Species Composition, Relative Abundance and Distribution of Rodents in Wof-Washa Natural State Forest, North Shewa, Amhara, Ethiopia

Mulu Negesse Dadi
Bonga University

Dereje Yazezew Mammo (deredbu2003@gmail.com)
Debre Markos University College of Natural and Computational Science https://orcid.org/0000-0001-7492-5370

Gezahegn Degefe Teferedegn
Debre Berhan University

Gezahegn Getachew Zelelew
Wollo University

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Abstract

Background: The species composition, relative abundance and distribution of rodents were studied in Wof-Washa Natural State Forest, Ethiopia from December 2016 to May 2017 during dry and wet seasons. A total of 49 Sherman live traps were set per grid at 10 m intervals in permanent 4900 m^2 (70mx70m) live trapping grids established in intact forest, disturbed forest, *Erica* woodland, plantation forest and Farmland habitats.

Result: A total of 621 individuals of rodents were captured in 2,560 trap nights by using both live traps and snap traps. Seven species of rodents in family Muridae were recorded. Out of the total rodents caught in the study period, *Stenocephalemys albipes, Pelomys harringtoni* and *Lophuromys flavopunctatus* are endemics to Ethiopia. Plantation forest had the highest mean trapping success whereas the lowest trap success was in the *Erica* woodland. The distribution of rodent species was significantly differed ($P<0.05$) among studied habitats. Higher trap success was recorded in dry season (26.2) than the wet season (24.4). The highest value of Shannon index was recorded in plantation forest (H' = 1.82) followed by farmland habitat (H' =1.67) during the wet season and the lowest value was observed in the intact forest (H' = 0.67) and *Erica* woodland (H' = 0.67) during the dry season. From the total catch, adults comprised 260(41.9%), sub-adults 248(39.9%) and juveniles 113(18.2%).

Conclusion: The present study provides the first valuable demonstration on the species composition, relative abundance and distribution of rodents in the WWNSF. Further monitoring and inventory of small mammals is warranted to document and conserve the different endemic and endangered rodent species to designing important biodiversity management plan in the area.

Introduction

Ethiopia is endowed with extensive and unique environmental conditions, ranging from 100 m below sea level at Kobar in Afar depression to the summits reach heights of up to 4620 m Ras Dejen [1, 2]. These endowments of topographical and environmental variability are sources of endemism in both fauna and flora of the country [3]. Many of these endemic faunal species are specifically associated with the high-altitude moorland and grassland habitats [1].

Rodents are vital components of food web in the ecosystem that provide the main supply of fresh food for many predators [4, 5], important sources of food or fur for humans [6, 7], serve as biological control agents [8], social and cultural values [9] and educational and research model [7, 10]. Rodents are the most successful mammals adapted to wide range of environments in the world and show great diversity in their ecology, morphology, physiology, behavior and life history strategies [11]. The distribution and abundance of rodents are influenced by availability of food sources and shelter, habitat heterogeneity and stability, seasonal variation of climatic conditions, predator status, and other ecological requirements like the nature and density of vegetation in their habitat [12–16].

Globally, rodents comprise 42% among mammalian orders and represent the largest order with Over 32 extant families, 468 genera and 2,277 species [17, 18]. There are about 14 families, 89 genera and 290 species of rodents in Africa which are most ubiquitous and abundant than other mammalian order [19]. Ethiopia possesses 84 species of rodents of which 36 are endemic that comprise 65.5% of the total endemic mammal species of the country [13, 20]. Faunal exploration is an important component of future conservation endeavor and helps in understanding the potential of the area in composition and diversity of animals [21]. Information regarding faunal diversity reinforces scientific knowledge and boosts the importance of an area to establish protected areas and refugia [7]. Although Ethiopia is endowed with high rodent diversity and endemism [7, 15, 22], no studies have been carried out on population and behavioral ecology of rodents in WWNSF due to inaccessibility, inhospitable conditions and remoteness of the area. Accordingly, the present study is crucial to document ecological information on species composition, relative abundance and distribution of rodents in WWNSF.

Materials And Methods

Study area

The study on the species composition, relative abundance and distribution of rodents was conducted in Wof-Washa Natural State Forest (WWNSF), which is located in North Shewa Zonal administration, Amhara Region, Northwestern highlands of Ethiopia. The escarpment forms part of the catchment of the Awash River system which drains into the Danakil Plains in the northern section of the Rift Valley [23]. It extends approximately between 9°42'- 9°47' N latitude and between 39 ° 43'- 39 ° 49'E longitude (Fig. 1). The area encompasses an altitudinal range between 1650 to 3600 m asl. WWNSF is one of the very few remaining Dry Afro-montane forests and the oldest natural state forest in Ethiopia. The mean annual temperature of the study area is 13.13^{0}C ranging from the mean annual minimum temperature of 6.3^{0}C to the mean annual maximum temperature of 20^{0}C. The rainfall distribution in the area is bimodal with the mean annual rainfall of the study area is 1840 mm[24]. The vegetation of WWNSF can best be described as dry evergreen afromontane forest mixed with both broadleaved and conifers in the eastern escarpment of the Northwestern highlands with clear Ericaceous belt at the higher altitude [24]. Generally, there are over 394 species of plants, of which, 46 species (12%) are endemic to Ethiopia while 7 (2%) are nearly endemic [25, 26]. In spite of the forest's biodiversity, economic, and

ecological significance for the districts harboring it, no action has been taken to preserve the forest and its surrounding villages until recently and the forest is under threat of reduction in size and density accordingly.

