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*Full Length Research Paper*

# Habitat use of mountain nyala (*Tragelaphus buxtoni,* Lyddeker, 1911) in the Bale Mountains National Park, Ethiopia

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**A study on habitat use of the mountain nyala (*Tragelaphus buxtoni*), an endemic ungulate known to science in 1908, was conducted from May to June 2007 in the Bale Mountains National Park (BMNP). The study area was divided into three major habitat group based upon the dominant vegetation and relative location. Vegetation use by the animal were accessed in randomly laid 171 square plots of 100 $m^2$ area size along randomly established transects. Of 171 plots 69 were in Gaysay grassland, 71 in Adelay and 31 in Dinsho woodland habitat. As related to the species use, of the habitat ground cover, incidence of browsing, vegetation height, slope, altitude, canopy openness, tree density and visibility were measured. Six vegetation types were identified and ranked for their use by *T. buxtoni.* The largest proportion (58%) of the Gaysay grassland habitat, was covered by grasses. In this habitat, *Hypericum revolutum* bush was the most used while open grassland was the least. Among the four vegetation groups that were identified in Dinsho woodland habitat, *Hagenia* and *Juniperus* and vegetable type covered the largest proportion (68%) in terms of area. In this habitat, open montane grassland vegetation was the most used by the animal; while *Euphorbia* and *Solanum* bushy vegetation were the least. Although the least used, in Adelay woodland habitat, *Hagenia* and *Juniperus* vegetation types covered the largest proportion (65%) of the area. In most obervation, levels of browsing decreased with increased in vegetation height. Greater availability of a given vegetation type did not necessarily result in higher use by the study animal. Proper conservation measures that could restore or rehabilitate the preferred habitats and vegetation types for the study animal are needed in the Park.**

**Key words:** Browse, habitat use, mountain nyala, preference, vegetation.

## INTRODUCTION

An intimate and complex relationship can be observed between a given species of animal and its habitat with certain biotic and abiotic requirements for persistence (Pullin, 2002). Ecological research has shown how key resources such as vegetation, water and shelter drive the distribution of herbivores (Illius and O'Connor, 2000; Apps et al., 2001). The broad-scale relationships between vegetation and animals have long been recognized. Important elements of the habitat of an animal are often provided by the vegetation of an area (Morrison et al., 1998). Vegetation provides essential requirements for animals such as cover and food.

An endemic antelope of Bale Mountains National Park (BMNP), mountain nyala (MN) (*Tragelaphus buxtoni*), was known to science in 1908 (Lydekker, 1911). The main range of MN is the Bale and Arsi Mountains. Areas outside of these mountains support only relic population in isolated areas, which include sites of Asebe Teferi, Arba Gugu and Mount Gara Muleta (Brown, 1966; Wilson and Reeder, 1993). A high-altitude woodland mosaic,

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bushland, heath, moorland, and valley grassland were favoured habitats of the species (Brown, 1969a; b; Hillman, 1986b; Kingdon, 1997; Refera and Bekele, 2004). In the habitats, the species browsed on leaves of herbs, shrubs and trees, as well as grasses, cultivars and aquatic flora (Evangelista et al., 2007). In the Bale Mountains, the species occurs between 3150 and 3550 m asl (Brown, 1969a) and 3000 and 4200 m asl (Kingdon, 1997). The study made on habitat suitability to the MN suggests strong correlation between the species' range and specific climate and topographic conditions (Evangelista et al., 2008). Since Brown's observation about 40 years ago in the Bale Mountains, a lot have changed with regards to abundance and distribution range of the species. The numbers of individuals of the species have reduced by 90% since the survey in 1966 (Malcolm and Evangelista, 2002). Furthermore, most of the species have been pushed down from the upper altitudes as a result of settlements, cultivation and grazing (Brown, 1969a; Hillman, 1986a; b; Gebrekidan, 1996; Kingdon, 1997). The extensive livestock grazing, cultivation and also deforestation within and outside the Park has deteriorated the quality of the habitats and reduced the vegetation composition available for MN leading them to leave their previously preferred habitats. Therefore, currently, the majority of the predicted suitable habitat of MN occurred in the remote forest found at the southern escarpment of the BMNP (Evangelista et al., 2008). Nevertheless, the Park's northern woodland habitat, from which they used to move to the bush areas of the northern grasslands below the tree line and the heather moorlands above the tree line (3,000 to 4,200 masl), have been observed as the strongholds for the species.

In an effort that assesses a species habitat requirement and preference, habitat use studies of the species is indispensable (Garshelis, 2000). Since no studies have been conducted on habitat use of the MN, only little is known of the habitat types and its vegetation compositions the MN preferred, selected and ecologically associated to in the study area (Mamo, 2007). However, the habitat deterioration and associated change in its vegetation composition which is getting worse, in the BMNP, could have negatively affected the animal's preferred habitat and its supplies to the species. This could in turn negatively affect the number of individuals of the species associated with the habitat, MN's reproduction and survivals in the area. Thus, a study that links available vegetation type, range and composition in the BMNP to the MN's habitat preference, selection and utilization, is vital to conservation endeavours aiming to restore or rehabilitate the species habitat quality and vegetation cover used. This could help to meet the favourable conditions in which the animals can realize maximum fitness. Moreover, habitat management of threatened species presupposes some understanding of the need of a species (Garshelis, 2000). The study was conducted between May and June, which is the beginning of rainy season in the area. The aims of the present study were to describe and characterize the vegetation types in the range of MN; quantify vegetation covers, availability and determine patterns of use of these by the animal (Johnson, 1980); and develop habitat use indexes (Morrison et al., 1998; Rondinini et al., 2004) based on vegetation availability and use by MN in the BMNP.

