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The Effects of Altitudinal Gradients in Botanical Composition and Dry Matter Yield of Herbaceous Species of Natural Grazing Lands of West Shoa, Ethiopia

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Abstract
The study was conducted at Meta Robi district, west Shoa zone of Oromia Regional State in October 2015 with the objectives to assess the effects of altitudinal gradients on grazing lands vegetation patterns with the objectives of assessing the vegetation pattern quantify the biomass yield of the grazing land along with different altitudinal gradients of meta-robi district. The Vegetation assessment was conducted with transect walk with in 4-5kms of in 270 quadrat 90 from each three altitudes having 1mx1m (for herbs layer) quadrant size. The botanical composition was determined by harvesting the herbaceous randomly selected samples (1m × 1m quadrat) within each transect at height of 0–5cm above the ground. Each botanical components were weighed separately to determine the contribution of each component in the total DM yield of the pasture (ILCA 1990). The DM yield of each botanical component in each plot was determined by drying a representative sample in an oven at 70 °C for 48h until constant weight followed by weighing (ILCA, 1990). A total of twenty-four herbaceous species are identified, at the study area. Among them 62.5% were different grasses species, 8.3% were legume species, 25% were forbs or weeds species and 4.2% were sedges. In life form 75% were annuals, while 25% were perennials in life forms. Higher botanical composition of grass species were recorded at lower altitude while higher legumes botanical composition was recorded at upper altitude. The highest dry matter yield of herbaceous species was recorded at lower altitude.
Keywords: Botanical composition , dry matter yield, altitudes, Herbaceous species , Grasses and legumes

Introduction

In Ethiopia vegetation species diversity differs along altitudinal gradient in different layers at different scales in distributions pattern (Rathod 2014). This is because, altitude is a factor that determines the distribution of climatic factors and land suitability, this influences the crops to be grown, rate of crop growth, natural vegetation types and their species diversity. Natural grasslands constitute the main highland pastures such as grasses, they contain 28 *Trifolium* species out of which eight are endemic (Alemayehu, 2006). Taking the proportion of legumes tends to increase with increasing altitude; particularly above 2200m, there is a wide range of annual and perennial *Trifolium spp* and annual *Medicago spp*. At lower altitudes native legumes are less abundant and commonly have a climbing or sprawling habit with a large variation in their range and density in wet bottomlands. This appears to be only partly due to edaphic differences.

According to Alemayehu (2006), in the lowlands browse and shrubs are dominant plants. The components of species diversity that determine the expression of traits include the number of species present (species richness), their relative abundance (species evenness), presence of the particular species (species composition), the interactions among species (non-additive effects) and the temporal and spatial variation in these properties. The permanent grasslands species composition and richness are influenced by management practices, and site characteristics such as topography, water, nutrient availability and light conditions (Araya et al., 2013).

Forage yield of natural pastures are influenced by altitude, rainfall and soil fertility status (Adane, 2008). The annual dry matter yield of natural pasture in the highlands of Ethiopia was 4.5tones ha^{-1}, while the annual dry matter yield of the natural pasture on infertile and freely drained soil ranged from 1-2tha^{-1} (Alemayehu, 1987). However, the average yield of natural pasture in Northwest lowlands of Ethiopia was 5.4 tones ha^{-1} (Bilatu et al., 2013). Another finding reported that pasture productivity in upland grazing or degraded lands of sloppy area was very low (0.5-1t DM ha^{-1}), in arable land grazing areas 1-3t DM ha^{-1} and in valley bottomland grazing areas ranged from 3-5t DM ha^{-1} (Kasahun et al., 2015). The biomass production of herbaceous species depends on climate, available water and altitude. The altitude becomes a limiting factor for plant growth. The higher the altitude is the lower the atmospheric temperature and higher precipitation, which is more likely to limit plant growth (Chollet et al., 2014).

According to Yadessa et al (2016), the dry matter yield obtained from natural grazing land differs along with different agro ecology of the study area. However the most dominant desirable species in area were not identified and recorded. Therefore this study was undertaken with objectives to identify the effects of altitudinal gradients on botanical composition and dry matter yields of herbaceous species.

Materials and Method

The study was undertaken between June to October 2015 during the 2015/16 growing season on communal grazing area of Meta Robi of western Shoa zone of western highlands of Ethiopia. Meta-Robi district is 110 km far from the capital Addis Ababa, and located at 13°59′ N, 38°28′ E at an altitude of 2473msl above sea level (figure1).