Methods

Preliminary survey was conducted from September to November 2016 to gather relevant information regarding climatic conditions, vegetation and habitat types and topography. Based on the topography and vegetation structure, the study area was classified into intact forest (IF), disturbed forest (DF), *Erica* woodland (EWL), Plantation Forest (PF) and farmland (FL). Representative grids were selected from these different habitat types in the study area (Table 1). The area of each grid was 4900 m^2 and coded sequentially. Both live-traps and snap-traps were used for data collection and trapping sites were located >200m apart each other.

Table 1. Description of habitat types of sampling sites

Habitat Type	Description
Intact Forest	A naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. This Forest type is largely the product of natural and ongoing evolutionary, ecological and biological processes with minimal disturbance events. It is located within altitudinal ranges of 2685-2721 m asl (Fig. 2 A) and dominated by tree species such as *Juniperus procera*, *Olea europaea spp. Cuspidiata*, *Podocarpus falcatus, Maytenus, arbutifolia, Erica arborea*, *Ilex mites, Myrsine africana* and *Galineira saxifraga* which accounted 65 % of the total density in the forest [27].
Disturbed Forest	Forest type with native or introduced tree species that spread and multiply by natural regeneration but vegetation structure cannot reflect natural optima due to changes in the structure and composition of a forest ecosystem and maintained in a degraded state due to human disturbance (Fig. 2B). The altitudinal range of grid selected in this habitat is 2706 to 2733 m asl.
Erica bushland	This habitat type is located in the highest peak of the forest dominated by *Erica* scrubs (Fig. 2C) and with altitudinal ranges of 3182 to 3232 m asl.
Plantation Forest	A forest established by planting or/and seeding in the process of afforestation or reforestation and consists of two or more introduced or indigenous species of trees and grasses with successful co-existence in monodominant forest (Fig. 2D). The grid selected in this habitat ranges 2702 to 2735 m asl.
Farmland	This habitat is dominated by cultivated crop species with few scattered remnants tress species indicating that the area is previously covered by forest (Fig. 2E). The grids were selected in the altitude ranging from 2900 to 2970 m. asl.

Trapping

Data were collected during both the dry season (December 2016 and February 2017) and wet season (April and May 2017). Permanent 4900 m^2 live trapping grids were established at five randomly selected sites to represent each habitat type [11]. A standard square (seven rows by seven columns) trapping grid was established in each trapping site, during dry and wet seasons [28]. Accordingly, a total of 49 Sherman live traps were set per grid at 10 m intervals (70mx70m) [12, 21, 29, 30] (Fig. 3). Traps were baited with peanut butter and covered with grass and tree leaves to discourage disturbances by local people. Traps were checked twice a day at early morning (between 07:00 and 09:00) and late afternoon (between 16:00 and 18:00). Trapping was conducted for three consecutive days in each habitat during each of the trapping sessions. GPS points of trap locations were recorded by their code number for check over. Each trapped rodents were removed from the traps and placed inside a transparent polythene bag, weighed and identified to the species level based on the weight and pelage colour. Moreover, sex, weight and approximate age (Adult, subadult and juvenile) of rodents were also determined [31]. Skin specimens of snap trapped rodents were prepared for further identification and comparison with the specimens available in the Zoological Natural History Museum of Addis Ababa University. Head to body length, tail length, ear length and hind foot

length were recorded for identification purpose. Data were analyzed using SPSS computer software programme version 20 and appropriate statistical methods. Chi-square test was used to compute species abundance, distribution, relative abundance and habitat association of rodents. Shannon-Weiner Index was used to compute rodent species diversity among the different habitat types. Habitat similarity was computed by using Simpson's Similarity index. Trapping success was calculated as

$$T = \left(\frac{Nm}{Ntn}\right) x100,$$

where *Nm* = is the set of individuals trapped, *Ntn* = the number of trap night.

