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Original Article

Comparative study of species composition, relative abundance and distribution of rodents between exclosure and control sites in the Web Valley of the Bale Mountains National Park, Ethiopia

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Abstract

This investigation deals with comparative study of rodents between exclosure and control sites, Ethiopia. To collect the rodent fauna, six study grid sites were identified and marked. These were three from exclosure and three from control sites. Twenty-five traps were used to capture the rodents. Four hundred sixty two (462) individuals of small mammals were captured and one recorded as observed species during both dry and wet season. They were identified into six species. Among these, 458 (99.1%) were rodents and 4 (0.9%) were insectivores. The trapped species were: *Lophuromys melanonyx* (242), *Stenocephalemys albocaudata* (126), *Arvicanthis blicki* (86), *Mus Mahomet* (3), *Dendromus lovati* (1), and *Crocidura fumosa* (4). *Tachyoryctes macrocephalus* was recorded as frequently observed species. Four endemic species of rodents were identified in the area (*Lophuromys melanonyx, Arvicanthis blicki, Dendromus lovati and Tachyoryctes macrocephalus*). The distribution and abundance of species varied between exclosure and control sites, and between seasons. Livestock grazing in the area was the major problem encountered affecting the rodent population. As a result, proper conservation measures have to be implemented to solve the problems and safeguard the endemic wildlife in the Park.

Key words: Abundance, conservation, control, exclosure, rodents, Web Valley.

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INTRODUCTION

Among African countries, Ethiopia has diverse topographic features. Fifty percent of the African highlands above 2000 m and 80% of the land above 3000 m asl (above sea level) occur in Ethiopia (Malcolm and Sillero-Zubiri, 1997). The Bale Mountains have the first largest area of Afroalpine habitat with high endemic mammalian species (Abunie, 2000). Among the mammals of Ethiopia, rodents account for 39.4% (Lavrenchenko *et al*., 1998) and contribute approximately 50% of the total number of endemic species (Bekele, 1996a; Yalden *et al.,* 1996). However, for many years, the natural habitats of Ethiopia have been altered by human pressures including overgrazing, which affect the wildlife. Ethiopia has the highest number of livestock in Africa with over 43 million cattle and 48 million caprines (FAO, 2007). The majority of livestock production in Ethiopia takes place in afroalpine grasslands. Rodents constitute the main natural grazers of the afroalpine and 15 of the 47 mammal species inhabiting the Bale Mountains are rodents (Yalden *et al*., 1996). In the Web Valley, these rodents occur at high densities and are important components of the diet of the endangered and endemic Ethiopian wolf (*Canis simensis*) (Sillero-Zubiri, 1994).

Livestock grazing produces severe effects on dynamics of grassland plants as well as on the abundance of small mammal population. As noted by Hatch *et al*. (1999), the impacts caused by grazing on a particular ecological system depend upon many factors, such type of large mammalian herbivores, habitat type, climate, taxa under study and seasonal timing and intensity of grazing.

Most of the highlands have been modified into agricultural and pastoral land. Exclosure studies are widely used to investigate the grazing impacts of ungulates on vegetation

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and animal communities by controlling ungulate access to plant resources (Firincioglu *et al*., 2007; Pei *et al*., 2008). Several studies have explored the interactions between livestock and small herbivorous rodents using such exclosures (Steen *et al*., 2005; Vial *et al*., 2011). This study will provide evidence for rodent responses to livestock removal in the study area. The study will build on and compliment earlier study by Vial *et al*. (2011), on the three rodent species such as *Tachyoryctes macrocephalus*, *Lophuromys melanonyx and Arvicanthis blicki.* Park has been under increasing pressure from a rapidly growing pastoralist population and their livestock (Marino *et al*., 2006). High densities of livestock are known to occur inside the key Ethiopian wolf habitats of the Web Valley, Sanetti and Morebawa (Vial *et al*., 2011). High levels of livestock grazing in Bale may affect the quality of the habitat suitable for the rodent community on which the wolves depend. These fossorial diurnal rodents are of great ecological importance as the dominant wild herbivores within the afroalpine ecosystem (Sillero-Zubiri *et al*., 1995). They are also an important component of the diet of a diverse guild of diurnal raptors which inhabit the Bale massif (Clouet *et al*., 2000), as well as the Ethiopian wolf. In this study, we aim to investigate how grazing-induced variations in vegetation influence rodents composition in exclosure and control plots, 5-6 years after the initial experiments of Vial 2008 and 2009 using the same plots. It revealed composition of rodent species, in addition to the three previously studied endemic species, and compared the immediate and long-term effects of excluding grazing on the abundance of rodents. Therefore, present study revealed the comparative study of species composition, relative abundance and distribution of rodents between exclosure (livestock removed) and control plots (grazing area).