## MATERIALS AND METHODS

### Study area description

The study area is located within 6°20′ and 7°40′ N latitude and 39°30′ and 39°58′ E longitude in southeastern highlands of Ethiopia (Figure 1) that supports the major global population of MN. The study sites included the northern montane grassland (3000 to 3100 m asl) which is a flat terrain located on the extreme north of the Park. It supports the largest population of MN. The area can be subdivided into three vegetation zones: open grassland, marshy grassland, and *Artemisia*/*Helichrysum* bush (Hillman, 1986a, b). The northern montane woodlands (3000 to 3400 m asl) and the adjacent *Erica* heatherland (3400 to 3800 m asl) can be subdivided into four zones mainly based on the major vegetation types: Hagenia/Juniperus woodland, *Hypericum* bush, montane grassland and *Hypericum* woodland (Figure 1).

Two concept swere used in the method namely habitat type and vegetation type were used here to denote the habitat of MN. The distinction posed by Jones (1986) was adopted in the present study, which defined habitat type as "an area, delineated by a biologist that has consistent abiotic or sub-dominant vegetation''. The term vegetation type was used to denote the major plant species composition within the habitat type. Accordingly, two habitat types namely Gaysay grassland and Adelay/Dinsho woodland were identified and considered for habitat assessment in the BMNP. Then, the habitats were stratified based on major vegetation types before lying down transect lines at random and the corresponding plots. Sampling units of circular and square quadrats were used in the study (Goldsmith and Harrison, 1976; Kent and Coker, 1992; Southwood and Henderson, 2000). Transect lines were laid down by following a cluster random sampling design, in which the clusters were represented by survey lines. The major parameters included were habitat or vegetation availability, vegetation cover, habitat utilization by MN and site-attributes (slope and altitude). 3 to 8% of the total area was sampled following Patton's (1997) suggestion by considering 2 to 5% as a minimum.

In Gaysay montane grassland area, five parallel transects were laid randomly in north-south direction with 20° bearing having at least a distance of 950 m in between any two transects. Random locations between 950 and 1000 m were selected for transects. The total transect length covered during sampling was 13.5 km. Along each transect, a number of sample plots were located randomly with a minimum distance of 150 m covering a sample size of 3%. The sampling units were square (10 m × 10 m) plots, with the centre lines (5 m measured inwards from the central part of either sides of the plots) placed on the transect line. A total of 69 plots were assessed. Each plot was sub-divided into 400 equal sub-squares of 0.25 $m^2$ for ease of data collection. Wooden frames were used to facilitate sample collections. Specific geographic locations, elevation and slope of each plot were measured using GPS, Altimeter and Clinometer devices, respectively. Vegetation height and ground cover of each plot were measured in all of the 400 partitions of 0.25 $m^2$ in each plot. The percentage of ground area in each plot covered by the dominant vegetation was estimated.

The woodland habitat that was included in the survey lay between 3,000 and 3,400 m asl and was located in two relatively