Results

Species composition and abundance

A total of 621 individuals of rodents belonging to seven species under family Muridae were captured in 2,560 trap nights by using both live traps and snap traps in all five habitats
types during both wet and dry seasons (Table 1). Out of the total captured rodents, 530 (85.3%) individuals were captured by Sherman live-traps in 1960 trap nights while 91 individual rodents were trapped using snap-traps in 600 trap nights. The species of rodents caught, identified and recorded in the study area during the trapping sessions were white-tailed Rat (*Stenocephalemys albicuadata,* Frick, 1914) 179(28.82%), Ethiopian white-footed mouse *(Stenocephalemys albipes,* Rüppell, 1842) 174(28.02%), broad beaked dolphins (*Pelomys harringtoni,* Thomas, 1903*)* 99(15.94%), yellow- spotted harsh/brush-furred rat *(Lophuromys flavopunctatus,* Thomas, 1888) 77(12.4%), typical veli rat (*Otomys typus,* Heuglin, 1877) 54(8.7%), Natal multimammate mouse (*Mastomys natalensis,* Smith, 1834) 20(3.22%) and gray-tailed narrow-headed rat (*Stenocephalemys griseicauda,* Petter, 1972) 18(2.9%) (Table 1). *S. albicuadata* and *S. albipes* were the most abundant and widely distributed to different habitat types while *S. griseicauda* and *Mastomys natalensis* were the least abundant and have limited distribution in the study area. Out of the total rodents caught in the study period, *Stenocephalemys albipes, Pelomys harringtoni* and *Lophuromys flavopunctatus are endemic to Ethiopia.* In addition to rodent species trapped during the trap sessions, other rodent species such as crested porcupine (*Hystrix cristata*, Linnaeus, 1758) and root rat *(Tachyoryctes splendens,* Rüppell, 1836) were recorded from the study area directly or through indirect evidences like quills and burrows.

Plantation forest had the highest mean trapping success in both dry and wet seasons (35.2%) followed by the farmland habitat with a mean trapping success of 30.7%. The lowest trap success was recorded in the *Erica* woodland in the wet season (13.7%) with the mean trapping success of 14.6% (Table 1). There was statistical variation in the trapping success between the different habitat types during the two seasons ($P < 0.05$).

Table 1. Species composition of rodent in different habitats and seasons.

	Habitat Types											
Species	IF		DF		EWL		PF		FL		Total	RA
	dry	wet	Dry	wet	Dry	wet	Dry	wet	Dry	wet		
S. albicaudata	26	21	18	18	24	17	11	12	15	17	179	28.82
S. albipes	40	28	34	18	16	18	8	12	-	-	174	28.02
P. harringtoni	0	0	5	1	0	0	25	24	26	18	99	15.94
L. flavopunctatus	0	0	0	0	0	0	21	15	22	19	77	12.40
O. typus	0	0	0	0	0	0	14	18	13	9	54	8.70
M. natalensis	0	0	0	0	0	0	5	6	4	5	20	3.22
S. griseicauda	0	0	0	0	0	0	5	4	3	6	18	2.90
Total No.	66	49	57	37	40	35	89	91	83	74	621	100.00
Trap nights	256	256	256	256	256	256	256	256	256	256	2560	
Trap success	25.78	19.1	22.3	14.5	15.6	13.7	34.8	35.6	32.4	28.9	24.26	

Designations: IF=Intact Forest, DF=Disturbed Forest, EWL= *Erica* Woodland, PF=Plantation Forest, FL=Farmland, RA= Relative abundance

Habitat association and seasonal variation

Most species were trapped from modified habitats (plantation and farmland habitats)
whereas least number of species were recorded from natural forest habitats. Among seven species of rodents trapped, *S. albicaudata* was found in all habitats while *S. albipes* trapped from four habitats followed by *P. harringtoni* trapped from three habitat types (Fig. 4). The total captured individuals during the wet and dry seasons were 335 (53.9%) and 286 (46.1%), respectively. Higher trap success was recorded in dry season (26.2) than the wet season (24.4). However, the overall abundance of rodent in dry and wet seasons was not statistically significant difference ($X^2 = 3.86$; df=1; $p > 0.05$). Most species were trapped from plantation forest habitat
whereas the least number of species were recorded from *Erica* woodland and intact forest habitats (Fig. 4). Higher mean trap success of rodents was recorded in the plantation forest (35.2%) followed by farmland habitat while the least was in *Erica* woodland.

Altitudinal distribution of rodent species

The abundance and diversity of species trapped at altitude 2685-2870 m asl was higher (seven species) than the higher altitude (3056-3240 m asl) (Table 2). *S. albicaudata and S. albipes* were abundant at the lower altitude of the trapping sites during the study period. Only these two

species were trapped from higher altitude with relative abundance of 12.08. Moreover, higher relative abundance (63.29) of rodents was trapped in the lower altitudes of trapping sites.

Species Diversity indices

The diversity indices revealed that the plantation forest habitat has a higher species richness (S = 7) whereas the least number of species has been recorded in the intact forest (S = 2) and *Erica* woodland (S = 2). Species diversity was higher during the wet season compared to the dry season in all habitats except disturbed forest. The highest value of Shannon-Wiener index (H') was recorded in plantation forest (H' = 1.82) followed by farmland habitat (H' =1.67) during the wet season and the lowest value was observed in the intact forest (H' = 0.67) and *Erica* woodland (H' = 0.67) during the dry season. Higher dominance index value was observed in

Table 2. Abundance of rodent species trapped from different altitudinal zonation.