MATERIALS AND METHODS

Description of the study area

Bale Mountains National Park (BMNP) is situated in the southeastern highlands of Ethiopia. Geographically, BMNP is located between 06°41'N, 39°03'E and 07°18'N, 40°00'E , about 400 km from Addis Ababa. BMNP contains the largest continuous area (over 1,000 km^2) of afroalpine habitat in Africa (Fishpoll and Evans, 2001). It is on the southeast part of the Ethiopian plateau, in the Oromia National Regional State. It is located within Bale Zone and belongs to the Bale-Arsi massif, which forms the western section of the southeastern Ethiopian highlands. The Park encompasses 2,200 km^2 of mountains and forest (Fig. 1). It covers an altitudinal range from 1,500 to 4,377 m asl (Fishpol and Evans, 2001). Tullu Deemtu (at 4,377 m asl) is the highest mountain in southern Ethiopia and second in the country. The present study plots are located in the Web valley (07°00'N, 39°40'E, 3500m asl), an area of extensive marshes and swamps (Vial *et al*., 2011).

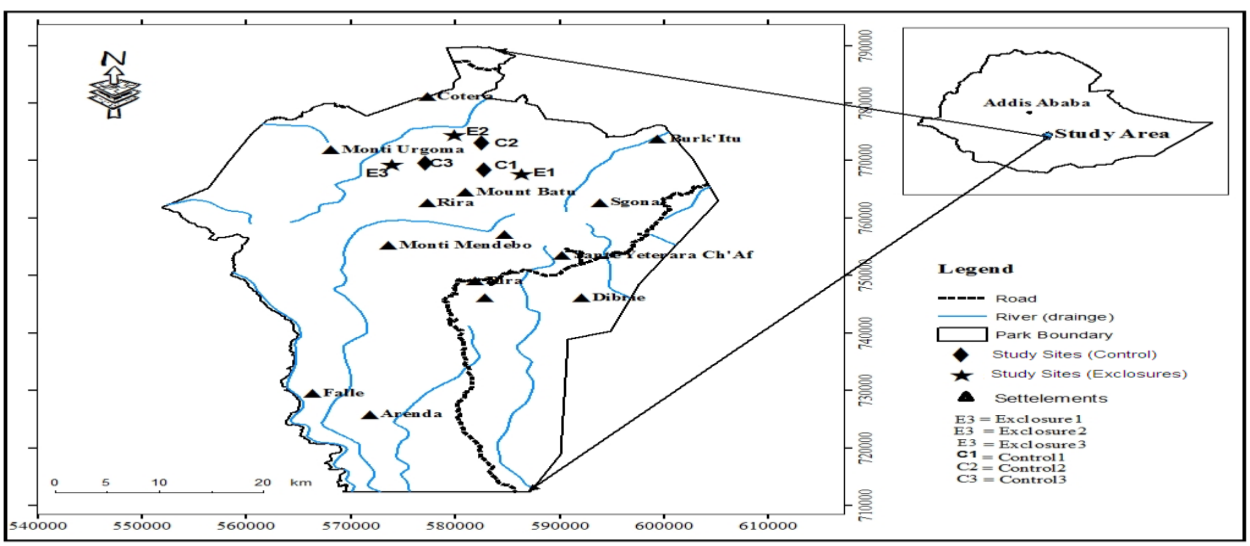

Figure 1: Map of the study area with location of the study girds.

According to Vial *et al*. (2011), three 50x50m livestock exclosures were built in March 2008 in the Web Valley for Vial's study, an area of high human and livestock density. All three exclosures are located on pastures dominated by grasses and *Alchemilla* herbs and paired with a control site (open to livestock) located between 300 and 1000 m away, with similar topography. The data used for the description of temperature and rainfall were obtained from the Ethiopian National Meteorological Service Agency (ENMSA) and office of the Park management for the years 2001-2014. Temperature is highly variable ranging 5-12.6 ºC. However, the temperature of the Park normally ranges between 5^{o}C and 20^{o}C. The warmest months of the year are between March and April. Whereas, the coldest are between November and December and it can range up to 1.5^{o}C.

Sampling procedure

A preliminary survey in the study area was carried out before starting actual data collection to gather relevant information from EWCP office and local community of the area. This helped to identify the boundaries of the Park areas to identify the number of grids. During this survey, all the available and relevant information about the area (seasons and topography) were collected including exclosures and control sites.

