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Habitat Preferences of the Bohor Reedbuck (*Redunca redunca*) and Common Warthog (*Phacochoerus africanus*) in Arsi Mountains National Park, South-eastern Ethiopia

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ABSTRACT

The habitat preferences of two ungulates mammals were studied in Galama mountains of Arsi Mountains National Park. A stratified random sampling design established around four dominant habitat types (dry evergreen Afro-montane forests, mixed plantation forests, Erica shrub lands and the Afro-alpine) was used to study the habitat preferences of the Bohor reedbuck and common warthog. Intensive-Modified Whitaker (I-MW) nested plot design was used to sample vegetation ground percent cover and scat of the Bohor reedbuck, warthog and livestock across the study area. The highest habitat preference indices for Bohor reedbuck (0.28) and common warthog (0.55) were recorded in the Afro-alpine habitat and mixed plantation forest respectively during dry season. There was significant difference in mean scat count of both Bohor reedbuck ($H = 9.27$, $df = 3$, $p = 0.026$) and warthog ($H = 11.32$, $df = 3$, $p = 0.010$) among habitat types. For warthog, livestock abundance was a good negative predictor of habitat use during the dry season, while both livestock abundance (negative predictor) and herb species percent cover (positive predictor) accounted for the wet season. Livestock abundance and slope were good negative predictors of Bohor reedbuck habitat use during the dry season, while livestock, slope average percent cover (positive predictor) accounted more in the wet season. Herb abundance used for forage and livestock encroachment determines the habitat preferences of the two mammals. Livestock encroachmentsabundance has been found to significantly limit the abundance of both warthog and Bohor reedbuck in Galama Mountains of Arsi Mountains National Park. As a result, to save the animals there is a need for urgent halting of livestock encroachments and other human disturbances.

Key Words: Conservation; Galama; Grazing; Livestock; Scat Count

INTRODUCTION

The African ungulate mammals population have been declining all over their ranges mainly due to habitat degradation, fragmentation and loss (Kotler et al. 1994, Hall et al. 1997, Atickem 2013, Tadesse and Kotler 2013, Kingdon 2015, Ripple et al. 2015). In order, to put in place sustainable conservation of the ungulates and their habitat there is a need for proper understanding of species-habitat interaction (Hall et al. 1997). The basic concept towards understanding wildlife species habitat interaction is the concept of habitat preference. Habitat preference of a wildlife species is the frequency of use of one habitat over the other by contributing to individual fitness (Johnson 2007). Habitat preference is a behaviour mediated process strongly governed by habitat essentials such as food, cover, water, space and presence and absence of threats(Kotler et al. 1994, Hall et al. 1997, Atickem 2013, Tadesse and Kotler 2013, Kingdon 2015). Particularly, the habitat preferences of ungulate mammals have been indicated to be strongly influenced by biophysical features such as slope, altitude, tree percent cover, shrub percent cover, herb percent cover and threats (livestock abundance)(Johnson 2007,Atickem et al. 2011,Tadesse and Kotler 2013,Girma et al. 2015). As a result, the knowledge of biophysical features of

preferred habitat is essential to maintain favourable conservation status of wildlife species.

Bohor reedbuck is a medium-sized, sandy coloured horned antelope (Estes 1991), while Warthog is a medium-sized pig like mammal with barrel-shaped bodies and prominent snouts ending in a disk-like nose and tusk (Estes 1991). There are five subspecies of Bohor reedbuck (*Redunca redunca*) namely; *R. redunca redunca, R. r. nigeriensis, R. r. cottoni, R. r. bohor and R. r. wardi,* mainly based on small differences in pelage coloration and horn shape (Kingdon2015). There are two species of warthog; common warthog *(Phacochoerus africanus)* and desert warthog (*Phacochoerus aethiopicus*) known to occur in Africa (Estes 1991, Kingdon 2015). There are four subspecies of common warthog namely; Nolan warthog *(P. a. africanus*), Eritrean warthog (*P. a. aeliani*), Central African warthog (*P. a. massaicus*) and Southern warthog (*P. a. sunde-valli*) (Kingdon 2015). There are two subspecies of desert warthog namely; *P. a.aethiopicus (*Cape warthog) and *P. a. delamerei* (Lorddelamere's warthog) (Kingdon 2015).

Bohor reedbuck is distributed mostly over equatorial region of Africa (Kingdon 2015); particularly, *R. redunca redunca* (Senegal east to Togo), *R. r. nigeriensis* (Nigeria, North Cameroon, South Chad and Central African Republic), *R. r. cottoni* (South Sudan, Northeast Democratic Republic of Congo and Northern Uganda), *R. r. bohor* (West, Central and South east Ethiopia and Blue Nile of Sudan) and *R. r. wardi* (Uganda, East Democratic Republic of Congo and East Africa) (Kingdon 2015). Hence, the sub species *R. r. bohor* inhabits the present study. The common warthog has wider distribution over most sub-Sharan African countries, while the desert warthog has much less restricted distribution known to occur only in arid regions of eastern Africa (Kingdon2015). Among the six subspecies of warthog, the Eritrean warthog *P. africanus aeliani* inhabits the present study area (Kingdon 2015).

