Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 7, Issue, 11, pp.23074-23082, November, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

HABITAT CHARACTERIZATION AND PREFERENCES OF THE MOUNTAIN NYALA (*TRAGELAPHUS BUXTONI*, LYDEKKER 1910) AND MENELIK'S BUSHBUCK (*TRAGELAPHUS SCRIPTUS MENELIKI*, NEUMANN 1902) IN ARSI MOUNTAINS NATIONAL PARK, SOUTH-EASTERN ETHIOPIA

[1, 2,*]Zerihun Girma, [1]George Chuyong, [3]Paul Evangelista and [2]Yosef Mamo

[1]Department of Botany and Plant physiology, University of Buea, Cameroon
[2]School of Wildlife and Eco-tourism, Hawassa University, Ethiopia
[3]Natural Resource Ecology Laboratory, Colorado State University, USA

ARTICLE INFO

Article History:
Received 04th August, 2015
Received in revised form
05th September, 2015
Accepted 07th October, 2015
Published online 30th November, 2015

Key words:

Diversity,
Habitat use,
Intensive-Modified Whitaker plot,
Preferences,
Mountain nyala,
Menelik's bushbuck.

ABSTRACT

Tragelaphus buxtoni and *Tragelaphus scriptus meneliki* are spiral-horned antelopes endemic to highlands and south eastern highlands of Ethiopia respectively. The ranges of both species often overlap and are threatened by the loss and degradation of their montane habitats. The objective of the study was to identify their preference and associated vegetation characteristics of montane habitats in Arsi Mountains National Park. Intensive-Modified Whitaker nested plot design was used to sample vegetation and scat across habitats. The Intensive-Modified Whitaker plot had four 1-m^2 non-overlapping sub plots and one 10-m^2 non-overlapping subplot, all nested within a 100-m^2 exterior plot. In each of the 1-m^2 sub plots, we recorded the presence and estimated percent cover for all plants encountered. In the 10-m^2 and 100-m^2 plots, unique plant species and scat piles of the wildlife species were recorded. The highest plant α-diversity was recorded in the natural forest (130 species). The highest Shannon-Wiener Diversity (4.509) was recorded from the mixed plantation. The highest habitat preference index for the mountain nyala (0.44) and Menelik's bushbuck (0.58) were recorded in the mixed plantation and natural forest during dry season respectively. Urgent conservation of natural forest and mixed plantations are required for the survival of both wildlife species.

Citation: Zerihun Girma, George Chuyong, Paul Evangelista and Yosef Mamo, 2015. "Habitat characterization and preferences of the mountain nyala (*Tragelaphus buxtoni*, Lydekker 1910) and menelik's bushbuck (*Tragelaphus scriptus meneliki*, Neumann 1902) in Arsi mountains national park, south-eastern Ethiopia", *International Journal of Current Research*, 7, (11), 23074-23082.

INTRODUCTION

The concept of animal-habitat interaction is cornerstone in effective conservation and management of wildlife populations. Hall *et al*. (1997) defined habitats as the resources and conditions present in an area that provides occupancy – including survival and reproduction of a given organism. The concept of habitat goes beyond vegetation or vegetation structure as it encompasses all the specific resources (biotic and abiotic) that are needed by organisms (Thomas, 1979). These resources include food, cover, water, and special factors needed by a species for survival and reproductive success. Habitat preference is the consequence of habitat selection, resulting in the disproportional use of some resources over others there by contributing to the individual's fitness (Johnson, 1980, 2007). Habitat use by an individual, group or population is strongly influenced by habitat essentials, such as food, cover, and escape access (Stephens and Krebs, 1986; Kotler *et al*., 1994; Tadesse and Kotler, 2013).

****Corresponding author: Zerihun Girma,***
Department of Botany and Plant physiology, University of Buea, Cameroon.

In most habitats, plant communities determine the physical structure of the environment, and therefore, have a considerable influence on the distributions and interactions of animal species (Balakrishnan *et al*., 1986). Our understanding of these interactions will help determine those environmental features that guarantee or predicts fitness and survival of wildlife species in given spatial and temporal scales.

Mountain nyala (*Tragelaphus buxtoni*) is a spiral-horned antelope endangered and endemic to south eastern highlands of Ethiopia. *Tragelaphus buxtoni* are commonly reported to range between 2,700 m and 4,300 m and prefer variety of montane forest types, heath land and alpine habitats (Brown, 1969; Yalden and Largen, 1992; Evangelista *et al*., 2008). Forested habitats are utilized for their good cover, food source and as breeding sites (Evangelista *et al*., 2007). Menelik's bushbuck (*Tragelaphus scriptus meneliki*) is a sub-species of the common bushbuck, and also a spiral-horned antelope endemic to Ethiopia's highlands. Menelik's bushbuck has been reported to inhabit forested areas with thick under growth montane vegetation than relatively open habitats like Erica scrubland

and Afro-alpine grassland (Yalden *et al*., 1984; Yazezew *et al*., 2011; Girma *et al*., 2012; Zerihun, 2012).

The south eastern highland mountains of Ethiopian often possesses three of the major vegetation types, forming a distinct vegetation belt from lower to high altitude that include; Dry evergreen Afro-montane Forest grassland complex, Ericaceous Belt (sub-alpine) and Afro-alpine belt (Bekele-Tesemma *et al*., 1993; Nigatu & Tedesse, 1989). Each vegetation type has its own characteristics plant species and is a home for various wild animals. The Afro-montane zone ranges between 2,300 and 3,250 m in elevation. It is dominated by the tree species *Hagenia abyssinica* and *Juniperus procera* with *Erica arborea* and *Hypericum revolutum* occupying the higher elevations (Nigatu and Tedesse, 1989; Bekele-Tesemma *et al*., 1993; Bussmann, 1997). It has been reported to be the best habitat for both mountain nyala (Evangelista *et al*., 2007) and Menelik's bushbuck (Yazezew *et al*., 2011), as it provides food source and cover throughout the year. The sub-alpine/ericaceous zone, ranges from 3,200 to 3,700 m in elevation. This habitat type is dominated by *Erica trimera* at higher elevations and *Erica arborea* at lower elevations (Miehe and Miehe, 1994; Wesche *et al*., 2000). It is described among the preferred habitats of mountain nyala (Evangelista *et al*., 2008; Girma *et al*., 2012), especially in areas where the Afro-montane forest is lost as a result of deforestation or other anthropogenic activities. The Afro-alpine zone is found above 3700m. The Afro-alpine zone has four major vegetation types: Bogs, rocky outcrop, alpine grassland/moorland and mix scrubland (*Alchemilla* community or *Dendrosenecio* forests/woodland) (Ahmed, 2013). It is dominated by *Alchemilla and Helichrysum* species and few scattered stands of giant lobelia (*Lobelia rhynchopetalum*) (Hedberg, 1964). The Afro-alpine provides good year round forage, but poor cover. It is rarely utilized for mountain nyala mostly during the dry seasons for fresh grasses and water sources (Brown, 1969; Evangelista *et al*., 2007; Girma *et al*., 2012). The Menelik's bushbuck has been reported not to utilize this habitat (Yazezew *et al*., 2011).

