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Exotic plantation and land modification impact on small mammals of Chilalo-Galama Mountains range of Arsi Mountains National Park

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Abstract

The investigation was carried out on Chilalo-Galama Mountains Range from September 2013 to December 2016. The main objective of this research was to make a survey on the impacts of artificial plantation of exotic species on small mammals' richness and abundance. Data was collected on small mammals' diversity, relative abundance, habitat association and preference. Based on the different type of plantation and its nearby natural vegetation five representative habitats namely Agricultural land, *Erica* forest, *Erica* scrub, Montane forest, and Plantation were selected. A 5x5 Sherman Live trapping grid with 15 m spacing was employed for three consecutive days in the selected grids. The traps were baited by peanut butter and checked twice a day early in the morning and late afternoon. Basic morphometric information of the captured small mammals was gathered. All live trapped animals were marked and released in the site with the exception of the selected representative sacrificed individuals after their species identification. The plantation of exotic species impact on small mammals was analyzed based on the species richness and relative abundance of small mammals in compares with the nearby natural habitat. A total of 13 small mammals belonging to order Rodentia (10 species) and order Philodotyphylla (2 species) were recorded, at least 55.56% were endemic to Ethiopia. Species richness in young plantation with mixed natural habitat and modified habitat had more number of species than the nearby natural habitats. However, the species richness and the relative abundance (18) in older plantation were lower than the nearby natural habitat (107). Artificial plantations with exotic species were significantly affecting the abundance, diversity of small mammal. Hence the regulation and control of the artificial plantation with exotic species practice in protected area had a significant contribution for small mammal conservation and management of their natural habitat.

Key words/Phrases: Arsi Mountains National Park; Chilalo-Galama Mountains Range; Conservation; exotic plantation; small mammals

1. Introduction

The small mammal habitat use, distribution and abundance are often influenced by macro and microhabitat characteristics. Among these, the nature and densities of vegetation play a significant role (Afework Bekele and Leirs, 1997) because it provides food, shelter, breeding site and protection against predators (Mohammed Kasso and Afework Bekele, 2013). Furthermore, it also creates favorable conditions for the prey

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of small mammals such as invertebrates, fungi and herbs (Mohammadi, 2010). The other microhabitat features like food availability, predation risk, temperature, status of moonlight is also important in determining the diversity and abundance of small mammals (Mohammadi, 2010). Small mammals are highly dependent on vegetation and habitat. Hence habitat loss, fragmentation, overexploitation of natural resources, pollution and the spread of invasive alien species have been recognized as the five foremost threats to them and other global biodiversity (Lopoukhine *et al.*, 2012).

Habitat loss and fragmentation affect the well-being and survival of individual populations, entire species and in the end, it may affect the functioning of the entire ecosystems (NRMMC, 2010). Meinig and Boye (2009) identified forest management, agriculture and habitat fragmentation to have strong negative impact on small mammals. Although, small mammals have a lower level of threat than large mammals like primates, almost half of the extinct species belong to this group (IUCN, 2015). Many of the small mammal species are considered as Data Deficient (Happold, 2013; IUCN, 2015). Climate change can reduce populations of mammals, in particular species living at higher altitudes (Meinig and Boye, 2009).

Humans are greatly modifying the landscape patterns that are frequently correlated with species assemblages that include the amount and structure of native vegetation, the prevalence of anthropogenic edges, the degree of landscape connectivity, and the structure and heterogeneity of modified areas (Mohammed Kasso and Afework Bekele, 2013). Species with limited mobility, large area requirements, and strong dependence on a certain type of habitat will be more affected and consequently their abundance and richness will be modified (Mohammed Kasso and Afework Bekele, 2013). However, the consequence of habitat modification to animals is complex, species respond differently to the loss and isolation of habitats. Many habitats of mammals are undergoing degradation due to high human encroachment for agriculture, pastureland, collection of firewood and medicinal plant, settlement and for other human activity like exotic plantation (Singleton *et al*., 2003). Most of Ethiopian habitats and landscapes including Chilalo-Galama Mountains Range is planted with exotic plant species by clearing the existing natural habitat despite the possession of high diversity of mammalian fauna. Despite reports of low abundance and richness in planation habitats (Mohammed Kasso *et al*., 2010) there is a literature gap on comparative aspect of exotic planation. Thus, the objective of the study is to assess the impacts of exotic plantation and land modification impact on small mammals of Chilalo-Galama Mountains range of Arsi Mountains National Park.