Bohor reedbuck prefers savanna grasslands for grazing and bush thickets for breeding and resting, while common warthog prefers savanna grasslands, open bushlands and woodlands (Estes 1991, Yalden and Largen 1992, Kingdon 2015, IUCN 2016). Bohor reedbuck diet is predominantly grass; often prefers to graze on fresh grasses around water sources (Yalden and Largen 1992, Kingdon2015), Similarly warthog is a grazer that eats grasses, fruits, roots and barks (IUCN 2016).

The conservation status of both Bohor and warthog species is least concern, with fairly abundant population distributed over equatorial African countries (White et al. 2010). Empirical studies in Ethiopia have indicated that both Bohor reed buck and common warthog are widely distributed over Ethiopian highlands and in the lowland savanna and river plains (Yalden et al. 1984, Hillman 1986, Afework et al. 2010, Habtamu et al. 2012).

Arsi Mountains National Park is a newly (2011) established national park located in south eastern part of Ethiopia. The area encompasses different vegetation zonations across altitudinal gradients; the lower altitude areas are dominated by remnant dry evergreen Afro-montane Forest grassland complex, while middle attitudes are covered by Erica (sub-alpine) vegetation and Afro-alpine vegetation characterizes the higher altitudes (Tekle 1984, Evangelista et al. 2007, Girma et al. 2015). The park supports isolated meta populations of endemic and endangered Ethiopian mammals such as mountain nyala, Ethiopian wolf and Menelik's bushbuck (Sillero-Zuberi 1994, Evangelista et al. 2007, Atickem 2013, Girma et al. 2015).

However, fuel wood collection, livestock encroachments, fire and clearing forest for expansion of agriculture and settlement are common illegal practices in the newly (2011) established national park(Girma et al. 2015). Particularly, studies carried out elsewhere in Africa have indicated that the habitats of both Bohor reedbuck and warthog are being fragmented and lost because of agricultural expansion, livestock overgrazing and deforestation (Butchart et al. 2010, Kingdon 2015, Ripple 2015). It has been revealed that livestock intensively compete with wild animals for food, water and space (Tadesse and Kotler 2013, Ripple 2015). In Ethiopia protected areas livestock population density have been noticed to exceed the carrying capacity and to fragile the wild animal habitats (Mamo and Bekele 2011, Atickem 2013, Tadesse and Kotler 2013). Particularly, in Bale Mountains National Park livestock selective grazing and browsing reduced palatable species and resulted in proliferation of unpalatable invasive species (Mamo and Bekele 2011). Furthermore, livestock grazing/browsing, uprooting, trampling, and high fruit/seed predation strongly affect seedling survival and the ability of understorey species to regenerate (Teketay 1992, Ripple 2015). On the other hand, deforestation such as tree steam removal for timber, fuel wood, fence etc, which are very common in the present study area (Evangelista et al. 2007, Girma 2016), reduces the foraging and cover opportunities of the wild animals ultimately affecting their survival.

In Ethiopia, it has been a common practice to focus wildlife studies only on endemic and endangered species (Sillero-Zuberi 1994, Evangelista et al. 2007, Atickem 2013, Girma et al. 2015), the ecology of relatively common species in Africa like the present study species have been less studied and given less attention. Particularly, in the present study area the habitat use, preferences and factors that determine warthog and Bohor reedbuck habitat preferences are not known. However, the knowledge of habitat preferences and how biophysical factors (slope, altitude, herb cover, shrub, tree cover) and anthropogenic activities (e.g. livestock grazing) affect the ungulates habitat preferences are important for sustainable conservation of the species and their habitat. The findings of the present study will be an important input for the preparation of management plan and to make appropriate conservation decisions (Tadesse and Kotler 2013, Girma et al. 2015). Furthermore, the results of this study can be extrapolated to other similar disturbed landscapes as an important input for other similar protected areas management. To this end, the present study is aimed at investigating the habitat preferences of Bohor reedbuck and common warthog; and how biophysical factors (slope, altitude, herb percent cover, shrub percent, and tree percent cover) and disturbance (livestock grazing) affects the habitat preferences of the ungulates as a proxy for sustainable wildlife conservation planning and management.

STUDY AREA

Arsi Mountains National Park is located in Oromiya Regional State of Ethiopia, in south eastern part of Ethiopia (OFWI 2015). The park was established in 2011 by demarcating four mountain fragments; namely Dera sanctuary (13 km^2), Chilalo-Galama block (792 km^2), Kaka block (104 km^2) andHunkolo block (22 km^2) to conserve the endangered mountain nyala (*Tragelaphus buxtoni*) and Ethiopian wolf (*Canis simensis*) together with the unique Afro-alpine habitat (OFWI 2015) (Figure 1). Based on the existence of diverse habitat types and strong hold population of warthog and Bohor reedbuck Galama Mountains (472.5 km^2)(Girma 2016)of the Chilalo-Galama block was selected purposively for this study. The Galama Mountains are geographically situated between 7º48´to 7º88´N latitude and 39º27´ to 39º51´E longitude (Figure 1). The Galama Mountains are located in the inter-boundary region of four Woredas (Districts) namely; Digeluna-Tijo, Lemu- Bilbilo, Shirka and Tena Woredas that are found in Arsi Zone (Figure 1). The Galama Mountains are characterized by rugged highland mountains ranging from 2300 m asl to over 4000 m asl(Girma 2016). The study area receives annual rainfall that ranges from 778.7 mm to 1089.65 mm, most of the rain rains from June to October (wet season) and little precipitation period exist during the months of March and April (ENMA 2015). The dry season occurs from November to February and in May. The mean annual maximum temperature is 22.4°C, while the minimum temperature is 11.1°C (ENMA 2015).