However, Habitat fragmentations, degradation and loss of the two wildlife species have occurred throughout their ranges. Tree lodging, fuel wood collection, livestock encroachments and clearing forest for expansion of agriculture is common phenomenon in the Afro-montane forest habitat (Nigatu and Tedesse, 1989; Evangelista *et al*., 2007; Girma *et al*., 2012). Fire is so frequent in the ericaceous belt and has been thought to be decades old, but more intensive and frequent in recent years (Johansson *et al*., 2012) and Livestock encroachment is so intense in the Afro-alpine habitat (Girma *et al*., 2012). Several studies have studied the ecology and conservation of mountain nyala most focused on population estimate based on projections from developed habitat suitability models in Bale Mountains National Park (BMNP) (Refera and Bekele, 2004; Evangelista *et al*., 2008; Mamo *et al*., 2010; Atickem *et al*., 2011; Mamo *et al*., 2011). Only, few studies addressed the ecology of the Menelik's bush buck in northern Borena Saynit National Park (Yazezew *et al*., 2011), in the central Menagesha Suba State Forest (Desalgne and Wube, 2012) and Wof-Washa Forest (Hailemariam *et al*., 2015) and BMNP (Zerihun, 2012) most focused on population estimation and feeding ecology. However, no detailed study has been carried out on the wildlife distribution and status in the present study area. However, few studies have pointed out that it is home to the endangered and endemic *Tragelaphus buxtoni* (Evengelista *et al*., 2007) and anecdotal evidences have shown that *Tragelaphus scriptus meneliki* exist in the remnant Afro-montane forest in the north eastern part of the study area. Therefore, the aim of our study was to characterize the wildlife habitats of the Arsi Mountain landscape and evaluate their preference by mountain nyala and Menelik's bushbuck as ultimate conservation of the two endemic species and their habitat. Our approach explored the relative importance of the distinctive bio-physical parameters as resource base to effectively describe the habitats and relate their suitability to levels of habitat use based to counts of scat piles.

MATERIALS AND METHODS

Study Area

Arsi Mountains National Park is located in Oromiya Regional State of Ethiopia, at about 200 km south east of Addis Ababa and at about 15 km from the town Asela (Young, 2012). The park is demarcated in five blocks including Dera sanctuary, Chilalo block, Galama block, Kaka block and Hunkolo block (Young, 2012). The present study area (Galama block) is geographically situated between 7º48´to 7º88´N latitude and 39º27´ to 39º51´E longitude (Figure 1). The Galama block is shared among four Woredas namely; Digeluna-Tijo, Lemu-Bilbilo, Shirka and Tena Woredas (Figure 1). It has a great diversity of landscape with altitudes ranging from 2,700 to more than 4,000 m asl. The climate is humid montane having bimodal rainfall pattern (long rainy season from June to end of October and the minor rainy season from (March to April). The mean annual maximum temperature is 22.4°C and minimum temperature of 11.1°C (ENMA, 2015). The average annual rainfall ranges from 778.7 mm to 1089.65 mm (ENMA, 2015). The study area is characterized by Afro-alpine vegetation at higher altitudes, ericaceous vegetation at the middle and little remnant Afro-montane vegetation at the lower altitudes, north eastern part (Tena Woreda) and mixed plantations of tree species in the southern tip of the range (Lemu-Bilbilo, Shirka Woredas). Plantation of *Cupressus lusitanica*, *Eucalyptus sp*., *Pinus patula*, *Pinus radiate* and *Pinus carribeani* have been established in the lower elevations of the area frequently intermixed with the remnant stands of the indigenous trees (Evangelista *et al*., 2007). 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). Poaching of mountain nyala and Menelik's bush buck has also been reported to occur among the Arsi Oromo people inhabiting the area (Evangelista *et al*., 2007). This has led to decline of the population of the two species.

Field Sampling

To better understand the preferences and vegetation characteristics of mountain nyala and Menelik's bushbuck habitats, we used a stratified random sampling design across the four dominant habitat types found in our study area; natural forests, mixed plantation forests, Erica shrub lands and the Afro-alpine.