2. Description of the Study Area

2.1. Location and area

The investigation was carried out on Western part of Chilalo Mountain, in the central part of the Arsi Administrative Zone, Oromia Regional State (Figure 1). Mount Chilalo is one part of Chilalo-Galama Mountains Range which is the largest block covering 85.07% of the total area. It has a great diversity of landscape from which many Katar Rivers tributary streams and rivers like Walkessa, Kunicha, Anku, Dosha, Kombolcha, Gonde, Gusha, and Kulumsa originate (Mohammed Kasso *et al*., 2010; Yazachew Etefa and Kasahun Dibaba, 2011; Mohammed Kasso and Afework Bekele, 2011).

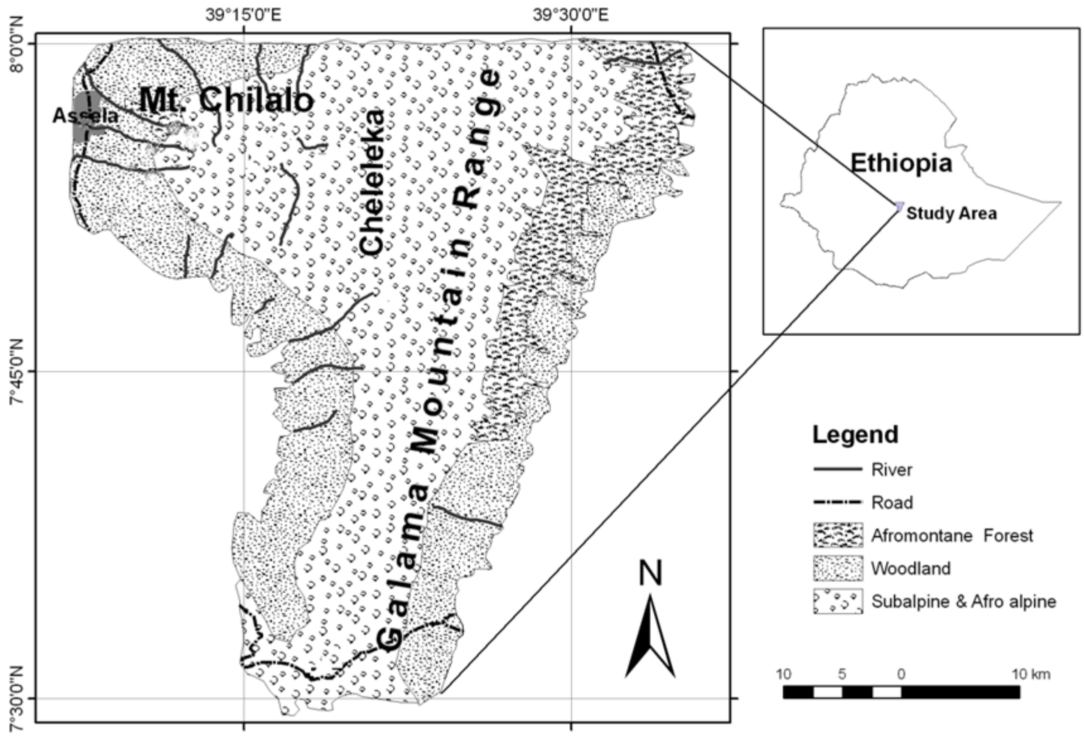

Figure 1. Map of the study area (Source: Mohammed Kasso *et al.*, 2010)