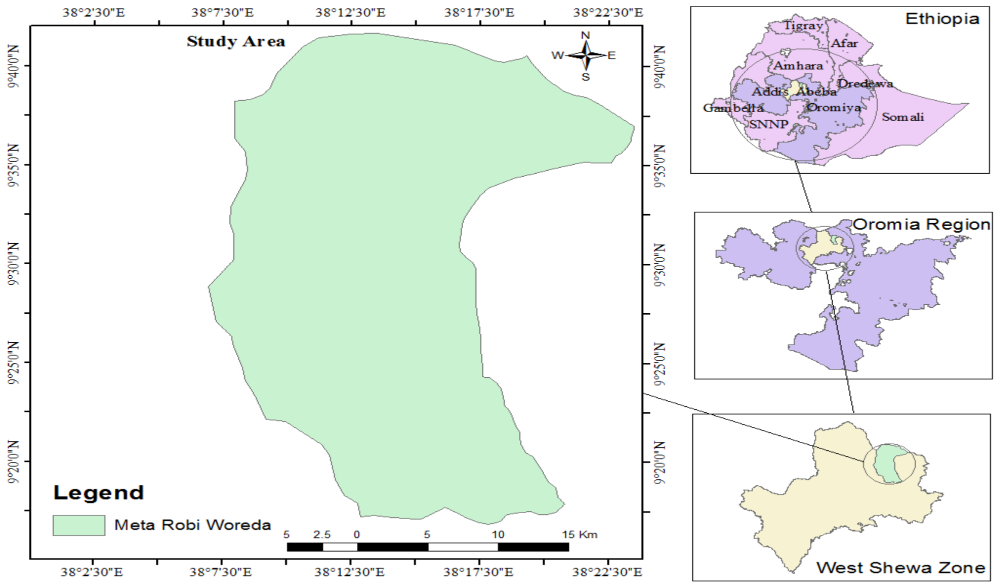

Figure1.location of the study area (EMA 2015)

The mean annual rainfall of the study area in 2015 (figure2) was in mm, ranging between 503.2 mm and 1573mm and was highly variable among years. The main rainy season was July to September. The mean annual minimum and maximum air temperatures of the experimental site were 15 °C and 31 °C, respectively (figure2). The experimental site was characterized by flat land, valley, mountains and rugged area estimated to be 60%, 8%, 9% and 23% respectively. The soil types of the district are classified into humic Nitosols (one of the best and most fertile soil, can suffer acidity and phosphorous fixation, and it becomes very erodible). The 0 to 20 cm soil layer of the experimental site was characterized by a pH of 4.94, a total N content of 0.296%, available phosphorus at (P) content of 1.16ppm/kg, organic carbon of 0.98% and 20.37ppm/kg of cations exchange capacity (Yadessa et al 2016). Visual observations in most parts of the grazing areas of the study site were conducted.

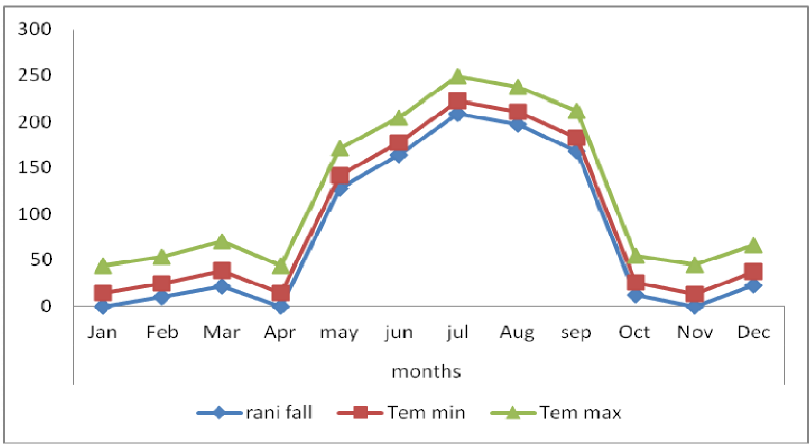

Figure 2.Rain fall and temperature of the study area: Source (EMA 2015)

Site selection and field layout

Site selection of vegetation assessment was conducted with discussions apprehended with the community members, elders in the kebeles and agricultural experts in the office who know about the major grazing areas and their locations. The numbers of sites in the district were decided based up on proportional basis of the available grazing lands in the district. The study district was divided into three based on altitude variations using geographical point system (GPS) 1650-2000msl, lower altitude, 2000-2350msl, as mid altitude and 2350-2700msl as higher altitude (Holechek et al., 1998), as it is widely argued, altitude has an important influence on the distribution, growth, and diversity of rangeland plants (Gemedo. 2004; Getachew et al., 2008).