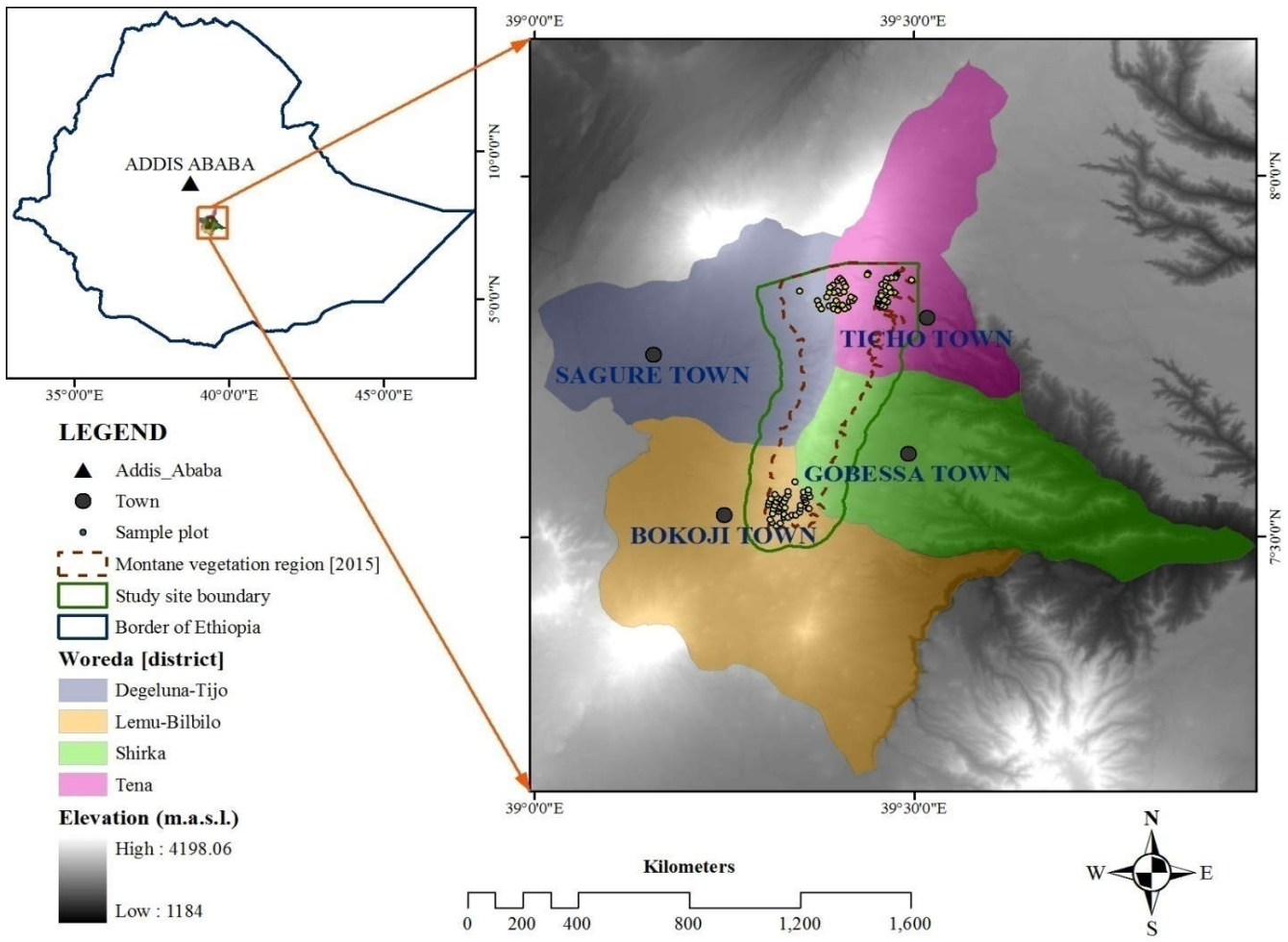

Fig. 1. Location of the study plots in Galama block, Arsi Mountains National Parks

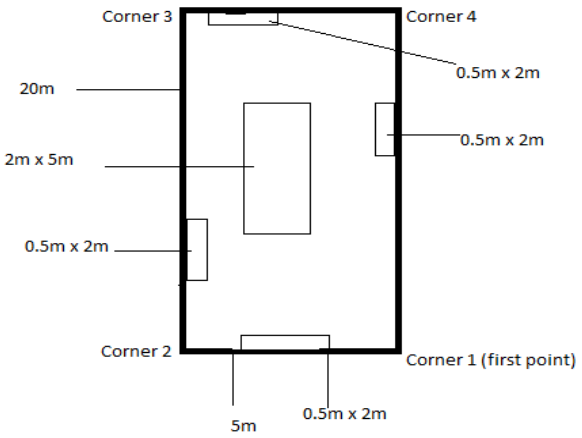

Fig. 2. Layout of the Modified Whitaker Nested intensive plot following Bernett & Stohlgren 2003

Location points were randomly generated in a geographic information system (GIS) using Arc GIS software v10.1 (ESRI, 2012). From our own field observations and site descriptions found in the literature (Evangelista *et al*., 2007), we estimated the approximate area of each habitat type in our study area to determine the proportion of sample plots needed to represent each of the four habitat types. A total of 104 sample plots were recorded; 24 in the natural forest, 9 in the mixed plantation forest, 53 in the Erica, and 18 in the Afro-alpine. We navigated to each plot location using a Garmin eTrex Legend Global Positioning System (GPS).

For our field plots, we used an Intensive-Modified Whitaker (I-MW) nested plot design to sample vegetation and scat across the study area (Barnett and Stohlgren, 2003). 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 center (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. For each of the four 1-m^2 sub plots, we recorded species richness, average height and estimated their relative percent cover. For the 10-m^2 subplot and 100-m^2 outer plot, we only recorded number of unique plants species richness. The percent cover of bare ground or exposed rock was also recorded when applicable. 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. The time since last burned was also estimated with the aid of park staff. We attempted to identify all plant species in the field; however, samples of each species encountered were collected, pressed and oven-dried and sent to the National Herbarium (ETH) located in the Department of Plant Biology and Biodiversity at Addis Ababa University for verification. The identification process was guided by the Flora of Ethiopia and Eritrea (FEE, 1989-2009) and the Flora of Tropical East Africa (FTEA, 1996-continuing) and by comparison with archived specimens from the collection housed at the National Herbarium and followed the APG III system (Chase and Reveal, 2009). Only about 3% were not identified to species level.

In addition to our vegetation sampling, we recorded the number of scat piles deposited by mountain nyala and Menelik's bushbuck in the 10-m^2 center plot and 100-m^2 outer plot as a proxy for habitat use during the wet and dry seasons respectively. A scat pile was defined as having 10 or more pellets grouped. Mountain nyala and Menelik's bushbuck scat were distinguished by their shape and size. The scat pellets of mountain nyala is conical shaped and pointed at one end and has relatively higher diameter than that of smaller, elongated pellets of the Menelik's bush buck (Figure 3a and 3b).