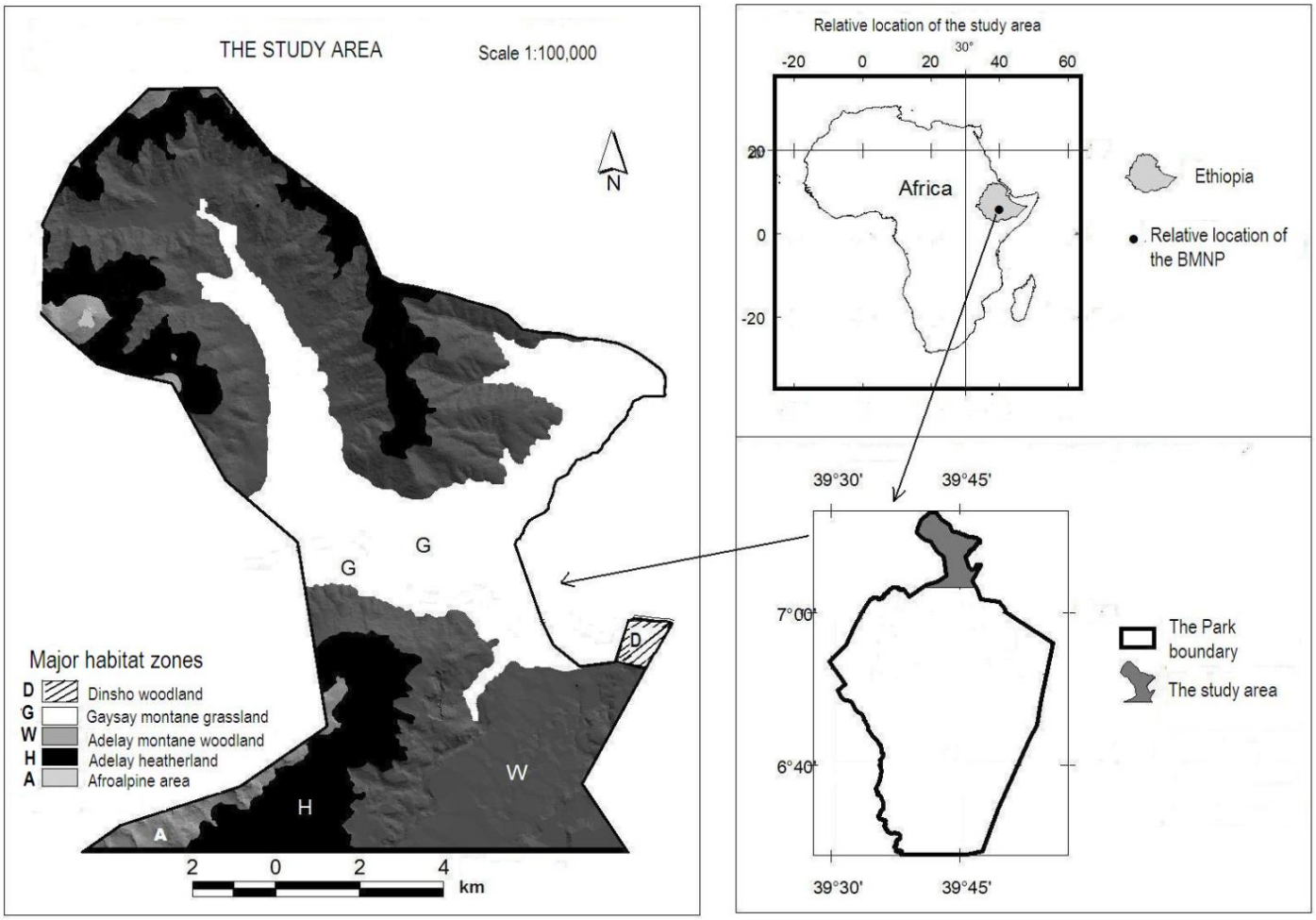


**Figure 1.** Location map of the study area with proposed extension.

isolated sites, namely Dinsho (Park headquarters) and Adelay Mountain. Because of the distinct dominant vegetation types in the area, the vegetation cover was estimated by measuring and recording way points at different key locations along the borders of each dominant vegetation type using GPS and a Silva compass. The size of the area covered by each vegetation types was calculated using Arc View GIS software.

Habitat parameters such as the dominant vegetation composition, structure (height), cover size, and incidences of browsing were collected by using randomly laid square and circular plots. Habitat-use and availability data were collected on MN that were not individually recognized (e.g. visual sightings or signs) but habitat availability and habitat-utilization were recorded when visual sightings and sign of MN were observed during the transect walks. When animals were encountered during the census, the vegetation type they were in was recorded along with notes of their activities (e.g., feeding, drinking, standing, moving, grooming) (Morrison et al., 1998). Habitat and vegetation information were collected in circular plots laid out randomly. At each sample point, a circular plot (100 $m^2$) was established with two smaller plots nested within. The bigger plot was labelled as 'tree plot' with an area size of 100 $m^2$ (r = 5.64 m), the medium as 'shrub plot' with an area size of 10 $m^2$ (r = 1.78 m) and the smallest as 'herb plot' with an area size of 1 $m^2$ (r = 0.56 m). Plot location along transects was not corrected for slope but plot area was measured as flat. Parameters that were measured in each 100 $m^2$ plot included geographic position, altitude, slope, tree density and height, diameter at breast height (DBH), canopy openness and visibility. Shrub height and ground cover were measured in 10 and 1 $m^2$ plots, respectively.

In Dinsho, three randomly laid transect lines in a north to south direction at 20°, starting from the base of the Sanctuary in the south were established. Eight percent of the area was covered as sample. Plots were randomly laid with a minimum distance of 200 m between sampling plots plus a random number between 0 and 50 m. A total of 31 circular plots of 100 $m^2$ area, each of them having 2 plots established randomly along the transect lines. In Adelay woodland, three transects, totaling 6.7 km running in northwesterly direction were randomly established with a minimum of 1,500 m distances in between. A total of 71 circular plots of 100 $m^2$ area, each of them having 2 plots were randomly laid on three transect lines with a minimum distance of 75 m between sampling plots. Three percent of the total area was sampled in this area.

The definition of Pietrzykowski et al. (2003) of patch size was used to define patch sizes in this study. Any vegetation cover with similar characteristics, mainly of species type was pooled together as a patch within randomly laid plots of 100 $m^2$ each. Slope information along with the numbers of MN observed was obtained from the raw data collected by Hillman from 1983 to 1985. The study area was divided into five slope categories: level to gentle slope or flat with slope degrees varied between 0.00 and 5.70;

moderate slope ranges between 5.70 and 16.25; strong to steep slope or steep ranges between 16.25 and 36.86; very steep slope ranges between 36.28 and 45.00; and extremely slope or cliff ranges between 45:00 and 90.00.

