population numbers, density and biomass were low during the first trapping session. This might be due to increasing death rate associated with flooding storm and chilling effects and seasonality of reproduction in most species of rodent.

Habitat associated population size, density and biomass of rodents was lowered in farmlands. This could be due to the fact that farmlands had homogeneity and the crops were not at fruiting stage, which could influence continuous food supply unlike to heterogeneous habitat that supports different species of rodents. Moreover, farmlands had been cleared entirely as well as nearby habitats that determine shelter of rodents. In addition, maize farmland was waterlogged, which was unfavorable for rodents. This is in agreement with Mulungu et al. (2013) reports in Tanzania. In addition to farmlands, in *Acacia* woodland, the population size was decreased during the first and the last trapping session. This could be due to the fact that the grazing effect of wild mammals (mainly warthogs) and the topography of the habitat which would favor water logging during the wet season.

During the second trapping session, the population size, density and biomass was higher than the other sessions. This could be due to the fruiting time of wild plants and agricultural crops that supplied enough food for rodents. This is in accordance with Gebresilassie et al. (2006) report. Moreover, at fruiting time natural habitats as well as farmlands have better ground cover attracting more rodents that protect from predators. Further, the post breeding effect was revealed during late wet and early dry seasons; as a result of this the population number, density and biomass was increased.

During the last trapping session in our survey, the biomass of rodents was lower than the other trapping sessions, particularly in farmlands after harvest. This could be the fact that the trapping activities was made during the long dry period when food resource and vegetation coverage scarcity evidenced. This could influence the migration rate of rodents in searching for suitable habitats food and shelter. This finding is in line with that of Chekol et al. (2012) report. Population size, density and biomass of rodents was higher in bushland whereas was least in farmlands. This might be due to suitable vegetation cover, food source, and moderate temperature and moisture contents as well as habitat heterogeneity in bushland rather than homogeneous farmlands. This is agrees with other findings by Chekol et al. (2012) and Addisu and Bekele (2013).

The highest biomass was recorded in *A. dembeensis* followed by *M. natalensis* and *M. erythroleucus* while *G. murinus* followed by *M. musculus* comprised the lowest biomass in the study area. Even though the abundance of *M. natalensis* was greater than *A. dembeensis*, the highest biomass was estimated for *A. dembeensis* because of body weight variation. Although *M. mahomet* was captured more abundantly than *S. albipes* and *R. rattus*, its contribution to the overall biomass was limited due to their size. The six individuals of *R. rattus* contributed more to the overall biomass than 33 *M. mahomet*. The largest and lowest biomasses per habitat type were recorded for *M. natalensis* and *M. musculus*, respectively from bushland.

In our survey, all age groups were represented in the population of most rodent species and in all trapping sessions. However, there was significant difference in age distribution among seasons. In most of the study periods, adults dominated the population structure. The age distribution in a population of most species at different seasons was directly related to the seasonality in reproduction. More young individuals were captured during the dry seasons compared to wet season. The low frequency of captured of young or sub-adults followed the high number of pregnant female. This is in agreement with different reports (Taylor and Green, 1976; Happold and Happold, 1991; Bekele and Leirs, 1997).

In conclusion, there was variation in population size, density and biomass of rodents in different habitats and seasons. These population fluctuations might be mostly due to variation in rainfall, habitat heterogeneity, vegetation cover, reproductive patterns, quality and quantity of food and water. There was significant variation on different age groups associated with seasons; as a result of high number of pregnant females during the wet season. Moreover, seasonal breeding patterns appeared in most species. Therefore, from the result, this study attempted to indicate the population structure of rodents in Alage, southern Ethiopia. This would have value to contribute knowledge about the biodiversity of the ecosystem.

Conflict of Interests

The author(s) have not declared any conflict of interests

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