Figure 3a. Scat of mountain nyala (Photo taken by Zerihun)

Figure 3b. Scat of Menelik's bushbuck

Data Analyses

Both vegetation and auxiliary data were summarized per plot and habitats. Species richness was determined for the main plant categories (trees, shrubs, climbers and herbs) in each habitat. The Whittaker's three kinds of diversity were then computed for each habitat: α-diversity as the average species richness per plot within a given habitat; β-diversity as ratio of total species richness of habitat to average species richness per plot; and γ-diversity as the habitat level richness (Schmitt *et al*., 2010). One-way ANOVA was used to test for significant variation between habitats and group information obtained from Tukey test. A checklist for the species encountered in the landscape was compiled and the top 5 ranking species in occurrence in each habitat were considered as dominants and used to assess compositional differences between habitats. Shannon-Wiener diversity index (H') was calculated for each habitat using relative abundance data generated from presence-absence of the different species in plots within each habitat as: $H' = -\sum P_i(\ln P_i)$ Where P_i is the proportion of plots in which a given species is present for each habit. Evenness was calculated using the following equation: $J' = H'/H_{max}$ Where $H'_{max} = \ln(S)$, H' is the Shannon-Wiener diversity index, H_{max} is the maximum possible diversity, S is the number of species in a particular habitat. Sorenson's similarity Coefficient (SOR) was equally calculated between pairs of habitats as: SOR = 2a/(2a+b+c) (Kent and Coker, 1992). Where a = number of species common to both habitat; b= number of species unique to habitat 1; and c = number of species unique to habitat 2.

Since the plots were selected from known habitats (a priori), the discriminat multivariate analysis was used to evaluate how the selected bio-physical variables (predictors) contribute to habitat separation. Linear discriminat functions were calculated for the habitats and a plot classified into a habitat if its squared distance (Mahalanobis distance) to the habitat centroid is minimum (De Maesschalck *et al*., 2000). The cross-validation routine was used to compensate for an optimistic apparent error rate. Combinations of variables resulting in the least misclassified were considered.

Habitat preference index (HPI) was calculated as the ratio between number of plots with piles of scat of mountain

nyala/Menelik's bushbuck to the total number of plots in the given habitat type.

HPI= n/N 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) through 1.0 (high use). The 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 that account for their disproportionate use. This was carried out for each species (Mountain nyala and Menelik's bushbuck) 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). The vegetation survey was carried out in the dry season only assuming that most habitat variables (predicators) don't vary significantly between the wet and dry season. All computations were done using MINITAB 17 (Minitab Inc., 2013).

RESULTS

Habitat characterization

Six of the descriptive variables were effectively used in characterizing the four given habitats. These variables include; species richness and average percent cover (for all growth habits), burn history, percent slope, average vegetation height and total percent cover of dominant species and are summarized in Table 1. These descriptors correctly classified 81 of the 104 plots to their assigned habitats (proportions of 0.56, 0.92, 0.68 and 1.00 for Mixed plantations, Natural forests, Erica and Afro-alpine respectively). The cross-validation rather unclassified all the plots in the mixed plantations and a few in the Erica.

The mixed plantations occupy lower altitude while the Afro-alpine occurs at the top most elevation. Burning occurred exclusively in the Erica habitat. While Erica and Natural forests are moderately sloppy, the Afro-alpine is more or less flat and the mixed plantations on high sloppy terrain (Table 1). The α-diversity differed significantly across habitats with the highest recorded in the natural forest and lowest in the Afro-alpine (Table 1). Species richness differed significantly for the different growth forms across the habitats. The highest herb species richness was recorded in the Erica while the lowest was in the afro-alpine. The highest shrub species richness was recorded in the natural forest, while the lowest was recorded in the Afro-alpine. Trees species richness was highest in the natural forest and mixed plantation forest and lowest in Afro-alpine. More climbers were found in the natural forest and less in Afro-alpine. The average vegetation height peaked in the natural forest and dropped to less than 0.5m in the Afro-alpine habitat. The highest average dominant species vegetation cover was recorded in the Afro-alpine habitat and the least in the mixed plantations (Table 1). The highest Shannon-Wiener Diversity and evenness were recorded from the mixed plantation, while the least Shannon-Wiener Diversity and evenness were from the erica habitat (Table 1). The highest Sorenson's species similarity Coefficient (CC) was recorded between natural forest and mixed plantation habitats, while the least was recorded between natural forest and Afro-alpine habitats (Table 2).

Asteraceae and Poaceae were the most abundant families in all four habitats with Apiaceae in Erica scrub and Lamiaceae in the natural forests and mixed plantations. *Alchemilla ellenbeckii and Erica arborea* ranked first in species abundance in the Afro-alpine and Erica habitats respectively. *Rubus studeneri and Alchemilla pedata* ranked first in species abundance in the natural forest and mixed plantations respectively. In the overall study area, *Alchemilla pedata, Erica arborea, Crassula alsinoides, Geranium arabicum* and *Haplocarpha rueppellii* are the five most abundant species in that order (Table 3).

Table 1. Bio-physical characteristics of selected plots in the Galama block of the Arsi Mountains National Park. Plots were sampled in the dry season of 2013. Means that do not share the same small letter for habitats are significantly different ($P \leq 0.05$)

Characteristics	Habitat type			
	Afro-alpine	Erica	Natural forest	Mixed plantations
Total area (Ha)	15533	27342	2500	1518
Total area sampled	1800	5400	2300	900
Number of plots	18	53	24	9
Altitude (m)				
Mean	3655.72	3539.66	3223.04	3269.55
Range	3276-4008	3202-3985	2843-3756	3181-3340
Inclination				
Mode	Flat	Moderate	Moderate	High
Proportion (%)	77.77	49.05	58.33	44.4
Species richness for				
Trees	1	3	9	9
Mean per plot	0.06±0.06c	0.36±0.09c	3.00±0.22a	1.56±0.34b
Shrubs	8	9	20	11
Mean per plot	0.56±0.14d	1.12±0.08c	2.83±0.19a	2.00±0.44b
Herbs	72	108	92	88
Mean per plot	17.5±1.16b	21.28±1.03ab	24.88±1.58a	23.67±3.24ab
Climbers	1	3	9	5
Mean per plot	0.06±0.06b	0.08±0.04b	0.63±0.17a	0.56±0.34ab
Entire Habitat (γ-diversity)	82	123	130	113
Mean per plot (α-diversity)	17.94±1.05[b]	22.85±1.08[b]	31.83±1.63[a]	30.6±2.0[a]
β-diversity (γ/α)	4.57	5.08	3.70	3.72
Shannon-Wiener	3.986	3.556	4.408	4.509
Shannon's Evenness	0.901	0.738	0.905	0.953
Mean Veg. Height (m)	0.29±0.06	0.69±0.06	8.14±1.78	2.40±0.66
Range (m)	0.01-0.9	0.032-1.7	0.35-37	0.2-6
Mean % cover of dominant species	40.13	30.55	23.39	17.92