The lower elevations (2,300 and 3,250 m asl) of Galama mountains are represented by remnant Afro-montane zone vegetation in the north-eastern part (Tena Woreda) (Figure 1), while it was converted in to agricultural lands in most part of the study areas (OFWI 2015). The Afro-montane zone is dominated by tree species of *Hagenia abyssinica* and *Juniperus procera* with *Erica arborea* and *Hypericum revolutum* occupying the higher elevations (Tekle 1984, Girma et al. 2015).The Afro-montane zone has been reported to harbour significant population of Menelik's bushbuck, while was avoided by mountain nyala unlike most Afro-montane vegetation (Girma et al. 2015). The total area coverage of the Afro-montane habitat is 94.2 km^2 (20.6% of the study area) (Girma 2016). The Afro-montane zone understory vegetation is sparse due to overgrazing and with open canopy due to tree logging for timber, fuel wood and other activities(Girma et al. 2015). The middle elevation areas (3250-3700 m asl) are predominately covered by two *Erica* species; *Erica arborea* and *Erica trimera*, the former being the most dominant(Girma 2016). The *Erica* habitat is known to be among the preferred habitats of the endangered and endemic mountain nyala (Girma et al. 2015). The total area coverage of the Erica habitat is 260.3 km^2 i.e., 56.7% of the study area (Girma 2016). The *Erica* habitat has relatively better ground cover due to relatively dense Erica shrub. However, fire is recurrent in this habitat type, wherever it occurs it greatly reduces the ground cover (Girma 2016). There was also high density of livestock population grazing in the Erica habitat especially during wet season (Girma 2016). The Afro-alpine zone grassland is dominated by diverse species of grasses and herbs such as *Alchemilla* and *Helichrysum* sp. The grassland is the typical specialized habitat of the critically endangered and endemic Ethiopian wolf (*Canis simensis*) (Sillero-Zuberi 1994). The total area coverage of the Afro-alpine habitat is 116 km^2 i.e., 23.1% of the study area (Girma 2016). In spite of the high livestock