As noted by Vial *et al*. (2011), rodent and vegetation surveys were carried out to investigate the response of endemic afroalpine rodents between exclosures and control plots (open to livestock) of similar topography and vegetation composition. As a result, three 0.25-hectare (50x50 m) livestock exclosures were built in March 2008 in the Web Valley. This is an area of high human and livestock density inside the park. All three exclosures were located on pastures dominated by grasses and herbs. Exclosures were 1.6 m high and fenced all the way to the ground with strong metal netting (5 cm mesh) and barbed wire. The resulting exclosures were livestock-proof (cattle, sheep/goats and horses/donkeys) and inhibited entry by Ethiopian wolves but not raptors. Exclosures were located between 2.4 and 3.4 km from each other (Vial, 2010). Rodent surveys are carried out during one wet season and two consecutive dry seasons.

Sampling methods of Bekele (1996b); Linzey and Kesner (1997) and Vial *et al*. (2011) were employed. Rodents were trapped using Capture-Mark-Recapture (CMR) technique by Sherman-live traps during the dry and wet seasons between 2013 and 2014. A total of six grids (three grids in exclosures and three in control plot/open to livestock) were used in the study area. The girds were surveyed once during wet and twice the dry seasons. The trapped animals were marked by fur clipping on their abdomen and released at the same site. Moreover, the representative of specimens and their pictures the animals were collected and the specimens were identified at species level by comparing with reference specimens of Zoological Natural History Museum, Addis Ababa University.

Data collected were analysed using SPSS version 19 computer software programme and appropriate statistical methods such as Chi-square test and descriptive analysis were used to compute the relative abundance and distribution of species. To compute species diversity at different habitats, Shannon-Wiener index (H'), Richness Index (R) and Simpson's Similarity Index (SI) were also used.

RESULTS

The study revealed seven species of small mammals from the study area. Of these, 6 species of small mammals were captured and the remaining one species was identified as observed species. Totally, four species were recorded as endemic species. A total of 462 individual small mammals belonging to five species of rodents and one species of insectivore were trapped during the study period. These are grouped into four families: Muridae (*Lophuromys melanonyx, Stenocephalemys albocaudata, Arvicanthis blicki, Mus mahomet*), Nesomyidae (*Dendromus lovati*), Soricidae *(Crocidura fumosa)* and Spalacidae *(Tachyoryctes macrocephalus)* (Table I). Out of the total captured small mammals, 462 individuals were trapped in 1350 trap-nights The number of rodent species collected from each site is given in Table II. Four species were captured from exclosure one and three, whereas only three species were trapped from each remaining grids. The number of species and the total number of individuals captured were less in control grids than exclosures during the study period. The variation in the total trapped species in the study area (exclosures and controls) was statistically significant (χ^2 =61.5, df = 5, P < 0.05). A total of 6 rodent species were recorded. Of these, 5 were the captured ones and the remaining one was observed during all trapping sessions in the area (Table III).

Table I: Species composition of small mammals in the study area

Family	*Species*	Total capture	Category
Muridae	*Lophuromys melanonyx*	242(36)	Endemic
Muridae	*Stenocephalemys albocaudata*	126(25)	Common
Muridae	*Arvicanthis blicki*	86(17)	Endemic
Muridae	*Mus mahomet*	3(0)	Common
Nesomyidae	*Dendromus lovati*	1(1)	Endemic
Soricidae	*Crocidura fumosa*	4(0)	Common
Spalacidae	*Tachyoryctes macrocephalus**	*	Endemic
Total	7	462	

Numbers in bracket show re-captures; * observed species,– = non-trapped species)

Table II: Grid surveyed, number of species and total capture of rodents recorded

Surveyed habitat type	Altitude (m asl)	No. of species captured	Total no. of individuals captured
Exclosure 1	3517	4	118
Exclosure 2	3524	3	89
Exclosure 3	3504	4	97
Control 1	3518	3	52
Control 2	3512	3	47
Control 3	3502	3	55

Table III: Species composition and relative abundance of trapped rodents

Species	Total capture	Relative abundance (%)
Lophuromys melanonyx	242	52.8
Stenocephalemys albocaudata	126	27.5
Arvicanthis blicki	86	18.8
Mus mahomet	3	0.7
Dendromus lovati	1	0.2
*Tachyoryctes macrocephalus**	*	*
Total	**458**	**100**

Abbreviations*= non-trapped/observed species.