Table 2. Sorenson's similarity Coefficients between habitats in the Galama block of the Arsi Mountains National Park

	Natural forest	Erica	Afro-alpine
Mixed plantation	0.42	0.41	0.35
Natural forest		0.39	0.34
Erica			0.38

Table 3. Plant species abundance ranking per habitat type and over all the study area (five top species were considered in each habitat types) (F= frequency of occurrence, R= rank)

Species	Family	Habit	Ranking and proportions per habitat type									
			Afro-alpine		Erica		Natural forest		Mixed plantation		Overall	
			F	R	F	R	F	R	F	R	F	R
***Alchemilla pedata* Hoche.**	Rosaceae	Herb	0.33	11	0.85	2	1.00	1	0.78	1	0.80	1
***Erica arborea* L.**	Ericaceae	Shrub	0.5	8	0.96	1	0.38	14	0.78	1	0.73	2
***Crassula alsinoides* (Hook f.) Engl.**	Crassulaceae	Herb	0.78	3	0.57	8	0.96	2	0.33	4	0.68	3
***Geranium arabicum* Forssk**	Rubiaceae	Herb	0.83	2	0.60	6	0.79	6	0.56	2	0.68	3
***Haplocarpha rueppellii* (Sch.Bip.) Beauv.**	Asteraceae	Herb	0.72	4	0.72	3	0.21	18	0.33	4	0.57	4
***Helichrysum forsskahlii* (J.F Gmel.) Hilliard & Burtt**	Asteraceae	Herb	0.61	6	0.72	3	0.04	22	0.56	2	0.53	5
***Andropogon abyssinicus* Fresen**	Poaceae	Herb	0.39	10	0.70	4	0.21	18	0.56	2	0.52	6
***Schoenoxiphium sparteum* (Wahlenb.) C.B. Clarke**	Poaceae	Herb	0.72	4	0.43	13	0.38	14	0.33	4	0.46	9
***Satureja puncutata* (Benth.) Briq**	Lamiaceae	Herb	0.06	16	0.58	7	0.13	20	0.78	1	0.40	10
***Satureja pardoxa* (Vatke) Engl. Ex Seybold**	Lamiaceae	Herb	0.06	16	0.11	27	0.08	21	0.78	1	0.34	14
***Rubus studeneri* Willd**	Rubiaceae	Shrub	0.00	-	0.02	32	1.00	1	0.44	3	0.31	16
***Alchemilla ellenbeckii* Engl. Afro**	Rosaceae	Herb	0.94	1	0.25	20	0.00	-	0.00	-	0.29	18
***Helichrysum stenopterum* DC.**	Asteraceae	Herb	0.22	13	0.17	24	0.92	3	0.78	1	0.24	22
***Myrsine melanophloeos* (L.) R. Br.**	Myrsinaceae	Tree	0.00	-	0.00	-	0.96	2	0.22	5	0.24	22
***Viola abyssinica* Oliv**	Violaceae	Herb	0.00	-	0.00	-	0.96	2	0.22	5	0.24	22

Table 4. Habitat preference indices of the mountain nyala and Menelik's bushbuck in four habitats in the Galama block, Arsi Mountains National Park during the wet and dry seasons respectively

Species	Habitat types							
	Mixed Plantation		Natural forest		Erica		Afro alpine	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Mountain nyala								
Total no of plots	9	9	53	53	24	24	18	18
No. of plots with scats	4	1	0	0	4	4	1	0
Habitat preference index	0.44	0.11	0	0	0.07	0.07	0.05	0
Menelik's bushbuck								
No. of plots with scats	3	3	11	5	1	0	0	0
Habitat preference index	0.33	0.33	0.58	0.21	0.02	0	0	0

Table 5. Summary statistics for selected models that describe habitat use by mountain nyala and Menelik's busbbuck 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
MN, Dry season	Constant	0.09				0.014	0.46	5.77	1.23
	Av. Tree % cover	0.052	0.014	1.00	6.24				
MN, Wet season	Constant	0.09					0.25	16.9	0.80
	Slope	0.570	0.001	1.07	5.06	0.001			
MB, Dry season	Constant	9.10							
	Herb richness	0.084	0.004	1.86	8.79	0.004	1.46	31.5	2.15
	Av. Veg. height	0.150	0.001	1.14	25.2	0.000			
	Elevation	0.002	0.007	2.05	7.69	0.007			
MB, Wet season	Constant	0.03							
	Av. height	0.060	0.001	1.00	27.2	0.000	0.60	21.05	1.38

Most species are distributed over more than one habitat; however few are confined only in a particular habitat. The natural forest has the highest number of unshared species while the Afro -alpine habitat has the least. *Arundinani alpina*, *Barleria orbicularis*, *Dombeya torrida, Ipomea sinensis*, *Hydrocotyle mannii*, *Nuxia congesta*, *Oenanthe polistris*, *Poa schimperiana*, *Podocarpus falcatus*, *Ptenis cretica*, *Scheflera abyssinica*, *Solanum garae*, *Umbilicus botryoides*, *Urera hypselodendron*, *Vernonia rueppellii* and *Wahlenbergia silenoides* were recorded only in the natural forests. *Denanthe palustins*, *Eucalyptus camaldulensis*, *Helictotrichon elongatum*, *Holothrix squammata*, *Plectocephalus varians*, *Polygala steudneri*, *Sanicula elata* and, *Schefflera volkensii* were confined only in the plantation forest. *Anthemis tigreensis*, *Astragalus fatmensis*, *Euphorbia polycnemoides*, *Crepis rueppelli, Euphorbia schimperiana*, *Helichrysum formosissimum*, *Heteromohph trifolia*, *Luzula abyssinica*, *Merendera schimperi*, *Orobincha ramose*, *Otostegia fruticosa*,

Parochaetus communis, *Saturajia simenssis* and *Swertia fimbriata* were only in the Erica. *Dianthoseris schimperi*, *Erigeron alpines*, *Eriocaulon schimperi*, *Festuca abyssinica, Festuca gilbertiana* and *Festuca macrophulla* were Afro-alpine specialists.