The area possesses different types of soils and vegetation zones at different altitudes (Mohammed Kasso *et al.*, 2010). It encompasses dry evergreen montane or Afromontane forest and Afroalpine and sub-Afroalpine vegetation types based on its attitudinal zonation. Relatively it has more or less intact sub-Afroalpine and Afroalpine although the historically existed dry evergreen montane forest and grassland complex already vanished from most part except in the western part of Mount Chilalo. There is also some stock of artificial plantation at different parts. The major artificial plantations are found in Western part of Chilalo (Checho and Gafrsa) that protected by Oromia Forest and Wildlife Enterprise. The dry evergreen montane forest and grassland complex ecosystem represent a complex system of successions involving extensive grasslands rich in legumes, shrubs and small to large-sized trees to closed forest with a canopy of several strata occurring between 1,900-3,300 m asl. The dry evergreen montane forest and grassland complex is inhabited by people for centuries. These made forests to be diminished and replaced to bushlands in most areas. The historical dominant plant species are *Hagenia abyssinica, Gnidia glauca*, *Schefflera abyssinica* and *Hypercum revolatum* at its very humid parts, whereas *Podocarpus falcatus* forest at lower altitude and *Juniperus procera* at higher relatively drier parts (Mohammed Kasso and Afework Bekele, 2011). The ericaceous forest zones (3,100-3,900 m asl) is characterized and dominated by *Erica arborea* and *Erica trimera* and also other dwarf *Erica* species named *Erica tenuipilosa*. In this zone, the low temperature inhibits tree growth, except low bushes, tuft grasses and lichens. The Afroalpine vegetation (3,300-4,200 m asl) largely comprises *Alchemilla helichrysum*, *Artimesia trimera*, and *Lobelia rhynchopetalum* and different grass species (Mohammed Kasso and Afework Bekele, 2011). In addition to the natural vegetation, there are also some patches of plantations of non-native tree species like *Cupressus lusitanica*, *Eucalyptus globulus*, *Eucalyptus amygdalina*, *Pinus patula*, *Pinus radiata* and *Pinus carribean* (Evangelista *et al.*, 2007;

Mohammed Kasso and Afework Bekele, 2011). It is endowed with varieties of Afromontane and sub-Afroalpine and Afroalpine animals with high proportion of endemic species. However, due to uncontrolled hunting and destruction of their natural habitat, there is rapid decrease of wild life in size, species and distribution (Yazachew Etefa and Kasahun Dibaba, 2011).

Chilalo-Galama Mountains range of AMNP has two rainy seasons, namely the small rainy season and the heavy rainy season that ranges 600 to 1000 mm. The small rain falls between March and June with its peak in April. The heavy rainy season is between July and October, with the highest peak in August. In the lower altitudes the amount of annual rainfall reaches while the higher altitudes get rainfall of 1000 up to 1400 mm annually (Miehe and Miehe, 1994).

The mean annual temperature and rainfall vary depending on the altitude ranging from 10-15^{o}C (Mohammed Kasso *et al.*, 2010). Areas above 3,300 m asl are the limit to human cultivation and predominantly occupied by heathlands (Mohammed Kasso *et al.*, 2010). There are few pastoralists residing above the crop cultivation zone in temporary nomadic huts and under different caves up to the summit of the peaks. Agriculture is the mainstay and land is an important economic base for the local communities that reside around Chilalo-Galama Mountains Range.

3. Materials and Methods

3.1. Methods

The study was carried out from September 2013 to December 2016. The study area was decided to include at least five habitat clusters. As Smith *et al.* (1975) stated the spatial arrangement of traps was determined by shape and amount of habitats available and intensity of effort and number of traps and other logistics. The trap configuration is based on transect and grids. Based on the topography, altitudinal zonation, nature of vegetation, size of the area and homogeneity or heterogeneity of habitat, 14 representative grids in four transects.

Trapping was carried out for three consecutive days. Three transects were selected around Asella town in Welkessa River, Child Care Centre and compound of the College of Agriculture and Environmental Sciences of Arsi University. Each transect was named by the respective PA or local area name as Gafarsa, Checho, Arsi University, Child Care Centre and Wolkessa. Based on nature of vegetation and topography feature of the area, a total of five habitats namely Agricultural land, *Erica* forest, *Erica* scrub, Montane forest and Plantation were selected (Plate 1).

Plate 1. Representative habitats selected from the study area

For the capture, handling and care of the small mammals, the guidelines of the American Society of Mammalogists (Gannon *et al.*, 2007) and the Research proposal approved by Ethiopian Wildlife Conservation Authority were followed.