Each altitudinal site was further classified in to the three grazing sites, moving from four to five Kms, considering the vegetation status of the study area discussing with district livestock agency further each altitudes classified in to three locations or sites. A 200 m x 50m at 4kms interval transect area was divided sampled using 1m x 1m, quadrat for herbaceous species, (Karami et al*.,* 2015).

Experimental design and treatments

The study was conducted using a three altitudinal gradient variations with 350msl as (1650-2000msl, 2000msl-2350msl and 2350-2700msls (Holechek et al*.,* 1998). The design of this experiment was factorial experiment arranged as randomized complete block design with three replications. Altitudinal gradients variations, transects and quadrat numbers were considered as treatments replications and plots.

The transects was laid out with 200m x50m at 4kms interval. The total number of treatments during the study were three treatments (three altitudinal variations).

Sampling procedures

Botanical composition

The botanical composition was determined by harvesting the herbaceous randomly selected samples (1m × 1m quadrat) within each transect at height of 0–5cm above the ground. Immediately after harvesting, the total fresh weight of the pasture in each plot was measured using a sensitive balance and then the sample in each plot was further classified into different botanical compositions based on biomass (grass, herbaceous legume and forbs) and each botanical components were weighed separately to determine the contribution of each component in the total DM yield of the pasture (ILCA 1990). Furthermore all species were listed, recorded and identified based on, their morphological, structural and floristic characteristics of each botanical component. Nomenclature was done following Fromann and Persson (1974), Edwards et al, (1995, 1997, 2000) and Hedberg et al, (2003),nomenclature follows. For those species that were difficult to identify in the field, herbarium specimens were collected and transported to the Herbarium of Addis Ababa University, Ethiopia, for further identification.

Dry matter yield.

The DM yield of each botanical component in each plot was determined by drying a representative sample in an oven at 70 °C for 48h until constant weight followed by weighing (ILCA, 1990). The DM yield of each botanical component was calculated separately and added together to provide the total dry matter yield of the plot, and the final dry matter yield was reported in tones per hectare (t ha^{-1}).

Data Analysis

The data acquired from assessments of vegetation (dry matter and botanical composition) were analyzed by analysis of variance (ANOVA) using the General Linear Model Procedure of SAS (SAS, 2002).

Results and Discussion

Characteristics of herbaceous species Botanical composition

Table 1 .Herbaceous species of the study area

No	Local Name	Botanical name	Family name	Functional group	Life forms	Palatability
1	Qamatee	*A. aspera*	Amaranthaceae	Forbs	Annual	P
2	Ballammi	*A. abysincus*	Poaceae	Grass	Annual	HP
3	Keeloo	*B. pilosa*	Astraceae	Forbs	Annual	HP
4	Adaa	*B. biternata*	Astraceae	Forbs	Annual	HP
5	Keesuu	*C. octandrum*	Poaceae	Forbs	Annual	LP
6	Citaa	*C .gayana*	Poaceae	Grass	Perennial	HP
7	Migira	*C. pycnothrix*	Poaceae	Grass	Annual	HP
8	Coqorsa	*C. dactylon*	Poaceae	Grass	perennial	HP
9	Qunnii	*C. rotundus*	cypraceae	Sedges	Perennial	LP
10	Marga qalla	*D. abyssinica*	Poaceae	Grass	Annual	p
11	Sardo harre	*E. indica*	Poaceae	Grass	Annual	p
12	Xaafii sinbiro	*E. tenuifolia*	Poaceae	Grass	annual	HP
13	Tufo	*G. scabra*	Compositeae	Forbs	Annual	P
14	Dagalaa	*H. anthistirode*	Poaceae	Grass	Perennial	P
15	Sembeliet	*H .rufa*	Poaceae	Grass	Annual	LP
16	Qorxobbii	*O. gratisimum*	Poaceae	Grass- like	Annual	LP
17	Mujjaa	*P. dustum*	Poaceae	Grass	Annual	HP
18	MIgra	*S. acromelacea*	Poaceae	Grass	Annual	p
19	Mujja	*S. polystachya*	Poaceae	Grass	Annual	HP
20	Murii	*S. pyramidalis*	Poaceae	Grass	Perennial	HP
21	Amekela	*T. terrestris*	Acanthaceae	Forbs	annual	p
22	Siddisa	*T. ruppellianum*	Leguminaceae	Legume	Annual	HP
23	Maget	*T. schuding*	Leguminaceae	Legume	Annual	HP
24	Sardoo	*P. clandestinum*	Poaceae	Grass	Perennial	LP

A total of twenty-four herbaceous species are identified, at the study area. Among them 62.5% were different grasses species, 8.3% were legume species, 25% were forbs or weeds species and 4.2% were sedges. In life form 75% were annuals, while 25% were perennials in life forms (Table 1)