Totally, 458 individuals of rodents were trapped. These were *Lophuromys melanonyx, Stenocephalemys albocaudata, Arvicanthis blicki, Mus Mahomet* and *Dendromus lovati. Tachyoryctes macrocephalus* was recorded as observed species.The variation in the total trapped of different species in the study area was statistically significant (χ^2 =94.9, df = 4, P < 0.05). *Lophuromys melanonyx* was the most abundant species constituting (52.8%) of the total trapping, followed by S. *albocaudata* (27.5%). Other species *Mus mahomet* (0.7%) and *D. lovati* (0.2%) were the least abundant species. The giant mole rat (*T. macrocephalus*) was observed throughout the study area. The highest number of rodent was trapped from the first exclosure 118 (25.8%), followed by the third exclosure 97 (21.2%) and least from the second control 47(10.3%). The total number of capture was statistically significant between different grid types (χ^2 = 61.5, df=5, P<0.05). *Lophuromys melanonyx, S. albocaudata* and *A. blicki* were distributed in all grid types (Table IV). *Mus mahomet* and *D. lovati* were only trapped from the first and third exclosures, respectively. *Tachyoryctes macrocephalus* was observed in all grids during the daytime. The relative abundance of rodent species in each grid type is given in Table V. *Lophuromys melanonyx, S. albocaudata* and *A. blicki were* recorded from all grid types with variation abundance. The highest abundance of each was *L. melanonyx* (24.8%), *S. albocaudata* (27.0 %) and *A. blicki* (24.4%), respectively from exclosure 1. However, *Mus mahomet* and *D. lovati* were only captured from exclosure1 and exclosure 3, respectively. Diversity indices of rodents in different grids are given in Table VI. Species richness varied across grids, *i.e.,* maximum of 5 species in the first and third exclosures and minimum of four species in the remaining grids were recorded. Species composition among the habitats was statistically insignificant (χ^2 = 11.92, df =5, P>0.05). Simpson's Similarity Index (SI) also showed greater than 90% (SI= 0.92). Rodent diversity index was highest in the first exclosure (1.103) and lowest in the third control H'=0.943. Richness Index (R) was high in the third (0.874) and the least in the second exclosure (0.668).

Table IV: The distribution of rodent species from six grid types

Gird type	Species						
	Lm	Sa	Ab	Mm	Dl	Tm	Total
Exclosure 1	60	34	21	3	-	*	118
Exclosure 2	51	21	17	-	-	*	89
Exclosure 3	49	28	19	-	1	*	97
Control 1	30	13	9	-	-	*	52
Control 2	19	17	11	-	-	*	47
Control 3	33	13	9	-	-	*	55
Total catch	242	126	86	3	1	*	458

Abbreviation: *: observed species, -: absence; Lm: *Lophuromys melanonyx, Sa: Stenocephalemys albocaudata, Ab: Arvicanthis blicki, Mm: Mus mahomet, Dl: Dendromus lovati, Tm: Tachyoryctes macrocephalus.*

Table V: Abundance of trapped small mammal species in each habitat

Species	Abundance of species in each grid type						
	E1	E2	E3	C1	C2	C3	Total
L. melanonyx	24.8	21.0	20.3	12.4	7.9	13.6	242
S. albocaudata	27.0	16.7	22.2	10.3	13.5	10.3	126
A. blicki	24.4	19.7	22.1	10.5	12.8	10.5	86
M. mahomet	100	-	-	-	-	-	3
D. lovati	-	-	100	-	-	-	1
T. macrocephalus	*	*	*	*	*	*	*

Abbreviations: - shows absence of trapped individuals; E1: exclosure 1, E2: exclosure 2, E3: exclosure 3, C1: control 1, C2: control 2 and C3: control 3).

Table VI: Diversity indices of rodents in different habitats

Parameters	Grid types					
	E1	E2	E3	C1	C2	C3
Number of species observed	5	4	5	4	4	4
Total catch	118	89	97	52	47	55
Shannon-Wiener index (H')	1.103	0.976	1.069	0.968	1.074	0.943
Simpson's Index (D)	0.623	0.574	0.618	0.571	0.651	0.557

Richness Index (R)	0.838	0.668	0.874	0.759	0.779	0.749
Trap nights	225	225	225	225	225	225
Trap success	**52.4**	**39.6**	**43.1**	**23.1**	**20.9**	**24.4**

Abbreviations: E1: exclosure 1, E2: exclosure 2, E3: exclosure 3, C1: control 1, C2: control 2 and C3: control 3