	Altitudinal zonation (m asl)			
Species	2685-2870	2871-3055	3056-3240	Total
S. albicaudata	106	32	41	179
S. albipes	140	-	34	174
P. harringtoni	55	44	-	99
L. flavopunctatus	36	41	-	77
O. typus	32	22	-	54
M. natalensis	15	5	-	20
S. griseicauda	9	9	-	18
No of individual	393	153	75	621
Relative abundance	63.29	24.64	12.08	100
Total no. of Species	7	6	2	7

intact forest followed by *Erica* woodland (Table 3; Fig. 5). Estimations of similarity indices between the five habitat types revealed that the intact forest and *Erica* woodland habitats were very similar in terms of species richness. Plantation forest has lowest species similarity with intact forest and Erica woodland (44%). The pairwise comparisons of habitat diversity indices (H') using the diversity *t* test showed significant difference between plantation forest and other habitat types except farmland ($p < 0.05$). Evenness was highest in the *Erica* woodland (E = 0.99) and the lowest in the disturbed forest (E = 0.73) (Table 3). There was no statistically significant difference in rodent species diversity between seasons in all habitats ($P>0.05$). Dominance was higher in the intact forest and *Erica* woodland where diversity was lowest.

Table 3. Diversity indices of rodent species in studied habitat types during wet and dry seasons

Habitat	Season	No. of Species	Abundance	H'	Hmax	E= H'/Hmax	Dominance	$D=1-\sum pi^2$
Intact Forest	Dry	2	66	0.67	0.70	0.96	0.52	0.48
	Wet	2	49	0.68	0.70	0.97	0.51	0.49
Disturbed Forest	Dry	3	57	0.89	1.10	0.81	0.46	0.54
	Wet	3	37	0.80	1.10	0.73	0.47	0.53
Erica woodland	Dry	2	40	0.67	0.70	0.96	0.52	0.48
	Wet	2	35	0.69	0.70	0.99	0.50	0.50
Plantation Forest	Dry	7	89	1.79	1.95	0.92	0.19	0.81
	Wet	7	91	1.82	1.95	0.93	0.18	0.82
Farmland	Dry	6	83	1.58	1.80	0.88	0.23	0.77
	Wet	6	74	1.67	1.80	0.93	0.20	0.80

H'=Shannon-Weiner Index; Evenness= H'/Hmax; D=Diversity Index; Hmax=ln(S)

The similarity index revealed that more species similarity was observed between intact forest and *Erica* woodland habitats (Table 4). However less similarity was recorded in plantation forest when crossed with intact forest and Erica woodland habitats. The overall similarity of species across all habitat types is very low (0.2).

Table 4. Similarity of rodent species among different habitat types during the study period

Habitats	IF	DF	ERW	PF	FL
IF	-	0.8	1	0.44	0.5
DF	0.8	-	0.8	0.6	0.67
EWL	1	0.8	-	0.44	0.5
PF	0.44	0.6	0.44	-	0.92
FL	0.5	0.67	0.5	0.92	-

Similarity Index (SI) = 2C/a+b+c+d+e+…

Sex and age composition

Out of the 621 individual rodents captured, adults comprised 260(41.9%), sub-adults 248(39.9%) and juveniles 113(18.2%). There was statistical difference between age groups (X^2 = 64.38, df =2, P<0.05). Adults were outnumbered subadults and juveniles in the study area. Out of the total trapped rodent species, the number of males 318(51.2%) was slightly higher than females 303(48.8%) though the variation was not significant.

Table 5. Sex and age composition of trapped rodents during entire study period

species	Sex		Age groups		
	M	F	Adult	subadult	Juvenile
S. albicaudata	93	86	70	69	40
S. albipes	88	86	63	67	44
P. harringtoni	48	51	46	44	9
L. flavopunctatus	40	37	36	24	17
O. typus	26	28	27	27	0
M. natalensis	13	7	6	11	3
S.griseicauda	10	8	12	6	0
Total	318	303	260	248	113
Relative abundance (%)	51.2	48.8	41.9	39.9	18.2

M=male, F=female

Species Composition and Relative abundance of rodents trapped by Sherman live traps and Snap traps

The relative abundance of live-trapped rodents varied from species to species with the highest capture (149) in the plantation forest and the lowest (70) in *Erica* woodland habitats during study period. From the snap trapped rodents the highest capture (31) was in plantation forest while the least (5) was in *Erica* woodland habitat. *S. albicaudata* was the highest captured species followed by *S. albipes* whereas *S. griseicauda* was the least trapped species in both Sherman live trap and snap trap captures. Highest trap success was recorded in the plantation forest (Sherman: 38.01, snap: 25.83) while the least was in the *Erica* woodland (Sherman: 17.86, snap: 4.17) during the study periods (Table 6).