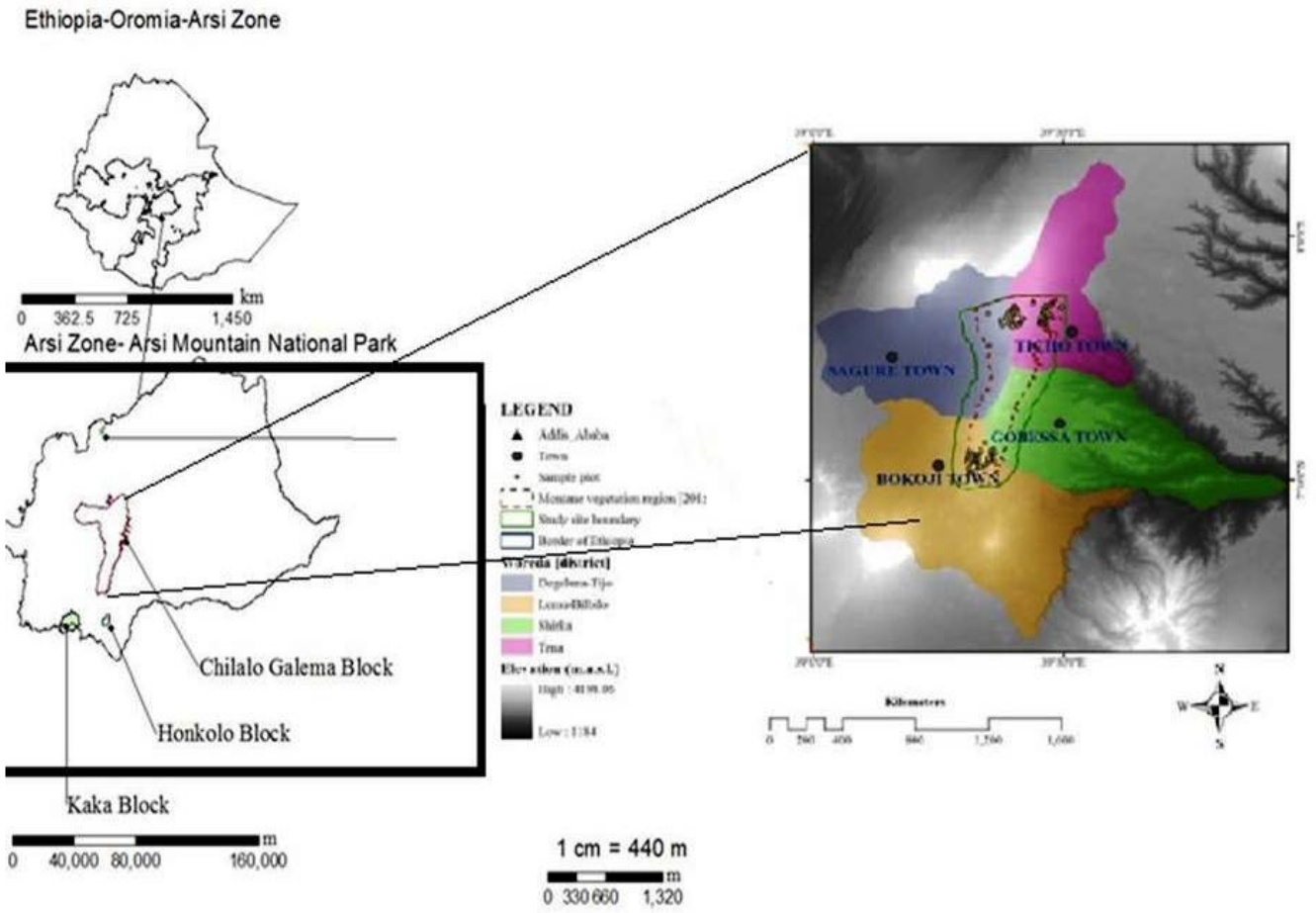

Figure 1. Location map of Arsi Mountains National Park (Galama Mountains)

population grazing in the Afro-alpine habitat, the ground vegetation (grass) cover is the densest among all the habitat types. Grasses are most abundant in this habitat type, but there are no trees and very limited shrubs, hence good foraging ground but poor cover for the animals. The Afro-alpine habitat serves as water tower and many perennial rivers and streams originate and flow down across other habitat types. There are a lot of wetlands and springs holding water throughout the year (Girma 2016). Plantation of *Cupressus lusitanica*, *Eucalyptus camaldulensis Eucalyptus globulus, Pinus patula*, *Pinus radiata* and *Pinus carribeani* have been established in the lower elevations of the area (Degeluna-Tijo and Lemu-Bilbiloworedas) frequently intermixed with the remnant stands of the indigenous trees as an afforestation program (Evangelista et al. 2007, Girma et al. 2015). The total area coverage of the mixed plantation habitat is 2.18 km^2 (0.005%) of the study area(Girma2016). The plantation forest is relatively with dense canopy cover, understory vegetation and little disturbance like livestock grazing due to especial protection by the park authorities to protect planted seedling trampling and uprooting (Girma 2016). The study area is surrounded by agriculture dominated landscape accompanied by human settlements, fire and livestock encroachments all degrading the forest landscape (Evangelista et al. 2007, Girma et al. 2015).

METHODS

Sampling Design

A stratified systematic sampling design established around four dominant habitat types (dry evergreen Afromontane forest, mixed plantation forest, Erica shrub land and the Afro-alpine) was used to study the habitat preferences of the Bohor reedbuck and common

warthog. The first plot in each habitat type was randomly generated in a geographic information system (GIS) using Arc GIS software v10.1(Figure 1).Following each plots randomly generated in each habitat types, plots were systematically generated with a spacing distance between 200 to 400 m based on accessibility and topographic differences. To minimize edge effect plots were established 200 m far away from the edge of the forest and main road. Plots were purposively established on the southern and northern ends of the study area to capture all the four dominant habitat types (dry evergreen Afro-montane forest, mixed plantation forest, Erica scrub and Afro-alpine) and areas where the Bohor reedbuck and warthog co-occurred with the livestock (Figure 1). Sampling the area between the northern and southern end of the Galama Mountains was purposively avoided because only the Erica and Afro-alpine habitats occurred in that particular area (Figure 1). The Afro-montane forest had been lost due to deforestation and no plantation programs have been initiated in areas between the norther and southern ends. From land use land cover change analysis (Girma 2016)the total area of each habitat type was estimated and was used to determine the proportion of sample plots used to represent each habitat types. Based on this a total of 104 sample plots; 24 in the dry evergreen Afro-montane forest, 9 in the mixed plantation forest, 53 in the Erica, and 18 in the Afro-alpine were established. Following (Barnett and Stohlgren 2003), Intensive-Modified Whitaker (I-MW) nested plot design was used to sample vegetation percent cover and scat of the Bohor reedbuck, warthog and livestock across the study area. The I-MW plot is framed within an outer 100-m^2 plot (20 x 5m) with four 1-m^2 sub plots (0.5 x 2 m^2) positioned at fixed locations inside its perimeter and one 10-m^2 (2 x 5 m^2) subplot in the centre (Figure 2). Each I-MW plot was situated lengthwise following the slope of the ground in an attempt represent subtle ecotones and capture the greatest number of plant species.