Habitat preferences of the mountain nyala and Menelik's bushbuck

The highest habitat preference indices for the mountain nyala (0.44) and Menelik's bushbuck (0.58) were recorded in the mixed plantation and natural forest during dry season respectively (Table 4). Mountain nyala (MN) has higher preference index in the dry season than the wet season in the mixed plantation and similar indices in the Erica. The Menelik's bushbuck (MB) has higher preference index in the dry season than wet season in the natural forest, where as it was similar in the Erica (Table 4).

Four models were eventually fitted that quantitatively and qualitatively explain which of the habitat components accounted for habitat use by the two wildlife species (Table 5). Habitat quality varied for both MN and MB during the wet and dry seasons respectively. While the average tree percent cover was a good predictor for MN in the dry season, slope account more in the wet season. The herb richness, and elevation determined habitat use by MB in the dry season and average vegetation height in both seasons (Table 5).

DISCUSSION

The highest species richness in the natural forest is mainly due to the presence of all life forms from herbs all the way to trees. This is resulted from relatively lower altitude falling below tree line that supported all life forms and due to favorable climate and edaphic factors. However, anthropogenic disturbance like deforestation and over grazing could have eliminated rare and grazing sensitive species that reduced species richness. The lowest species richness from the Afro-alpine habitat is mainly attributed due to altitudinal, light, edaphic factors and climatic factor (Ahmed, 2013). Since this habitat fallows above tree line predominately herbs and very few shrubs can grow. Due to extreme climatic conditions only herbs and shrubs that can withstand harsh climatic conditions and grow. For example, *Alchemilla/Helichrysum* species that are dominant in the Afro-alpine community have the potential of obstructing/and limiting light penetration to the ground layer (Hedberg, 1957). Hence, the genera and species common to these vegetation communities are non−shade loving herbaceous taxa often with creeping, climbing, and tussock forming habits. The fluctuation of temperature is high in the Afro-alpine zones during the day and night, that is, "summer everyday and winter every night" (Hedberg, 1957). Water and nutrient uptake is impaired since during the night and the early hours of the day, the soil temperatures is below zero (Hedberg, 1957). Consequently species that have only a certain adaptation survive in the area.

The dominance of the herbaceous community in the natural forest could be an indication of disturbance where most of the tree species have been logged and shrubs cut for fuel wood and fencing of the farmers' compound. It has been indicated that human-induced disturbances are the major causes for changes in forest structure and composition (Kumar and Ram, 2005), and the extent of these effects are dependent on the type and severities of the disturbances (Chown, 2010). For example, the disturbed Jibat humid Afro-montane forest was dominated by herbaceous community (34.5%) (Burju *et al*., 2013). Furthermore, invasive herb species that are favored by degradation of habitats may be expected to be more abundant in the moderately disturbed habitat (Addisu *et al*., 2015).

The highest diversity indexes in the mixed plantation forest could be attributed to the ability to grow all the plant growth forms (herb, shrub, tree and climber), high litter fall and decomposition rate, elevation (species diversity decreases as altitude increases) (Schmitt *et al*., 2010). The highest similarity index among the natural forest and plantation forest could be due to the fact that the two habitats are almost at the same altitude, have same soil type, climate and originally the plantation forest was covered by the natural forest that was lost due to indiscriminate deforestation (Nigatu and Tedesse, 1989).

The habitat preference of mixed plantation forest over other habitats by the mountain nyala could be attributed to the higher tree percent cover and less disturbance. The stepwise regression analysis has indicated that tree species percent cover determines the proxy of habitat utilization for mountain nyala. It has been revealed that mountain nyala prefers the habitats with high tree percent cover for hiding from predators, for breeding, resting and thermal cover (Brown, 1969; Mamo *et al*., 2012). The mixed plantation forest is strictly protected from most threats as compared to other habitats in an attempt to grow seedlings for forest utilization and management. In Bale Mountains mountain nyala individuals, have been reported to mainly occupy woodlands while avoiding human developments areas (Atickem *et al*., 2011). The high sloppy characterization of the mixed plantation could have also provided mountain nyala inaccessible refugee cover for breeding and resting. Atickem *et al*. (2011) found out that the abundance of mountain nyala pellets increased marginally with slope, though at 95% confidence interval had no significant effect. Erica could be moderately preferred because it provides better cover than Afro-alpine habitat and forging opportunity including water requirements. Particularly in areas where the natural forest is lost or highly degraded could be used as refugee and breeding places (Atickem *et al*., 2011). A number of studies have described that Erica is the habitat for mountain nyala and is among the preferred ones (Brown, 1969; Yalden & Largen, 1992; Evangelista *et al*., 2007; Evangelista *et al*., 2008; Girma *et al*., 2012). The absence of mountain nyala in the natural forest is presumably attributed to ever increased disturbances and degradation in the natural forest such as deforestation, livestock encroachments and other human activities. Atickem *et al*. (2011) supports the same notion that Mountain nyala was never present in areas exceeding 50% human developments. However, historically it has been known that mountain nyala existed in the natural forest of Ticho (northern eastern side of the study area) (Evangelista *et al*., 2007) when the forest was intact and with little human inhabitation.

The clear preference of the Menelik's bushbuck for the natural forest habitat could be due to low altitude, high herb species richness (that could be used as food) and tree cover (used for hiding against predators and against extreme weathers) as revealed from the step wise regression analysis. Ecologically the bushbuck occupies lower altitude than the mountain nyala (Yalden *et al*., 1984). Menelik's bushbuck prefers habitat with sufficient cover and adequate forage (Kingdon, 1997; Yalden *et al*., 1984). Studies in the north eastern Ethiopia (Borena Sayint National Park) (Yazezew *et al*., 2011) and central Ethiopia (Wof-Washa Forest) (Hailemariam *et al*., 2015) revealed that the Menelik's bushbuck prefers natural forest over habitats like Erica, plantation and Afroalpine.