Table 6. Comparison of rodent species composition, relative abundance and trap success of Sherman and snap trapping techniques from different habitat types

Species	IF		DF		EWL		PF		FL		Total		RA	
	Live trap	Snap trap	Live trap	Snap trap	Live trap	Snap trap	Live trap	Snap trap	Live trap	Snap trap	Live trap	Snap trap	Live trap	Snap trap
S. albicaudata	38	9	31	5	39	2	20	5	23	7	151	28	28.5	30.76
S. albipes	61	7	41	11	31	3	15	5	0	0	148	26	27.9	28.57
P. harringtoni	0	0	3	3	0	0	46	6	34	7	83	16	15.6	17.58
L. flavopunctatus	0	0	0	0	0	0	32	4	39	3	71	7	13.4	7.69
O. typus	0	0	0	0	0	0	27	4	21	2	48	6	9.05	6.59
M. natalensis	0	0	0	0	0	0	4	5	14	1	18	6	3.4	6.59
S. griseicauda	0	0	0	0	0	0	5	2	6	0	11	2	2.07	2.19
Total	99	16	75	19	70	5	149	31	137	20	530	91	100	100
Trap nights	392	120	392	120	392	120	392	120	392	120	1960	600		
Trap success	25.26	13.33	19.13	15.83	17.86	4.17	38.01	25.83	34.95	16.67	27.04	15.17		

Designations: IF= Intact forest, DF= Disturbed forest, EWL= Erica Woodland, PF= Plantation Forest, FL= Farmland, RA= relative abundance (%).

Table 7. Comparison of the number of species trapped and number of habitat types surveyed with other studies.

Study site	Source	Number of rodent species	No. of habitat types
Southeast Ivory Coast	[32]	13	3
Alage, Southern Ethiopia	[35]	11	4
Mayuge district, Eastern Uganda	[36]	11	4
Wondo Genet, Ethiopia	[29]	7	5
Chebera Churchura National Park, Ethiopia	[12]	15	7
Aridtsy forest, Awi, Ethiopia	[33]	7	4
Yetere Forest, Ethiopia	[37]	5	4
Klte-Awla'elo District, Tigray, Ethiopia	[30]	6	4
Alto Beni, Bolivia	[38]	10	2
Aquatimo forest, East Gojjam, Ethiopia	[34]	8	4
Wof Washa Natural State Forest, Ethiopia	This study	7	5

Discussion

Although WWNSF is deemed to encompass iconic species of small mammals endemic to the country, no study has been conducted yet regarding species composition, abundance and population of rodents in the area. Accordingly, this study presents the first inventory of rodent species in WWNSF, Ethiopia. The current findings of the study have been compared with studies conducted elsewhere in the country as there was no longitudinal data documented concerning rodent species of this study area.

Seven species of rodents were identified during this study. The number of species recorded in this study was much lower in contrast to several studies in other localities in Ethiopia and other regions in Africa which possibly a reflection of either lower rodent diversity or lower trap chance in catching more species of rodents including other small mammals [12, 32] (Table 7). Indeed, the lower number of rodent species in this study might also be attributed to the seasonal factors of the trap period or the intensiveness of trap survey duration. Moreover, other studies reported equivalent data though there is variation in the number of habitat types surveyed which possible yield variance [29, 30, 33, 34].

Out of the seven species recorded in the area, *S. albicuadata* (28.82) and *S. albipes* (28.02) were the most abundant. Most species were trapped from modified habitats (plantation and farmland habitats) whereas least number of species were recorded from natural intact and disturbed forest, and *Erica* woodland. Among seven species of rodents trapped, *S. albicaudata* was found in all habitats while *S. albipes* trapped from four

habitats followed by *P. harringtoni* trapped from three habitat types. Other four species were distributed in two habitats with lower abundance. *M. natalensis* (3.22) and *S. griseicauda* (2.9) were the least abundant species trapped from plantation and farmland habitats. This is contrary to the view point that *M. natalensis* have been considered as the most adaptable and widespread species of rodent in Ethiopia [7, 12, 33, 37]. However, the finding confines to the report that stated *M. natalensis* as a common species in crop fields including human environment than in natural vegetation [7, 39].

In this study, trapping success varied among habitat types and between seasons. The highest mean trap success was recorded from the plantation forest (35.2%) and farmland habitat of (30.7%) during both seasons while *Erica* woodland habitat (14.65%) was with the least mean trap success. This might be associated with low predation risk and food availability in plantation and farmland habitats. Moreover, the topographical location of *Erica* woodland habitat might pose climatic stress on rodent species affecting their activity patterns as this habitat is at a higher elevation. The overall mean trap success (24.26%) of the present study area was higher as compared with studies from Arbaminch Forest and Farmlands (17.6%) [39], Menagesha-Suba State Forest (9.1%) [31], Aquatimo forest, East Gojjam (13.6%) [34], Bumdeling Ramsar Site, Trashiyangtse, Eastern Bhutan (11.03%) [40], Wondogent (12.7%) [29] and Yetere Forest, Gishe Rabel, Ethiopia (13.74%) [37]. This might possibly associated with factors like Climatic factors, vegetation types, changes in the availability of food, cover and activity of animals which have dropping effect on trap success [12, 31, 37].