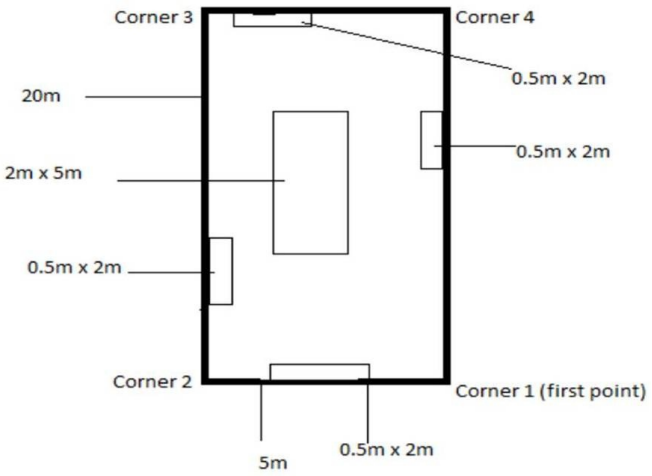

Figure 2. Layout of the Modified Whitaker Nested intensive plot following Barnett and Stohlgren (2003)

Data Collection

Data collection was carried out from July 2016 to February, 2017 covering both dry and wet season. To locate sampling plots at field eTrex Legend Global Positioning System (GPS) was used. Vegetation (herb, shrub and tree) ground percent cover and average vegetation height were recorded for each of the four 1-m^2 subplots in both dry and wet seasons. In the 10-m^2 sub-plot and 100-m^2 outer plot, fresh (intact, green colour) scat count of Bohor reedbuck, warthog and livestock (cattle and sheep) was carried out during both dry and wet seasons. After each scat counting session, scats were cleared out of the plots and were ready for next session. Behaviourally, both Bohor reedbuck and common warthog deposit pellets aggregated together. As a result, only pellet groups more than 10 pellets aggregated together were considered as one scat and counted to avoid scat count overlap. The scat pellet of Bohor reedbuck, common warthog and livestock were distinguished by their shape and size (Figure 3). The scat pellets of Bohor reedbuck is conical shaped and pointed at one end, while the scat of common warthog is much larger in size and bean shaped, closely resembles the dung of domestic donkey, but smaller (Figure 3a, b). The dung of cattle is much larger in size than the wild mammals and unlike other most animals it is aggregated in few numbers piles (Figure 3c). The scat of sheep closely resembles that of Bohor reedbuck, but the former is round and less pointed (Figure 3a,d). Furthermore, behaviourally sheep drops the scat pellets while moving, hence pellets often found scattered, while the Bohor reedbuck drops the pellets at one point like many other ungulate wild mammals. In addition, ancillary data, such as elevation above sea level, latitude and longitude, percent slope inclination (flat - 0-2%; moderate - 2- 5%; high - 5-10% and steep >10%) were recorded with a GPS and clinometer.

Data Analysis

The scat count (Bohor reedbuck, warthog, and livestock), vegetation (percent cover per growth form and average