Trapping for small mammals (rodents and shrews) was carried out by using collapsible Aluminum Sherman Live Trap of 7.5 x 9 x 22 cm. Arboreal, fossorial and semi fossorial small mammals may not be sufficiently sampled unless the traps are placed in their appropriate place (Smith *et al.*, 1975).

In each intensive and extensive trapping grid, five parallel transect lines with a length of 75 m that form square gird of 5,625 m^2 (75 m x 75 m) were established at different habitats and altitudinal ranges. Each live trapping grid has 25 trapping stations spaced at 15 m interval. Traps were covered by available material like hay, leaves, branches, ferns and lichen and grasses in order to avoid the trapped animals from harsh environmental condition and to minimize its observation to foreign intruders. Traps were mostly baited with peanut butter and during favorable climatic condition, it was also baited with peanut butter mixed with roasted barley flour. The bait was replenished each day or at any time if it was eaten by trapped animal or other animals (insects), got wet, grew mold, or dried up. Traps were checked twice a day early in the morning (6:30 to 8:30 a.m.) and in the late afternoon from (4:30 to 6:30 p.m.). From all the trapped and animals' relevant information were gathered.

3.2. Data analysis

The collected data were tabulated, organized and analysed with appropriate statistical method. IBM®SPSS® Statistics Version 24 computer program and PAST (Paleontological Statistics Software package for Education and Data Analysis) Version 3.14 Statistical computer programs (Hammer *et al.*, 2001) were used. All the observed (directly or indirectly) and trapped mammals were identified to species level by using the taxonomic characters listed in Kingdon (2013; 2016), Yalden and Largen (1992), Wilson and Reeder (2005) and Happold (2013).

For the analysis of relative abundance, distribution, habitat preferences the new capture of small mammals were used. Since there was variation in the number of grids in each habitat to ease the compare mean and relative abundance was computed.

4. Results

Over all a total of 13 species were recorded. Out of these ***Stenocephalemy** albipes* was the relatively the dominant (Table 1).
The abundance of small mammals in plantation habitat of grid CH-02 (56) was much lower than the abundance of small mammals in nearby Montane forest habitat of Grid CH-01 (139) and *Erica* forest habitats of Grid CH-03 (158) (Table 1).

Table 1. Species composition and abundance of small mammals in plantation and nearby natural habitats

Species	**MF* CH-01**	**PL# CH-02**	**EF* CH-03**	**PL# CH-10**	**ES* CH-11**	**AL# CH-Ag**	**MF* CH-AS1**	**PL# CH-AS3**	**Total**
Sa	77	21	31	8	4	28	76	19	264
Sg	5	15	63	1	36	13	0	27	160
Lb	21	6	49	2	32	0	0	0	110
Lc	35	2	0	2	0	0	3	11	53
Mn	1	8	0	2	0	30	5	6	52
Mm	0	2	0	0	2	26	0	3	33
Ct	0	0	15	0	6	0	0	0	21
Co	0	0	0	2	0	4	0	0	6
Rr	0	0	0	0	0	4	2	0	6
Aa	0	2	0	0	0	1	0	1	4
Sc	0	0	0	0	3	0	0	0	3
Oh	0	0	0	1	1	0	0	0	2
Mi	0	0	0	0	0	1	0	0	1
Total	**139**	**56**	**158**	**18**	**84**	**107**	**86**	**67**	**715**
No. of species	**5**	**7**	**4**	**7**	**7**	**8**	**4**	**6**	**13**

Aa=*Arvicanthis abyssinicus*, Co=*Crocidura olivieri*, Ct=*C. thalia*, Lb=*Lophromys brevicaudus, Lc= L. chrysopus*, Mn=*Mastomys natalensis*, Mi=*Mus imberbis*, Mm=*M. mahomet*, Oh=*Otomys helleri*, Rr=*Rattus*, Sa=*Stenocephalemys albipes*, Sg=*S. griseicauda*, Sc= *S. albocaudata*, Al=Agricultural land, BL=Bushland, EF=Erica forest, ES=Erica scrub, GL=Grassland, MF=Montane forest, ML=Moorland, PL= Plantation, *- gird more or less natural habitat nearby the modified habitat, # - grid with modified habitat

However, in species richness, the modified plantation habitat had more number of species than the two natural habitats (Table 1). The abundance in relatively older plantation habitat of Grid CH-10 was lower (18) than the nearby *Erica* scrub (84) habitat even though both were equal in species richness (7). The agricultural land habitat of Grid CH-Ag had relatively more abundance (107) than the other plantation habitat close to it. However, in species richness, it was the highest. The plantation habitat of grid CH-AS3 had lower abundance of rodents and shrews than the nearby relatively natural montane forest habitat of Grid CH-AS1 though it had more number of species (Table 1). The highest species richness was recorded for the modified habitat of agricultural land.