The highest habitat preference indexes during the dry season that the wet season in most habitats is mainly attributed to the increased disturbances like increased number of livestock and associated human activities in the wet season than dry season. This is mainly because during wet season the farmlands below are covered by crops and livestock has no place to graze on the lower altitude farmlands, hence move up to the wildlife habitats. It has been revealed that the number of livestock is negatively correlated with wildlife population (Stephens *et al*., 2001; Evangelista *et al*., 2007; Evangelista *et al*., 2008; Mamo and Bekele, 2011; Yazezew *et al*., 2011; Girma *et al*., 2012).

The habitats of mountain nyala and Menelik's bushbuck (classified as four principal habitats; Afro-alpine, Erica, natural forest and mixed plantations) are characterized by high altitude land ranging from 2843 to 4000 m asl, and mostly is moderate to high sloppy areas. It is characterized by relatively high species richness with high herb diversity. Mountain nyala prefers mixed plantation forest and Erica habitat over other habitats. However, the Menelik's bushbuck prefers natural forest habitat over the other. Based on the results of this study to ensure the conservation of Mountain nyala and Menelik's bushbuck and their habitat in Arsi Mountains National Park it is recommend to stop deforestation, over harvesting of grasses, livestock grazing, temporary settlements of humans and to strength the capacity of patrolling, law enforcement, awareness of local community about the biodiversity and arrange for benefit sharing of values of biodiversity conservation for local community.

Acknowledgements

This study was funded by International Foundation for Science (IFS) and Muruller Foundation. We are grateful to Hawassa University Wondo Genet College of Forestry and Natural Resources for providing transport cars to field sites. We thank the Oromiya Regional State Forest and Wildlife Enterprise, The Arsi Mountains National Park authority and the involved District Authorities for permission to carry out this study in the park under their respective jurisdictions. We are grateful to Nicholas Young for helping in the setup of the plots and Birhanu Belay for his help in field plant identification. We duly acknowledge the National Herbarium at Addis Ababa University for allowing us to work on stored plant material. We thank Melaku Wondeafrash for the unreserved support during plant identification in the Herbarium. We are grateful to all the field assistances and park scouts for their dedication and assistance with fieldwork. Thank you, Habtamu Tadesse for preparing the study area map.

REFERENCES

Addisu, A., Yosef, M., Girma, M. and Anteneh, S. 2015. Woody plant diversity along disturbance gradients in the northern Afro-montane forests of the bale mountains, Ethiopia. *International Journal of Development Research*, 5: 37-45.

Ahmed, A.A. 2013. Diversity and distribution of the Afro-alpine flora of Eastern Africa with special reference to the taxonomy of the genus *Pentaschistis* (poaceae). PhD Thesis, Kenyatta University, Nairobi. Pp: 258.

Atickem, A., Loe, L., Langangen, O., Rueness, K., Bekele, A. and Stenseth, N. 2011. Estimating population size and habitat suitability for availability in croplands and adjacent forest. *Journal of Applied Ecology*, 35: 596–606.

Balakrishnan, M., Easa and P.S. 1986. Habitat preferences of large mammals in Parambikulam Wildlife Sanctuary, Kerala. India. *Biol. Conserv*., 37: 191-200.

Barnett, D. and Stohigren, T. 2003. A nested-intensity design for surveying plant diversity. *Biodiversity and Conservation*, 12: 255–278.

Bekele–Tesemma, A., Birnie, A. and Tengnas, B. 1993. Useful trees and shrubs for Ethiopia. Swedish International Development Authority Regional Soil Conservation Unit, Stockholm. Pp: 474.

Brown, L.H. 1969. Observations on the status, habitat, and behavior of the mountain nyala (*Tragelaphus buxtoni*) in Ethiopia. *Mammalia*, 33: 545-597.

Burju, T., Kitessa, H. and Ensermu, K. 2013. Floristic Composition and Structural Analysis of Jibat Humid Afromontane Forest, West Shewa Zone, Oromia National Regional State, Ethiopia. Ethiop. *J. Educ. & Sc*., 8: 11-33.

Bussmann, R.W. 1997. The forest vegetation of the Harenna Escarpment (Bale Province, Ethiopia) − syntaxonomy and phytogeographical affinities. *Phytocoenologia*, 27: 1−23.

Chase, M.W. and Reveal, J.L. 2009. A phylogenetic classification of the land plants to accompany APG III. *Botanical Journal of the Linnaean Society*, 161: 122–127.

Chown, S.L. 2010. Temporal biodiversity change in transformed landscapes: a southern African perspective. *Philosophical Transactions of the Royal Society*, *Biological Sciences*, 365: 3729-3742.

De Maesschalck, R., Jouan-Rimbaud, D. and Massart, D.L. 2000. The Mahalanobis distance. *Chemometrics and Intelligent Laboratory Systems*, 50: 1-18.

Dessalegn, A. and Wube. T. 2012. Population density, structure and grouping pattern of Menelik's bushbuck in the Menagesha-suba state forest, Ethiopia. *SINET: Ethiop. J. Sci*., 35: 129–134.

ESRI (2012). Arc GIS software 10.1. Environmental Systems Research Institute. California.

Ethiopian National Meteorological Agency (ENMA). 2015. Meteorological data. National Metrological Agency, Addis Ababa.

Evangelista, P., Norman, J., Berhanu, L., Kumar, S. and Alley, N. 2008. Predicting habitat suitability for the endemic mountain nyala (*Tragelaphus buxtoni*) in Ethiopia. *Wildlife Research*, 35: 409–416.

Evangelista, P., Swartzinski, P. and Waltermire, R. 2007. A Profile of the Mountain Nyala (*Tragelaphus buxtoni*). Retrieved from www.africanindaba @co.za on October, 20, 2012.

Flora of Ethiopia and Eritrea. (1989-2009). Volumes 1–9. The National Herbarium, Addis Ababa and the Department of Systematic Botany, Uppsala.