Vegetation use index was developed to compare availability of vegetation types to their respective use in order to determine which vegetation types were used most (Garshelis, 2000; Johnson, 1980; Morrison et al., 1998; Rondinini et al., 2004). Vegetation use indexes were determined based on vegetation and slope description data, and number of studied animals observed in each slope category and vegetation types. Vegetation variables that represented unused habitats had a value of UI = 0, while optimum use was represented by UI = 1. Five assumptions were made on how VUI values varied between 0 and 1 in relation to the use of the vegetation types to MN: a) MN assumed to be distributed randomly in the habitat; b) MN assumed to have free access to all vegetation types within the survey area; c) numbers of MN in a given vegetation type indicates its level of use; D) optimum habitat for the MN assumed to fall within the 95% Confidence Internals of a given vegetation parameters. Percent of vegetation visibility, slope, canopy closure/openness, shrub cover, grass/ground cover and shrub height were estimated using descriptive vegetation data collected from woodlands of Adelay and Dinsho habitats.

#### Data analysis

Vegetation preference index was calculated as the ratio between the proportion/number of MN observed in a given vegetation type to the proportion of area covered by a given vegetation. The index varied from 0 (total avoidance) through 1.0 (high use).

$$I_{ik} = N_{ik}/O_i$$

Where $O_i$ is the percentage of the observed area (sampled area) covered by vegetation type $i$, and $N_{ik}$ is the percentage of all observations of MN species $k$ which were recorded in vegetation type $i$. The vegetation uses were ranked based on the observed abundances of MN versus the area coverage of respective vegetation types.

Linear regression was used to test an alternate hypothesis that the slope is different from zero ($b \neq 0$) between levels of browsing and vegetation heights and/or patch size in different vegetation types. $y = a + bx$; where: $Y$ = levels of browsing (dependent variable); $a$ = the intercept (the value of y when x=0); $b$= slope; and $x$ = patch size and/or vegetation height (predictor, explanatory variable). Descriptive statistics, T-test and ANOVA were used to characterize and compare habitat parameters and vegetation types between habitat types (Datiko and Bekele, 2011). Descriptive statistics was used to analyze habitat suitability and use indexes based on the abundance estimate made during the census period and incidences of browsing measurements during habitat survey. SPSS version 16 statistical software package was used to analyze the data (SPSS Inc., Chicago, IL, USA).

## RESULTS

Major habitat types and landforms (slope classes) in the study area that MN commonly associated with included woodland and grassland habitats, both of which lie below 3400 m asl. The percent of slopes and land form in degrees is given in Table 1. A large proportion of the MN preferred to occupy landform categories between 11 and 30%, which falls within moderate slope category. The association between percent slope and levels of browsing were not significantly different, although browsing decreases as slope percent increases more in Dinsho than Adelay woodland.

In Gaysay grassland habitat, more than half (58%) is classed as open grassland, and is dominated by genera of *Andropogon*, *Bromus*, *Festuca* and *Poa*. The second largest (14%) vegetation type in the grassland is collectively recognized as *Artemisia* bush, of which *Artemisia afra* is the predominant plant species. Marshy grassland habitat represented about 10% of the area covered by grasses and sedges of especially the genera of *Cyperus* and *Scirpus*. The rest of the area is covered with *Helichrysum* bush (6%), with *Helichrysum splendidum* as the dominant plant species; mixed vegetation (9%), which represents more than two species within the measured quadrats, and *Hypericum* bush (3%), which has *Hypericum revolutum* as a predominant plant species. The proportional cover of vegetation types showed very high significant difference (*Artemisia* bush: $F_{44} = 4.354$, $P < 0.001$; *Helichrysum* bush: $F_{42} = 5.385$, $P < 0.001$; *Hypericum* bush: $F_{32} = 4.360$, $P < 0.001$; marshy grassland: $F_{19} = 16.565$, $P < 0.001$; open grassland: $F_{64} = 29.515$, $P < 0.001$; and mixed vegetation: $F_{57} = 3.551$, $P < 0.001$). The vegetation distribution across Gaysay area was not uniform. Vegetation heights also showed very high significant difference among the vegetation types ($F_7 = 98.408$, $P < 0.001$) and the observed average height was 42 cm, which includes 56% of the vegetation cover in the area. The tallest vegetation type was *Artemisia* bush with an average height of 81 cm, while the shortest is open grassland that reached an average height of 14 cm (Figure 2). Most of the vegetation in Gaysay grassland was under the reach of MN for browsing in terms of height. Dinsho woodland was predominantly covered by four vegetation types: *Hagenia/Juniperus* woodland (74%), *Hypericum* bush (15%), *Euphorbia/Solanum* bush (7%), and open montane grassland dotted with heavily browsed *Hypericum* bush (4%).

Adelay woodland shares common vegetation features such as tree density and dominant height with Dinsho Sanctuary (Table 2). Almost 65% of the area was covered by *Hagenia abyssinica* and *Juniperus procera*, commonly called *Hagenia/Juniperus* woodland. *Hypericum* bush (with dominant plant species of *H. revolutum*) and heather (with dominant plant species of *Erica arborea*) cover an equal proportion (12%) of the area. *Hypericum* woodland accounts for about 9%, while montane open grassland for 2% of the area cover.

Feeding is the dominant activity of MN in Gaysay grassland while standing under cover is the dominant activity in Dinsho woodland. Drinking is less frequent in Dinsho woodland compared to other habitat types (Figure 3).