In the present study, more species diversity of rodents was recorded during wet season compared to the dry season in all habitats except disturbed forest. The highest value of Shannon-Wiener index (H') was recorded in plantation forest (H' = 1.82) followed by farmland habitat (H' =1.67) during the wet season and the lowest value was observed in the intact natural forest (H' = 0.67) and *Erica* woodland (H' = 0.67) during the dry season. This is contrary to reports that stated the presence of more rodent species diversity in the natural habitats than in modified habitats (plantation and farmland) [39]. However, this finding supports reports that presented highest number of species from farmland habitat than the natural habitats [33, 34]. The higher number of rodents in the plantation and farmland habitat might be associated with availability of diversified food sources and lower abundance of predators as compared with natural forest habitats. Estimations of similarity indices between the five habitat types revealed that the intact forest and *Erica* woodland habitats were very similar in terms of species richness. However, plantation forest showed lowest species similarity with intact forest and Erica woodland (44%).

Out of the 621 individual rodents captured, adults comprised 260(41.9%), sub-adults 248(39.9%) and juveniles 113(18.2%). There was statistical difference between age groups (X^2 = 64.38, df =2, P<0.05). Adults were outnumbered subadults and juveniles in the study area. This is in line with other study that stated domination of rodent population structure by adult individuals [35]. The possible reason for high abundance of male rodent in a population might be high mobility behavior of males and low mobility of females due to reproduction and parental care engagement. Although the difference was not significant, the number of males 318(51.2%) was slightly higher than females 303(48.8%) though the variation was not significant. Opposite finding was reported by [39] where females comprised 319 (51.4%) and males 301 (48.6%).

The relative abundance of both live-trapped and snap trapped rodents varied from species to species with the highest capture (Sherman: 149, snap: 31) in the plantation forest and the lowest (Sherman: 70, snap: 5) in *Erica* woodland habitats during study period. This shows that there was no variation in the abundance ranking of rodent species trapped in the area with reference to the trapping technique type. This finding is contrary to the report that showed a reverse abundance ranking of *S. albipes* and *L. flavopunctatus* based on the trapping tools used [29]. This might be associated to the variation in the time of data collection, habitat cover, the bait used the two studies, physiological situation of the animals and human disturbance level in the two studies.

In conclusion, the present study provides the first valuable demonstration on the species composition, relative abundance and distribution of rodents in the WWNSF. Out of the total rodents caught in the study period, *Stenocephalemys albipes, Pelomys harringtoni* and *Lophuromys flavopunctatus* are endemics to Ethiopia.

The following points are recommended to enhance the conservation value of Rodents.

- Although, the research result confirmed the presence of seven rodent species in the study area, it provides a window on the need of further, more extensive sampling with the incorporation of additional trap sites to the lower altitude for further monitoring and inventory of small mammals to document the different endemic and endangered rodent species.
- The forest area has not been clearly demarcated. Accordingly, there should be demarcation to hinder agricultural expansion into the forest area which provide travel corridor to villages for pest rodents that cause yield damage.

Abbreviations

DF: Disturbed forest; EWL: Erica Woodland; FL: Farmland;, IF: Intact forest; PF: Plantation Forest; RA: relative abundance; WWNSF: Wof Washa Natural State Forest.

Declarations

Ethics approval and consent to participate

Permits for this research were issued by the Ethiopian Wildlife Conservation
Authority (EWCA), Tarmaber District Rural Development and Agriculture Office and WWNSF forest management office.

Consent for publication

This manuscript does not contain any individual person's data, and further consent for publication is not required/ applicable.

Competing interests

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Authors Contributions

MN collected, analyzed the data and was a major contributor in writing the draft manuscript. DY organized the manuscript and checked the data collected and analyzed for final submission. GD and GG revised both the draft manuscript and the final version. All authors read and approved the final manuscript.

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Availability of data and materials

The data used to support the findings of this study are available from the corresponding author request.

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Figures

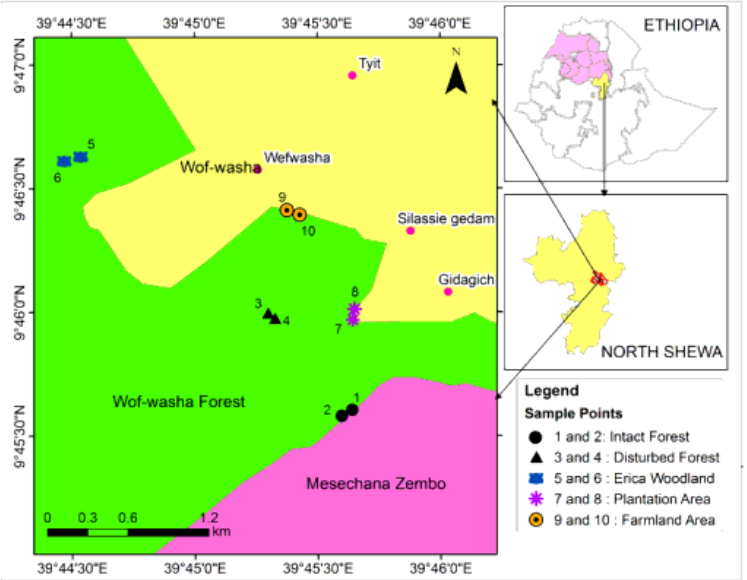

Figure 1

Map of the study area and location of sampling area. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