Flora of Tropical East Africa. (1996-continuing). The royal botanical gardens, Kew and The East African Herbarium, Nairobi.

Girma, Z., Bekele, A. and Graham, H. 2012. Large mammals and mountain encroachments on Mount Kaka and Hunkolo Fragments, Southeast Ethiopia. *Asian J. Applied Sci*., 5: 279-289.

Hailemariam, B., Gadisa, T., Habtamu, T. and Gelaye, H. 2015. The status and feeding ecology of Menelik's bushbuck (*Tragelaphus scriptus meneliki*, Neumann 1909) in Wof-Washa Forest, North Showa, Ethiopia. *International Journal of Current Research*, 7: 16366-16370.

Hall, L.S., Krausman, P.R. and Morrison, M.L. 1997. The habitat concept and a plea for standard terminology. *Wildlife Society Bulletin*, 25: 173-182.

Hedberg, O. 1957. Afro-alpine Vascular Plants; A taxonomic Revision. *Symb. Bot. Ups*., 17: 1.

Hedberg, O. 1964. Features of Afro-alpine Plant Ecology. *Acta Phytogeog. Suecica*, 49: 1−144.

Johansson, M.U., Fetene, M., Malmer, A. and Granström, A. 2012. Tending for cattle: traditional fire management in Ethiopian montane heathlands. *Ecology and Society*, 17: 19.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology*, 61: 65-71.

Johnson, D.H. 2007. Measuring habitat quality: a review. *The Condor*: *The Cooper Ornithological Society*, 109: 489-504.

Kent, M. and Coker, P. 1992. Vegetation Description and Analysis: Ambo Practical approach. Bent Haven Press, New York.

Kingdon, J. 1997. The Kingdon Field Guide to African Mammals. Princeton University Press, New Jersey.

Kotler, B.P., Gross, J.E. and Mitchell, W.A. 1994. Applying patch use to assess aspects of foraging behaviour in Nubian Ibex. *Journal of Wildlife Manage*, 58: 299–307.

Kumar, A. and Ram, J. 2005. Anthropogenic disturbances and plant biodiversity in forests of Uttaranchal, central Himalaya. *Biodiversity and Conservation*, 14: 309-331.

Mamo, Y. and Bekele, A. 2011. Human and livestock encroachments into the habitat of Mountain Nyala (*Tragelaphus buxtoni*) in the Bale Mountains National Park, Ethiopia. *Trop. Ecol*., 52: 265-273.

Mamo, Y., Bekele, A. and Mengesha, G. 2012. Habitat use of mountain nyala (*Tragelaphus buxtoni,* Lyddeker*,* 1911) in the Bale Mountains National Park, Ethiopia. *International Journal of Biodiversity and Conservation*, 4: 642-651.

Mamo, Y., Pinnard, M.A. and Bekele, A. 2010. Demography and dynamics of mountain nyala (*Tragelaphus buxtoni*) in the Bale Mountains National Park, Ethiopia. *Current Zoology*, 56: 660–669.

Miehe, G. and Miehe, S. 1994. Ericaceous forests and heathlands in the Bale Mountains of South Ethiopia−Ecology and man's impact. Hamburg, German: Stiftung Walderhaltung in Africa.

Minitab Inc. 2013. Statistical package software. Release 17. Minitab Inc. State College, PA.

Nigatu, L. and Tadesse, M. 1989. An ecological study of the vegetation of the Harenna Forest, Bale, Ethiopia. *SINET: Ethiop. J. Sci*., 12: 63–93.

Refera, B. and Bekele, A. 2004. Population status and structure of mountain nyala in the Bale Mountains National Park, Ethiopia. *African Journal of Ecology*, 42: 1–7.

Schmitt, C.B., Denich, M., Demissew, S., Friis, I. and Boehmer, H.J. 2010. Floristic diversity in fragmented Afro-montane rainforests: Altitudinal variation and conservation importance. *Appli. Veg. Sci*., 13: 291–30.

Stephens, D.W. and Krebs, J.R. 1986. Foraging theory. Princeton Univ. Press, Princeton Pp: 247.

Stephens, P.A., Candy, A.S., Sillero-zuberi, C. and Leader-Williams, N. 2001. Impact of livestock and settlement on the large mammalian wildlife of Bale Mountains National Park, southern Ethiopia. *Biological Conservation*, 100: 307-322.

Tadesse, S.A. and Kotler, B.P. 2013. Habitat use by mountain nyala *Tragelaphus buxtoni* determined using stem bite diameters at point of browse, bite rates, and time budgets in the Bale Mountains National Park, Ethiopia. *Current Zoology*, 59: 707–717.

Thomas, J.W. 1979. Wildlife habitats in managed forests: The Blue Mountains of Oregon. U.S.D.A. Forest Service, Washington D.C.,

Wesche, K., Miehe, G. and Kaeppeh, M. 2000. The significance of fire for Afro-alpine vegetation. *Mountain Research and Development*, 20: 340-347.

Yalden, D.W. and Largen, M.J. 1992. The endemic mammals of Ethiopia. *Mammal Review*, 22: 115-150.

Yalden, D.W., Largen, M.J. and Kock, D. 1984. Catalogue of the mammal of Ethiopia: 5 Artiodactyla. *Italian Journal of Zoology*, 19: 140-145.

Yazezew, D., Mamo, Y., Bekele, A. 2011. Population Ecology of Menelik's bushbuck (*Tragelaphus scriptus meneliki*, Neumann, 1902) From Donkoro Forest Proposed National Park, Northern Ethiopia. *International Journal of Ecology and Environmental Sciences*, 37: 1-13.

Young, J. 2012. Ethiopian Protected Areas A 'Snapshot': A reference guide for future strategic planning and project funding. Retrieved from <http://www.james@ayzosh. com.> Accessed in 2012, February 4.

Zerihun, M. 2012. Population Status, Habitat Association, Feeding Behaviour and Diurnal Activity of Menelik's Bushbuck (*Tragelaphus scriptus meneliki*) in Dinsho, Bale Mountains National Park, Ethiopia. Masters Thesis, Addis Ababa University, Addis Ababa.

****