The similarity cluster for modified habitats and nearby semi-natural habitat based on abundance data were shown in Figure 2. According to the dendrogram, except the plantation habitat of CH-10, all the remaining modified habitats were more closely related. In particular, the two modified plantation habitats of Grid CH-AS3 and Grid CH-01 were much related. In the same way, the semi- natural montane forest habitats and both the *Erica* habitats showed high similarity (Figure 2).

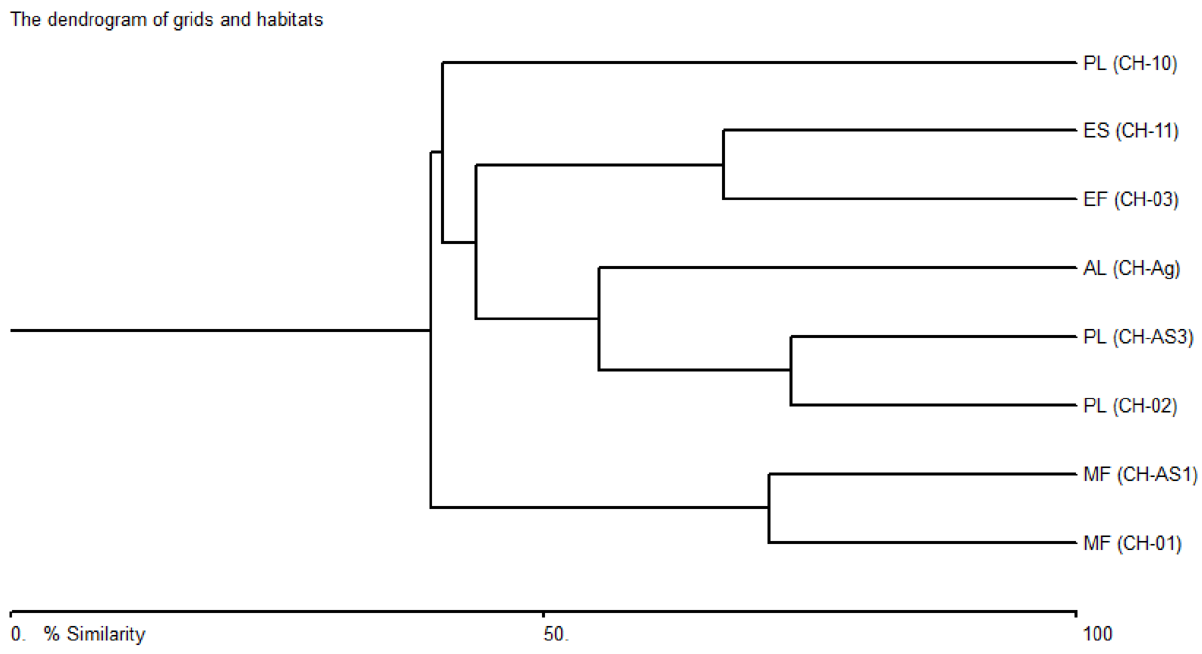

Figure 1. Dendrogram for selected modified habitats and nearby semi-natural habitat using Bray-Curtez similarity based on abundance data

5. Discussions

Land use practices play a great role in affecting structure and function of the ecosystem. For instance, forest practices and agriculture are a tool that can dramatically alter habitat structure and ecological succession. It can cause profound impact on wildlife and their habitats. Small mammals may play an integral role in natural habitat as prey, benefitting mammalian and avian predators. Thus, the different land use practices cause a cascading ecosystem-level effect on small mammals and other biodiversity. They are an ideal subject for examination of the response of animal communities to land use practices. They are also ubiquitous and sufficiently fecund to be a useful tool for scientific investigations across landscapes responding quickly to disturbances in a particular well developed habitat (Getachew Bantihun and Afework Bekele, 2015).