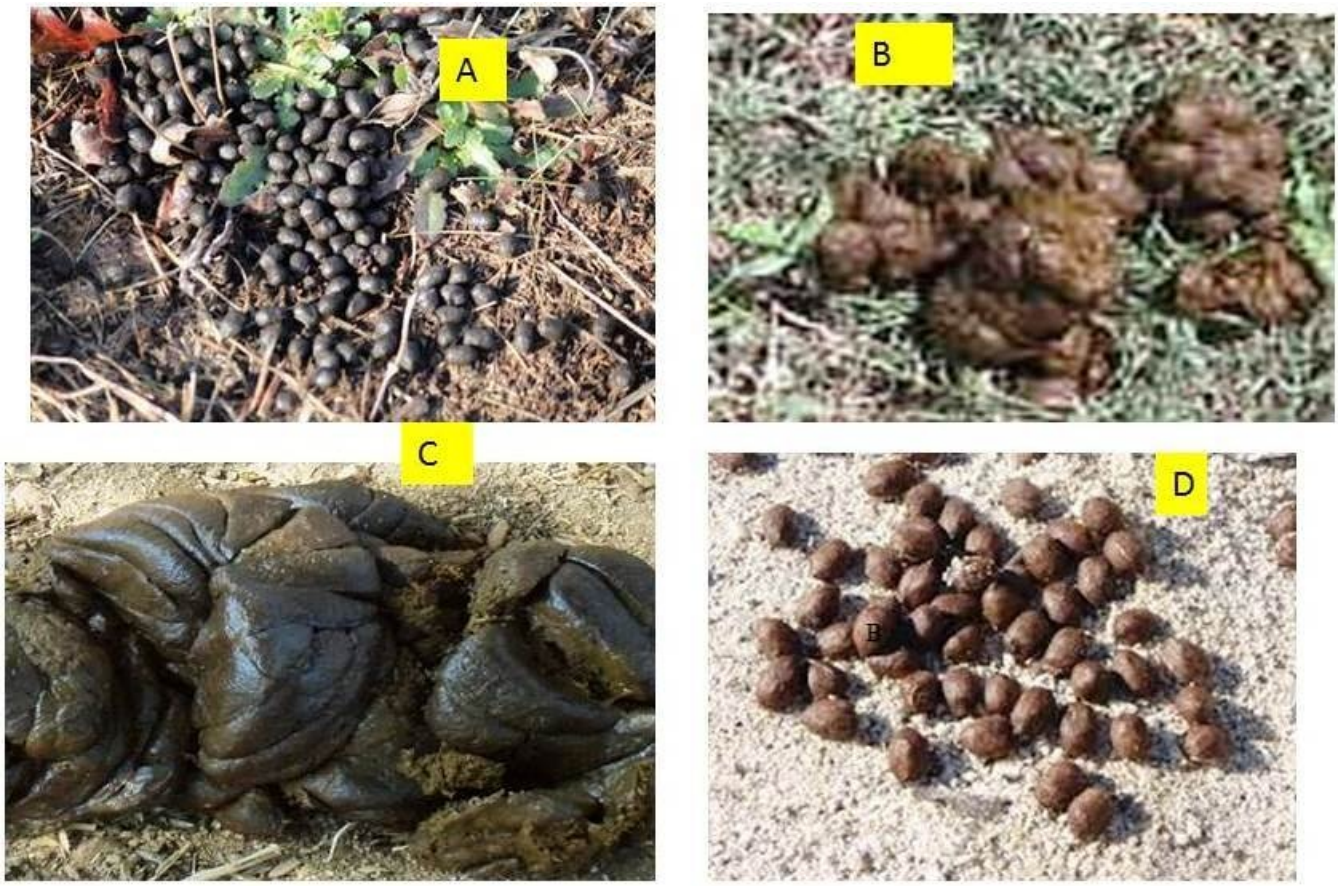

Figure 3. Scats of wild mammals and livestock: A, Bohor reedbuck B, Warthog C, cattle D, sheep (Photos by Zerihun Girma 2015).

vegetation height) and auxiliary (elevation, latitude and longitude, percent slope inclination) data were analysed per plot using MS Excel software 2010. Habitat Preference Index (HPI) was calculated for each species (per plot, habitat and season) as the ratio between number of plots with piles of scat of Bohor reedbuck or common warthog to the total number of plots in the given habitat type.

$$HPI = n/N \quad (1)$$

where; n is number of plots in which piles of scats were observed in a particular habitat and N is the total number of plots in the particular habitat type. The index varied from 0 (total avoidance) to 1.0 (high use).

The mean scat count (Bohor reedbuck and warthog) per plot and per season among habitat types was analysed using bar graphs. The non-parametric Kruskal-Wallis test was used to test the mean scat count (Bohor reedbuck and warthog) variations among habitat types. On the other hand one sampled t-test was used to test the mean scat count (Bohor reedbuck and warthog) variation among season.

Step wise regression analysis (backward elimination technique) was carried out on the number of scat piles as the outcome variable to evaluate parameters of the habitats (elevation, slope, tree percent cover, shrub percent cover, herb percent cover, and average vegetation height and livestock dung piles) that account for their disproportionate use. This was carried out for each species (Bohor reedbuck and Common warthog) in both dry and wet seasons and model selection was based on F and *P* values. Durbin-Watson statistic and VIF were used to examine autocorrelation and multicollinearity of the predictors. Backward elimination continued until the "*minimum F-to remove"* dropped below the specified probability level (0.1). MINITAB release 17was used for the computations of all the statistical analysis.

RESULTS

The highest mean scat count per plot (1.00±1.05) and habitat preference index (0.28) for Bohor reedbuck were recorded during the dry season in the Afro-alpine habitat

(Table 1; Figure 4). For warthog, the highest mean scat count per plot (1.33±0.95) and highest habitat preference index (0.55) were recorded during the dry season in the mixed plantation habitat (Table 1; Figure 4). There was significant difference in mean scat count of both Bohor reedbuck ($H = 9.27$, $df = 3$, $p = 0.026$) and warthog ($H = 11.32$, $df = 3$, $p = 0.010$) among habitat types. There was also significant difference in mean scat count of warthog between dry and wet season in the mixed plantation ($t = -2.39$, $df = 8$, $p = 0.044$) and dry evergreen Afro-montane forests ($t = -2.05$, $p = 0.042$, $df = 144$).

Three models were eventually fitted that quantitatively and qualitatively explain which of the habitat components determine the habitat use of warthog and Bohor reedbuck (Table 2). Both warthog and Bohor reedbuck habitat quality varied during the wet and dry season. For warthog, livestock abundance was a good negative predictor of habitat use during the dry season, while both livestock abundance (negative predictor) and herb species percent cover (positive predictor) accounted for the wet season (Table 2). Livestock abundance and slope were negative good predictors of Bohor reedbuck

Table 1.Habitat preference indices for Bohor reedbuck and common warthog among four dominant habitat types of Galama Mountains, Arsi Mountains National Park.