*Hypericum* bush ranks highest in terms of supporting more numbers of MN (Table 3) while open grassland was

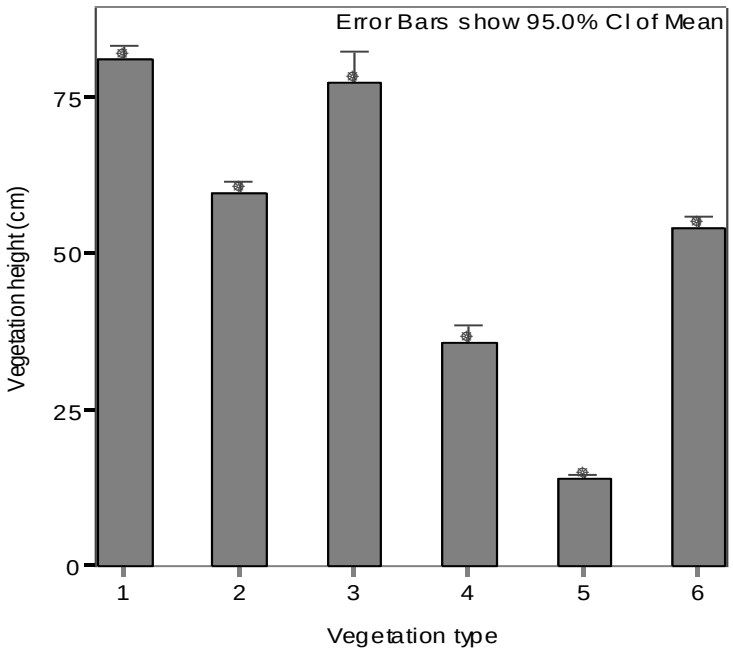


**Figure 2.** Height of major vegetation types in Gaysay grassland habitat (numbers on x-axis represent: 1= *Artemesia* bush; 2= *Helichrysum* bush; 3 = *Hypericum* bush; 4 = Marshy grassland; 5 = Open grassland; and 6 = Mixed vegetation).

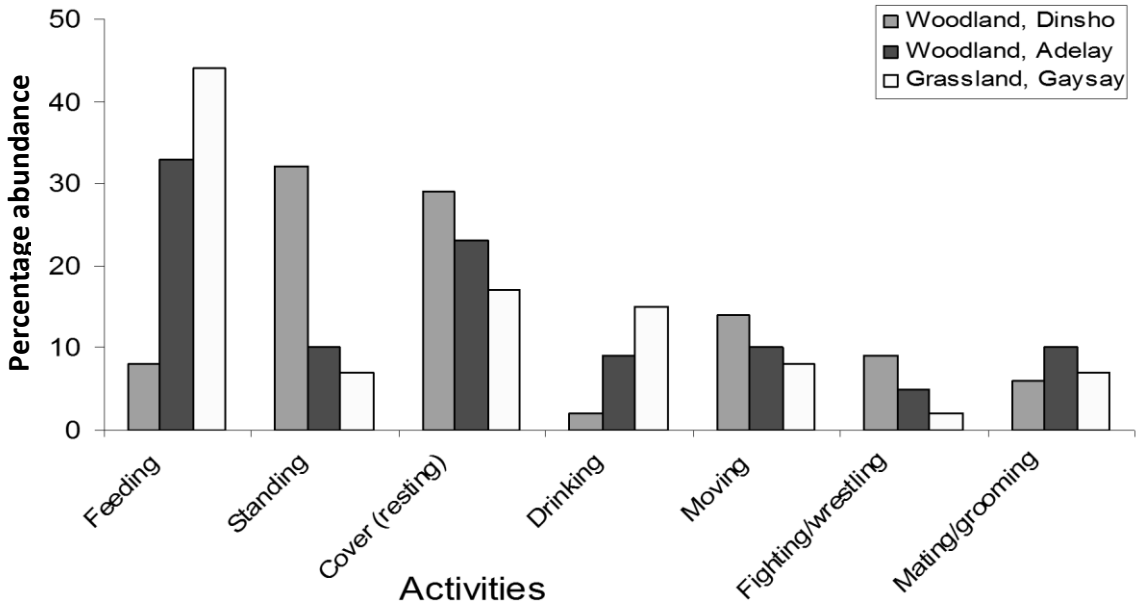


**Figure 3.** Proportion of activities displayed by mountain nyala in grassland and woodland habitat types in different study sites.

the least when the vegetation types were compared by their relative availability as determined from area coverage. From commonly occurring plant species in Gaysay grassland habitat, *H. revolutum* was heavily browsed species while *H. splendidum* was the least (Figure 4). Heavily browsed *H. revolutum* plant species was the result of large number of MN in the area.