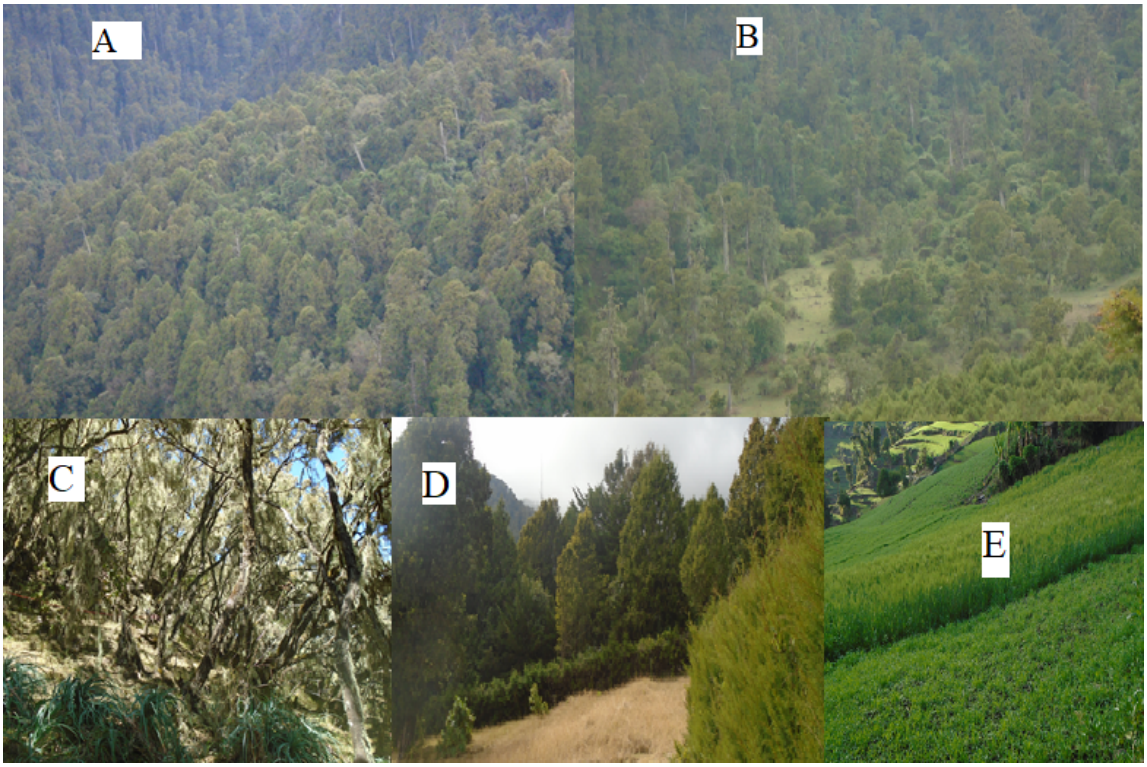

Figure 2

Habitat types of sample grids: Intact forest (A), Disturbed forest (B), Erica woodland (C), Plantation forest (D) and Farmland (E) habitats.

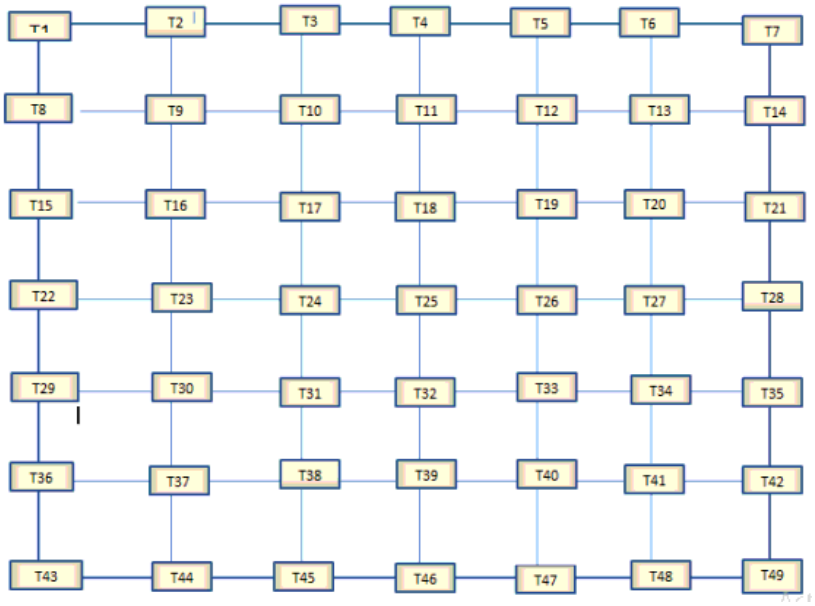

Figure 3

Diagrammatic representation of Sherman live trappings grid length were recorded for identification purpose.