In the present study, substantial variation in abundance of small mammals was detected in different modified habitats and grids compared to its nearby natural habitats and grids. The abundance of small mammals in plantation habitat was much lower than the nearby natural montane forest and *Erica* forest habitat, although the modified plantation habitat had more number of species. Relatively, the abundance of small mammals in older plantation was lower than the nearby *Erica* scrub habitat. Coverage of ground, coarse woody debris, and downed trees are critical factors for the small mammal species. Changes in vegetation cover may expose small mammals during foraging and increase their predation risk. The resulting predator avoidance behavior may force small mammals to alter their feeding, activity ranges and thus distribution (Puan *et al*., 2011). However, such conditions are not common in plantation of the present study area. On the other hand, grids with *Eucalyptus* plantation and sparsely planted with open canopy and ground vegetation coverage seem to attract more small mammals. The diversity of species, capture probability, and population size vary with vegetation types. Small mammals are mobile to disperse to suitable sites and leave unsuitable sites (Getachew Bantihun and Afework Bekele, 2015). Habitat has a very strong influence on small mammal community structure (Happold, 2013). In plantations, regular control of ground cover may influence small mammals feeding behavior, activity ranges and distribution and foraging because they must avoid predators in open habitat (Puan *et al.*, 2011). The occurrence of such variations implies the difference in the levels of resources, levels of exploitation of these resources by small mammals and the numbers and diversity of predators in each habitat (Happold, 2013).

The abundance of small mammals in agricultural land habitat was relatively higher when compared with other grids of plantation habitat. Furthermore, the highest species richness was recorded for the modified habitat of agricultural land. Several studies have shown that changes in habitats associated with agricultural practices alter small mammal assemblages (Puan *et al.*, 2011). Land management is one of the most important factors threatening mammal species (Meinig and Boye, 2009). Natural forest diversity is significantly reduced by common management practices like the exclusion of clear cutting, natural fires and cattle grazing. Even in a developed country like Germany, agriculture is considered to cause strong negative impact on wildlife (Meinig and Boye, 2009). The high altitude residents of Chilalo-Galama Mountains Ranges traditional livelihood system were based on livestock herding and beekeeping. However, currently the increase in population made them to change their livelihoods dominantly on crop cultivation than livestock rearing. The population increase around Chilalo-Galama Mountains range creates more pressure on the natural resources and land use practices. Residents use the land for crop cultivation, grazing and settlement even though show insecure land use rights. In this process, many forest land and grazing land have been converted to agricultural land due to lack of effective land administration and land management systems. These agricultural land habitats attract many pest rodents and other small mammal that are able to survive in human modified habitats.

The similarity cluster for modified habitats and nearby semi-natural habitat based on abundance clearly shows that plantation habitat with heterogeneous type of vegetation harbor more species richness of small mammals. In the same way, the semi- natural montane forest habitats and both the *Erica* habitats showed high similarity. Many studies have suggested that reductions in vegetation cover or complexity affects small mammal assemblage (Torre *et al.*, 2007).

6. Conclusion and Recommendations

In the present study, the significant variation in abundance and species richness of small mammals' records in different modified habitats and grids compared to its nearby natural habitats and grids can clearly indicate level of impact on small mammals. Particularly, the lower abundance of small mammals in plantation habitat when compared with the nearby natural montane forest and Erica forest habitat its level of impacts is tremendous although the there is a record of more species richness modified plantation habitat. The relatively lower abundance of small mammals in older plantation than the nearby Erica scrub habitat can be used as a good indicator for the extent of impact on small mammals by artificial exotic plantation with limited understory cover. Chilalo-Galama Mountains Range has the largest block covering 85.07% of the total area of AMNP and has the second largest sub-Afroalpine and Afroalpine habitats in Ethiopia and also in Africa even though it is currently under threat. Hence the clearing of natural forest to replace it with exotic species should be interrupted.

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8. Conflict of Interest

There is no any conflict of interest.

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