In Dinsho woodland, when compared to availability, vegetation on patchy areas of grasses was the most utilized while the vegetation dominated by *Euphorbia* and

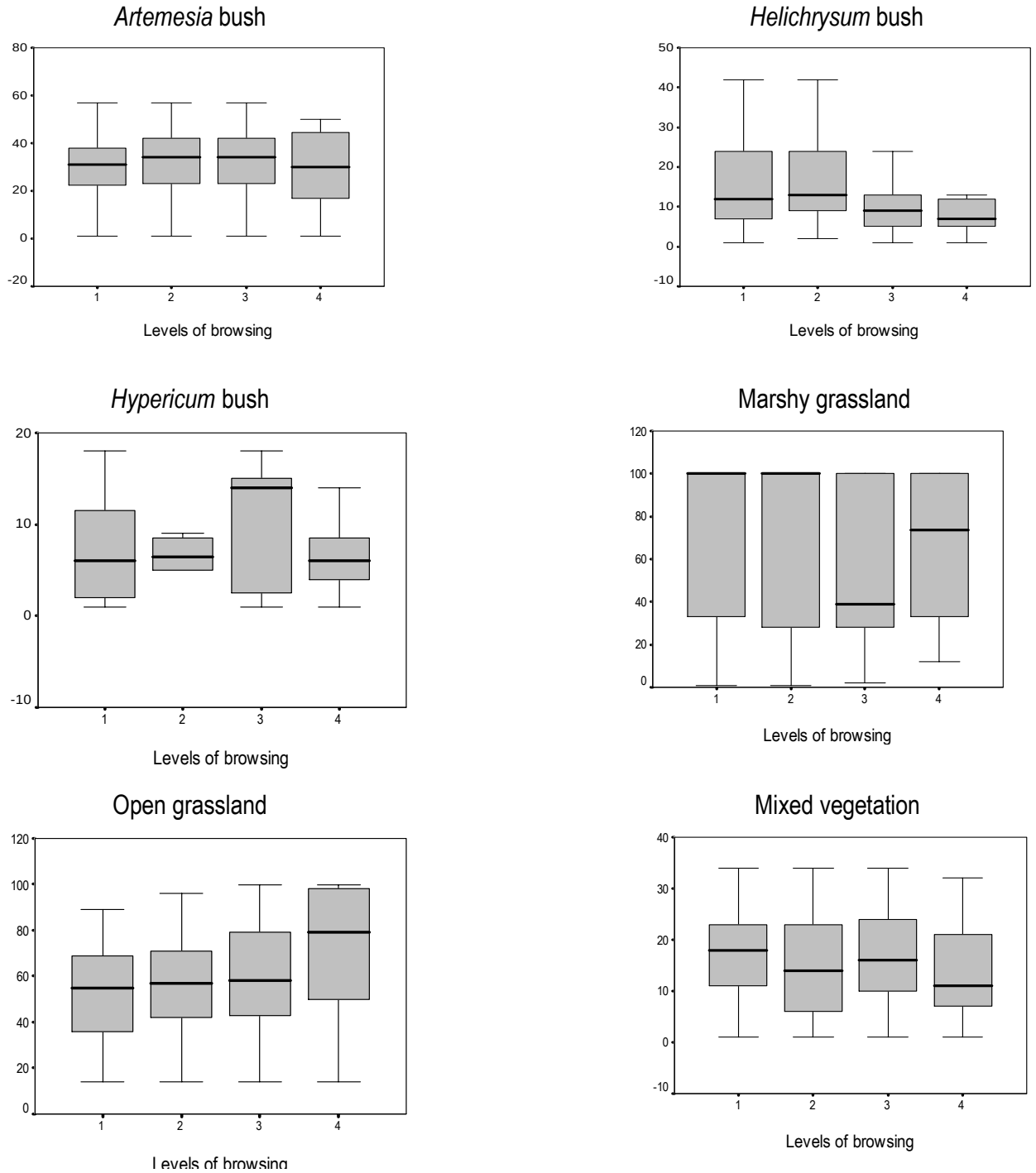


**Figure 4.** The relationship between patch size ($m^2$) and levels of browsing in different vegetation types (numbers on x-axis refer: 1= not browsed, 2 = lightly browsed, 3 = moderately browsed, and 4 = heavily browsed). The box-plots show error bars at 95% CI of mean.

*Solanum* bush were the least utilized. Similarly, in Adelay woodland, vegetation on patchy areas of grasses was the most utilized while vegetation dominated by *H. abyssinica* and *J. procera* were the least. *H. abyssinica* tree is often beyond the reach of MN, however, the animals were observed feeding on fallen leaves of the tree (Table 4). In woodland habitats, levels of browsing were negatively influenced by heights of the shrub layer. Negative but significant correlation was observed between levels of browsing and shrub height in Dinsho woodland

**Table 1.** Slope categories and their occupancy by the mountain nyala.

| Slope categories (degree) | Slope (%) | Proportional availability of areas (%) | Observed animals (O) | Expected animals (E) | O-E* | **Use rank |
|---|---|---|---|---|---|---|
| 0.00 – 5.70 | 0 – 10 | 43 | 9252 | 7583 | 1669 | 2 |
| 5.70 – 16.25 | 11 – 30 | 24 | 6125 | 4232 | 1893 | 1 |
| 16.25 – 36.86 | 31 – 75 | 12 | 2245 | 2116 | 129 | 3 |
| 36.28 – 45.00 | 76– 100 | 11 | 12 | 1940 | -1928 | 5 |
| 45.00 – 90.00 | >100 | 10 | 0 | 1763 | -1763 | 4 |

* Numbers of observed animals (O) minus expected numbers (E). **The rank given by consecutive numbers with '1' representing the highest use value.