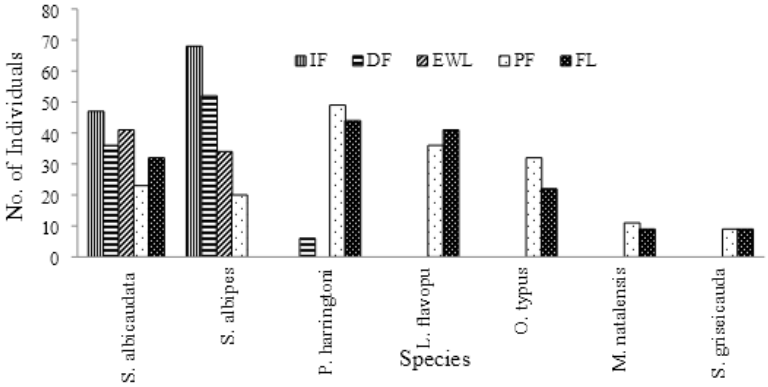

Figure 4

Abundance and distribution of rodent species in five different habitat types of WWNSF (IF: Intact Forest, DF: Disturbed Forest, EWL: Erica Woodland, PF: Plantation Forest, FL: Farmland)

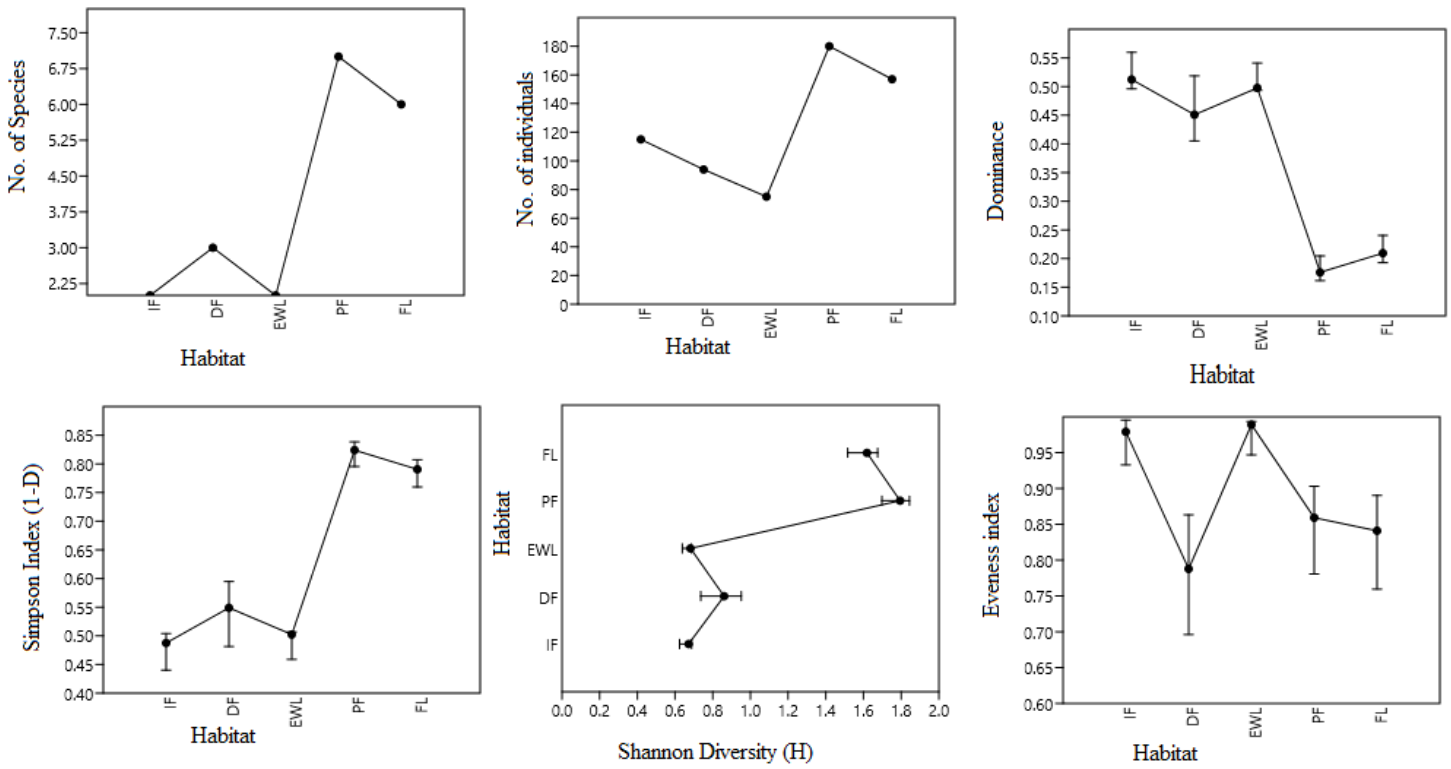

Figure 5

Diversity indices of rodent species at WWNSF (IF: Intact Forest, DF: Disturbed Forest, EWL: Erica Woodland, PF: Plantation Forest, FL: Farmland).