DISCUSSION

The present study revealed the presence of seven species (five species of trapped rodents, one shrew and one observed rodent) of small mammals in the Web Valley. Among these, four species are endemic rodents, indicating that the Park is an ideal habitat for endemic species of rodents. The study of Vial (2010) also revealed similar endemic rodents from the area except *Mus mahomet*. A great variation was observed in the relative abundance of rodent species. Among the trapped species, *L. melanonyx* was the most abundant species in the area. Similarly, Vial *et al*. (2011) showed high` number in Bale Mountains National Park. Several studies revealed that *L. melanonyx* is one of the endemic rodents in the Bale Mountains. Vial (2010) also suggested that *L. melanonyx* are restricted to some afroalpine habitats. The next abundant rodent was *S. albocaudata*, it is a common rodent in the Bale Mountains National Park. However, *D. lovati* and *M. mahomet were* the least abundant and distributed rodent species in the present study area. They were considered as a rare species. *Dendromus lovati* was an uncommon species (Yalden and Largen, 1992). The species was captured rarely in their survey work. Yaldan (1988) also noted that *D. lovati* was limited in number and collected only from disturbed or grazed areas to the high plateau of Ethiopia. It has been recorded from 2,500 to 3,550 m asl. The present study also confirms their existence in this restricted afroalpine habitat. *Mus mahomet* was collected from exclosure one only. For this animal, their small size/weight might also limit trapability that leading to less springing of the traps. This might show that the distribution of a species may not be the same in the similar habitat.

It is important to recognize the limitations of the design and results of this study. Plots were only 0.25 ha in size and restricting the number of replicates to three may not be adequate to evaluate the effects of livestock removal on the rodent populations (Nash *et al*., 1999). Similarly, the small size and isolation of ungrazed patches may not be big suitable habitats to detect significant differences in overall rodent use as noted by Datiko and Bekele (2013). Moreover, the exclosures have excluded the main predator of these rodent species, the Ethiopian wolf, in addition to livestock. Contrary to our prediction, there were no significant differences in the number of rodent species between the two studies sites (Exclosure and control). However, the number of rodents captured in the exclosure site (304) was significantly larger than the control site (154). Our results were inconsistent with other previous studies that showed grazing may even increase the number of rodents (Karmiris and Nastis, 2007). In contrast, other studies on the rodent species did not find such increase in density (Hayward *et al*., 1997; Jones *et al*., 2003). Thus, these might be related to heterogeneity between sites as a major explanatory factor for survival rates. *Lophuromys melanonyx* and *S. albocaudata* were the most distributed species in both sites, while *M. mahomet* and *D. lovati* were the least abundant species. *Tachyoryctes macrocephalus* was observed in all sites. Similar studies of Vial (2010) had documented the dominance of *L. melanonyx* from the area. Our results support previous findings, which suggested that habitat disturbance affects the abundances of rodents.

The distribution of species varied from site to site. The three rodent species, *L. melanonyx, S. albocaudata* and *A. blicki* were widely distributed in both exclosures and control sites. However, their abundance varied from species to species. Most rodents were captured more from exclosures than control sites. Vial (2010) also showed similar situation on these species in her previous studies.

Habitat complexity in relation to food availability and cover might be a key factor to influence the overall distribution of rodents in the study area. The study of Makundi *et al*. (2005) and Chekol *et al*. (2012) also confirmed that population size of rodents fluctuates greatly as a result of change in quality and quantity of resources in an environment. Lack of cover in the control might expose the rodents to predators, which could force them to migrate to more suitable habitats (Hansson, 1999). Moreover, the Shannon Wiener index (H') also showed higher value in the exclosure and lowest in control sites. Control sites were poor in the abundance of rodent species. Low species richness and abundance in the control sites might be a result of permanent overgrazing by domestic animals, thereby restricting immigration or avoiding the area. In addition, sparse ground vegetation exposes the animals to predation. This might be due to the habitat composition of the area such as cover sites and food habits of rodents. Previous study by Datiko and Bekele (2013) from Chebera Churcura National Park also made similar observations. The diversity indices of rodents also varied in different sites. For instance, the Shannon Weaver index (H') was highest in the exclosure one (1.103) and lowest in control three (0.943). This might be attributed to the presence of several microhabitats such as habitat cover and their diverse resources.

Conclusion

The present investigation provides valuable information on vegetation cover, availability of food and overgrazing were the main factors for the distribution and abundance of rodents among sites (exclosure and control) and between seasons. The study also revealed that a habitat with good ground vegetation cover is more suitable for rodents. BMNP has a great potential and for country's wildlife and tourism development. The studied species and others have great biological and economic values. The need for further research should be carried out get detailed information on the ecology of each species. Therefore, it is necessary to take appropriate conservation measures (community based conservation activities) to minimize the problems.

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