**Table 2.** Quantitative description of vegetation in the woodland habitats.

| Parameters | Sites | Mean ± SE | Df(between, within) | F | P value |
|---|---|---|---|---|---|
| Tree density (no./ha) | Adelay Woodland | 115 ± 3.8 | 1 , 125 | 1.08 | 0.300 |
| | Dinsho Woodland | 108 ± 4.4 | - | 2.00 | - |
| | Total | 113 ± 3.0 | - | | - |
| Dominant height (m) | Adelay Woodland | 26 ± 1.4 | 1 , 79 | 9.13 | 0.003* |
| | Dinsho Woodland | 19 ± 1.4 | - | 3.00 | - |
| | Total | 24 ± 1.1 | - | - | - |
| *Hagenia* DBH (cm) | Adelay Woodland | 79 ± 5.1 | 1 , 22 | 3.08 | 0.093 |
| | Dinsho Woodland | 63 ± 3.6 | - | 7.00 | - |
| | Total | 75 ± 4.1 | - | - | - |
| J*uniperus* DBH (cm) | Adelay Woodland | 74 ± 6.2 | 1, 99 | 15.89 | 0.000** |
| | Dinsho Woodland | 34 ± 5.1 | - | 93.00 | - |
| | Total | 62 ± 4.9 | - | | - |
| *Hypericum* DBH (cm) | Adelay Woodland | 16 ± 4.3 | 1, 12 | 0.28 | 0.604 |
| | Dinsho Woodland | 12 ± 2.2 | - | 4.00 | - |
| | Total | 14 ± 3.1 | - | - | - |

Significant at 0.01* and 0.001** level.

(r = -0.680, $P < 0.001$), but the correlation was not significant in Adelay woodland.

When compared to availability, open montane grassland was the most utilized vegetation type while the vegetation in *Hagenia* and *Juniperus* woodland is the least in Dinsho woodland (Table 4). Similarly, in Adelay woodland, open montane grassland was the most utilized, and *Hagenia* and *Juniperus* woodland the least. *H. abyssinica* tree is often beyond the reach of mountain nyala, however, they were observed feeding on fallen leaves from the tree.

Vegetation suitability ranges were extrapolated from descriptive vegetation data collected from woodlands (Adelay and Dinsho) of the study area. Accordingly, habitat with canopy closure range between 90 and 93% was considered to be suitable cover range to MN. Shrub cover suitability to the animal ranged between 13 and 19% with optimum suitability at 15%. Visibility that ranged between 56 and 63% was considered to be suitable to MN with optimum at 59% visibility. Habitats with slopes category between 20 and 25% were considered suitable with optimum at 22%. Woodland habitat with grass cover between 73 and 87% was considered to be suitable, with optimum suitability at 60% grass cover. Shrub height suitability ranged between 138 and 154 cm with optimum suitability at 142 cm. Shrubs within the reach of MN height were considered as suitable potential source of browse.

When all vegetation types were pooled together for analysis, level of browsing in grassland habitat decreased significantly ($F_{3277} = 566.310$, $P < 0.001$) with increase in vegetation height, but increased with increase in patch sizes ($F_{3272} = 487.481$, $P < 0.001$). As illustrated by linear regression, the overall relationship between browsing and

**Table 3.** Vegetation Use Index based on vegetation availability and abundance for MN in Gaysay grassland.

| Vegetation types | Proportional area coverage (%) | Observed animals (%) | Vegetation use index | *Rank based on the index value |
|---|---|---|---|---|
| *Artemisia* bush | 14 | 28 | 0.7 | 3 |
| *Helichrysum* bush | 6 | 3 | 0.2 | 5 |
| *Hypericum* bush | 3 | 8 | 1.0 | 1 |
| Marshy rassland | 10 | 14 | 0.5 | 4 |
| Open Grassland | 58 | 25 | 0.1 | 6 |
| Mixed vegetation | 9 | 22 | 0.9 | 2 |
| Total (%) | 100 | 100 | - | - |

*The rank was given by consecutive numbers with '1' representing the highest use value.

**Table 4.** Vegetation Use Index based on vegetation availability and abundance of mountain nyala in Dinsho and Adelay woodlands.

| Vegetation/habitat type | Proportional area coverage (%) | Observed animals (%) | Vegetation suitability index | Rank based on the index value |
|---|---|---|---|---|
| **Dinsho woodland** | | | | |
| *Hagenia* and *Juniperus* woodland | 68 | 59 | 0.5 | 3 |
| *Hypericum* bush | 18 | 21 | 0.8 | 2 |
| *Euphorbia* and *Solanum* bush | 5 | 4 | 0.4 | 4 |
| Open Momtane grassland | 9 | 16 | 10 | 1 |
| Total | 100 | 100 | - | - |
| **Adelay woodland** | | | | |
| *Hagenia* and *Juniperus* woodland | 65 | 31 | 0.1 | 5 |
| *Hypericum* woodland | 9 | 23 | 0.5 | 2 |
| *Hypericum* bush | 12 | 28 | 0.4 | 3 |
| Open montane grassland | 2 | 10 | 1.0 | 1 |
| Heatherlan | 12 | 8 | 0.2 | 4 |
| Total | 100 | 100 | | |

*The rank was given by consecutive numbers with '1' representing the highest use value.

vegetation height in Gaysay grassland area was expressed as: Levels of browsing = 3.10 + -0.01 × Vegetation height; while browsing with patch size was expressed as: Levels of browsing = 1.92 + 0.01 × Patch size (Figure 4). Positive correlation was observed between patch size and level of browsing for *Artemisia* bush and open grassland, while negative correlation was the case for the other of vegetation types. The relationships between levels of browsing and vegetation heights in most vegetation types were negatively correlated except for *Helichrysum* bush.