Species	Habitat types							
	Mixed plantation		Dry evergreen Afro-montane forest		Erica		Afro-alpine	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Bohor reedbuck								
Total number of plots	9	9	24	24	53	53	18	18
Number of plots with scats	1	2	0	0	8	3	5	3
Habitat Preference index	0.11	0.22	0	0	0.15	0.05	0.28	0.16
Warthog								
Number of plots with scats	5	1	4	0	8	3	1	3
Habitat Preference index	0.55	0.11	0.17	0	0.51	0.09	0.33	0.39

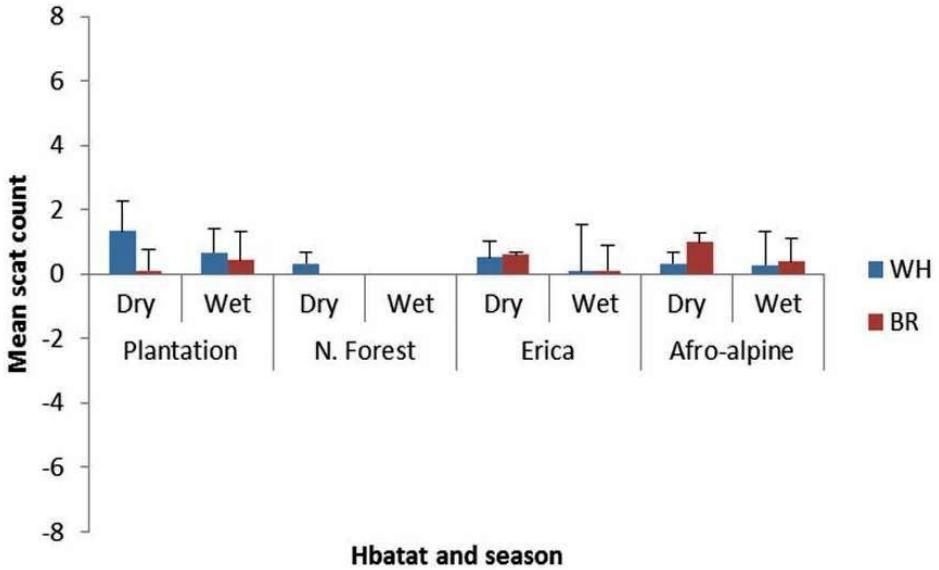

Figure 4. Mean scat count of Bohor reedbuck and warthog per plot per season among four most dominant habitat types. Note WH- warthog, BR- Bohor reedbuck.

Table 2. Summary of statistics for selected models that describe habitat use by Bohor reedbuck and Warthog in the Galama Block, Arsi Mountain National Park in the dry and wet seasons. The Durbin-Watson statistic (D-W) and Variance Inflation Factor (VIF) were used to examine autocorrelation and multicollinearity of the predictor variables.

Model		Predictor				Overall model			
	Habitat Variable	Coefficient	p	VIF	F	p	S	R(%)	D-W
WH, Dry season	Constant	0.931				0.000	1.56	7.16	1.93
	Livestock dry season	-0.073	0.006	1.00	7.87				
WH, Wet season	Constant	-0.171				0.049	0.70	9.72	1.96
	Livestock wet season	-0.009	0.054	1.03	2.76				
	Av. herb % cover wet	0.077	0.023	1.14	5.63				
BR, Dry season	Constant	1.743				0.002	2.01	6.43	1.68
	Slope	-0.425	0.045	1.01	3.23				
	Livestock dry	-0.071	0.039	1.01	4.37				
BR, Wet season	Constant	0.082				0.056	0.58	10.55	2.01
	Livestock wet season	-0.011	0.010	1.00	6.90				
	Av. herb % cover wet	0.055	0.028	1.00	4.96				

Key: WH- warthog, BR- Bohor reedbuck; Av. Herb= average herb.

habitat use during the dry season, while livestock, slope and average percent cover (positive predictor) accounted more in the wet season (Table 2).

DISCUSSION

The habitat preference of Afro-alpine habitat over other habitats by the Bohor reedbuck isprobably attributed to the quality of the forge and open nature of the habitat. It has been revealed that Bohor reedbuck prefers grass dominant areas, where it can easily access nutritious grasses with high protein and less fibre (Newell 1999). The Afro-alpine habitat mainly consisted of grass and herb species such as *Alchemilla*, *Helichrysum* and *Andropogon* sp. that are nutritious (high crude protein and less fibre) (Girma et al. 2015,Girma 2016). In Ethiopia, at Bale mountains national park and Jimma airport Bohor reedbuck have been observed to prefer grasslands than forested habitat, presumably due to their preference of grasses with high protein content and less fibre (Afework et al. 2010, Habtamu et al. 2012). It could also be attributed to abundant water resources of the Afro-alpine habitat. The Afro-alpine habitat is a water tower being the source of Afro-alpine lakes and numerous springs and rivers (Girma 2016). It has been revealed that Bohor reedbuck prefers river plains and wetlands with abundant water source and quality forage (Yalden et al. 1984, Hillman 1986, Afework et al. 2010, Habtamu et al. 2012). Furthermore, the open nature of the Afro-alpine habitat could grant vigilance effect from potential carnivore predators as compared to other habitat types (Afework et al. 2010, Habtamu et al. 2012, Tadesse and Kotler 2013). It has also been reported that Bohor reedbuck strongly avoids forested habitat types due to its poor ability to jump and scape danger (Estes 1991, Kingdon 2015).