The correlation between levels of browsing and vegetation heights in most vegetation types in Gaysay grassland area were negatively correlated except for *Helichrysum* bush. In woodland habitats, shrub height of *H. revolutum* was negatively correlated (r = -0.706) with levels of browsing ($F_{44}$ = 37.759, $P$ < 0.001) in Dinsho woodland, but the correlation was not significant ($F_{101}$ = 1.672, $P$ > 0.05) in Adelay woodland (r = -0.164).

## DISCUSSION

The present study suggested that vegetation type, height and patch size have considerable influence on how MN select and use their habitat. All vegetation types were considered accessible to MN in Gaysay area as the average vegetation height was less than one meter, which is within the reaches of the nyala. MN preferentially selected and used *H. revolutum* and *H. splendidum.* These preferred vegetation types were those that were the least available in the habitat during the study period. This is in agreement with Evangelista et al. (2008) that stated the diet of the MN fluctuated with seasonal changes, habitat type and land-use activities. Different studies showed presence of an animal or a group of

animals recorded the activities such as feeding/browsing, resting and hiding. Furthermore, the studies indicated the habitat or vegetation type used by the species (Morrison et al., 1998). Similarly, this study identified feeding habit of MN in the different vegetation types of the BMNP. The state of feeding activates of MN could affect the vegetation and tree size within the Park. One of the tree species used, *H. revolutum*, potentially grows as a tree with in the park but in Gaysay grassland area the species is a bush attaining a height of only less than a meter. This might be partly due to apparent browsing of the tree by the animal in this grassland habitat. Similar species like St. John's wort (*Hypericum*), Lady's mantle (*Alchemilla*) and goose grass (*Galium*) were also observed as the commonly browsed plants by mountain nyala (Kingdon, 1997). Hillman and Hillman (1987) noted additional plant species such as *Artemesia afra*, *Carduus ellenbeckii*, *Kniphofia foliosa*, *Streblochaete longiarista* and *H. abyssinica* that serve as feed for MN. Of the varieties of vegetation type utilized, the present study revealed *H. revolutum* as the most preferred vegetation type by MN.

Studies by Fritz et al. (1996) showed that habitat choices by large herbivores are often associated with the abundance of high quality food resources. However, although herbivores are generally attracted to a preferred vegetation, the spatial relationship between a preferred and a non-preferred one is of paramount importance in driving the system dynamics (Illius and O'Connor, 2000; Palmer et al., 2003). Generally, the study indicated that incidence of browsing for dominant vegetation type (open grassland) increased with increasing patch size. Similar result was reported by Pietrzykowski et al. (2003) that browsing was greater in larger patches than smaller ones. The degree of accessibility and suitability of the Dinsho and Adelay woodland habitats to MN were minimal when compared to Gaysay grassland habitat although mature *H. abyssinica* and *J. procera* trees provided shelter to the species.

The result showed that MN more often stand, take cover and rest than feed in the woodland habitats particularly in Dinsho woodland. The dominant vegetation types in *Hagenia*/*Juniperus* habitat were beyond the reach of MN. But the shrub layer dominated by *H. revolutum* species (within the reach of the animal) was where relatively high abundance of MN was observed feeding. *H. revolutum* was among the top suitable species, as determined by suitability index, to MN in the woodland habitats. Vegetation suitability indexes are assumed to represent the rate of species-habitat relationships (Schamberger et al., 1982; Morrison et al., 1998). A study by Morrison et al. (1998) also showed that suitable environmental or habitat factors have influence on the occurrence and abundance of a wildlife species as similar to this study.

MN used the woodland and heath as a cover and as refuge presumably to get away from the interferences of livestock and local people, which were so prevalent in the grassland area. The woodland habitat also provided shade to MN during sunny days. Regular visits of MN to the agricultural field, as observed in Dinsho, could suggest that the species has limited feeding resources within the habitat range that they currently occupy. This indicated that there is a need for extending the species range to minimize close contact of the species with crops on the agricultural field and livestock.

## CONCLUSION AND RECOMMENDATION

The study revealed that the Gassey grassland with bush was the most suitable habitat for MN. *H. revolutum* is the most selected and preferred plant species for the species in the BMNP. Moreover, transitional areas between woodland and grassland habitats dominated by bushy growth of and *Helichrysum* spp. were the most preferred habitats of MN. The Adelay and Disho woodlands that consisted of tall trees beyond the reach of MN to browse on preferred species of plants were indicated as less frequently used habitats by MN. However, the different habitat and vegetation types utilized by the MN were getting deteriorated. Hence, urgent conservation measures that could restore or rehabilitate the habitats should be put in place in order to maintain these habitats and conserve the remnant, endangered and endemic mountain nyala species in Ethiopia.

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