Warthog are generally habitat tolerant can exist in various habitat types including grassland, open bushland and woodland (De Jong et al. 2016). The highest preference to mixed plantation forest could be attributed to that fact that the mixed plantation habitat types offer better cover for hiding from predators, for breeding, resting and thermal cover (Mohammed 2005, Tadesse and Kotler 2013). The anthropogenic disturbances survey such as livestock abundance and tree stump count also indicates that disturbances are much less in the mixed plantation forest, due to the fact that it is better protected than other habitat types due to the presence of newly planted seedlings that are protected from livestock trampling, than other habitat types. This buttresses the argument that the area could be used for breeding, resting and hiding from predators. Furthermore, since the mixed plantation forest is near to farm lands, could be a potential refugee for the warthog to come out during night time to ride crops grown (Girma et al. 2015, Girma 2016). During, the study period the local farmers bitterly complained that warthog is the top crop rider and causes

the highest crop loss. Cultivated crops could provide free meal and presumably with better nutritional quality and are readily available at close proximity. Hence, could shift to dominant crop raiding behaviour so as to maximize its foraging opportunity. Most scholars agree that warthogs are notorious crop raiders; capable of causing heavy crop damage in all their ranges they occur (Gobosha et al. 2016, Tufa 2016).

The relatively higher abundance of both Bohor reedbuck and warthog during the dry season than the wet season is probably due to the fact that disturbances like livestock abundance and human activities are more common during wet season than dry season. This could limit the abundance of Bohor reedbuck and warthog (Afework et al. 2010, Habtamu et al. 2012). During wet season lower elevations are covered with crops and availability of grazing land decreases. As a result, livestock shift to higher attitudes especially to the dry evergreen Afro-montane forest and Erica for grazing opportunities. The increased number of livestock grazing reduces the forage opportunity of the wild herbivores by directly competing and consuming the nutritious forage. This could lead the wild herbivores to consume the less nutritive one. Furthermore, livestock grazing could also reduce the cover opportunity for the wild herbivores though over browsing and removing the herbaceous underground cover. Livestock grazing has been described as a powerful driver of plant population dynamics and community succession (Stephens et al. 2001, Mamo and Bekele 2011, Tadesse and Kotler 2013, Girma 2016), and influences the abundance and distribution of the animal communities inhabiting in a particular habitats (Girma et al. 2012, Mamo et al. 2012, Tadesse and Kotler 2013). Furthermore, the abundant crops during the wet season on the farmlands could offer better forging opportunity for both warthog and Bohor reedbuck initiating shift in habitat type leaving their natural habitat aside (Afework et al. 2010, Habtamu et al. 2012, Gobosha et al. 2016, Tufa 2016).

The significant positive correlations of herb percent cover with abundance of both Bohor reedbuck and common warthog during the wet season could be mainly attributed to the foraging behaviour of the species. Both common warthog and Bohor reedbuck are known to prefer herbs predominately grasses (Yalden and Largen 1992, Kingdon 2015). Hence, their habitat use could be influenced by the presence of herbs, so as to forage optimally.

On the other hand, the negative correlation of livestock abundance with abundance of both common warthog and Bohor reedbuck is mainly attributed to the fact that livestock encroachments reduces the foraging and cover opportunities of the species through direct competition and ecological degradation. It has been revealed that livestock intensively compete with wild animals for food, water and space (Tadesse and Kotler 2013, Ripple 2015). In Ethiopia protected areas livestock population density have been noticed to exceed the carrying capacity and to fragile the wild animal habitats (Mamo and Bekele 2011, Atickem 2013, Tadesse and Kotler 2013). For instance, in Bale Mountains National park livestock selective grazing and browsing reduced palatable species and resulted in proliferation of unpalatable invasive species (Mamo and Bekele 2011). Furthermore, livestock grazing/browsing, uprooting, trampling, and high fruit/seed predations strongly affect seedling survival and the ability of understorey species to regenerate (Teketay 1992, Ripple 2015). On the other hand, deforestation such as tree steam removal for timber, fuel wood, fence etc, which are very common in the present study area (Girma et al. 2015,Girma 2016), reduces the foraging and cover opportunities of the wild animals ultimately affecting their survival.

CONCLUSION AND RECOMMENDATIONS

Generally, herb percent cover and disturbance like livestock encroachments have been found to determine the habitat preferences of Bohor reedbuck and common warthog in Galama Mountains of Arsi Mountains National Park. Bohor reedbuck preferred Afro-alpine habitat, where there are abundant grasses and water sources. On the other hand, warthog preferred mixed plantation, where there are better cover and less disturbances. As disturbance escalates could alter the normal behaviour of the animal as it is witnessed by the shift towards cultivated habitat. This in turn aggravates the crop raiding behaviour that causes economic loss ultimately inducing human-wildlife conflict. The human-wildlife conflict could escalate and threatens the survival of the wild ungulates. As a result, to save the animals there is a need for urgent halting of livestock encroachments, deforestation, expansion of agriculture and other human disturbances.

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