The herbaceous species indentified were; *Andropogon abysincus, Cynodon dactylon, Eragrostis tenuifolia, Sporobolus pyramidalis, Eleusine africana, Chloris pycnothrix, Pennisetum clandestinum, Hyparrhenia rufa, Lolium multiflorum, Digitaria abyssinica, Cerastium octandrum, Snowdenia polystachya, Setaria acromelacea, Eleusine jagrie, Eleusine flocci folia, Eleusine indica, Cyperus rotundus, Trifolium ruppellianum, Guizotia scabra, Bidens biternata, Amarhantus aspera and Bidens pilosa;* were major herbaceous species identified in the study area which were similar what was indicated by (Alemayehu, 2006 and Kasahun *et al.,* 2015).

Most of the herbaceous species identified at the study area have similarities with previously reported herbaceous species composition in the highlands of Ethiopia indicating the high lands are rich in pasture composition particularly indigenous grasses and legumes (Alemayehu, 2006 and Kasahun *et al*., 2015).

Botanical composition

The SAS analytical results of the botanical composition of herbaceous species disclosed that, the legume botanical composition of natural grasslands were highly influenced by variations of altitudinal gradients than grass herbaceous species (Table 3).The effects of altitudinal gradients had affected significantly, legume herbaceous species at ($P<0.01$) in lustrated in (Table 3).The herbaceous legume botanical composition was affected at ($P<0.0001$). The current results indicated that more grass botanical composition was found between altitudes 1650-2000msl. Whereas, botanical composition of herbaceous legume was more concentrated at upper (2350-2700msl). Legume component showed a decrease trend towards altitude decrease and this confirmed in other similar agro ecologies of high and mid altitudes of Horo and Guduru districts in Oromia region Ethiopia by (Kasahun *et al.,* 2015). According to Alemayehu (2006), the trends increasing and decreasing of legume botanical composition along altitudinal gradients due to high grazing intensity. As revealed from this study, the fact that legume species less at lower altitude might be due to lower altitude rich in organic matter which concentrated and deposited at bottom due erosion from upper altitude. The organic matter availability favors the growth of grass species and dominate over legumes. This was confirmed by Chang Wang *et al*. (2007), the fact that, soil organic matter, nutrients and soil moisture contents were greatest at lower altitudes and therefore the relatively high nutrient availability made a few species so robust that the less vigorous species were excluded, the ability of a species to utilize resources becomes more important in the presence of high nutrient availabilities, so the plant species that can grow taller and more quickly will become more abundant. The reason of legume botanical composition decline along decrease of altitude is due to edaphic differences (Alemayehu, 2006; Mekonnen and Ali, 2013).

Dry matter yield

Table 2. Botanical composition and dry matter yield of natural pasture

	Botanical compositions (%)			
Treatment	% of Grasses	% of Legumes	% of Forbs	DMY
2300-2700msl	53.922b	37.578[a]	8.433[a]	2.05556[b]
2000-2300msl	57.067[a]	35.189[a]	8.022[b]	2.13333[b]
1650-2000msl	59.922a	31.578[b]	8.433[b]	2.7000 [a]
Mean	58.20000	28.55926	13.30370	2.296296
CV	20.55159	39.19492	63.10475	28.11777
LSD	0.035127	0.032874	0.024655	0.1896
SEM	5.901930	4,776946	0.822514	0.602726
SL	0.0217	<0.0001	<0.0001	<0.0001

[a,b] means in a column with the same category having different supper scripts differ (P<0.05); CV= Coefficient of variations; DMY= Dry matter yield; LSD= Least significance difference; SEM = Standard error of the mean and SL= Significance level.

The analytical results from (Table 2) disclosed that the altitudinal gradients variation had high significantly affected the herbaceous species dry matter yield per of the grassland at (P<0.001). The higher forage biomass yield was recorded at lower altitude and this was due to higher soil organic matter and less acidity where as the lowest dry matter was recorded at upper altitude because of high precipitation causes soil nutrient leaching (Table 2). The current study in agreement with Kasahun *et al*. (2015) at Horo and Guduru districts revealed that, highest DMY was reported at mid-altitude than higher altitude due to hilly topography, large number of equines which have deep grazing habit and larger population density of livestock which selectively feed palatable species of grassland.

The study by Gezahegn et al. (2015), confirms that grasslands are more productive at valleys and bottomlands grazing areas ranged from 3-5 t DM ha^{-1} , whereas grasslands of upper lands and degraded sloppy area were in ranges of (0.5-1 t DM ha^{-1}), which considered as very low. Another findings by Bilatu et al. (2013), confirmed that lowlands are productive grassland in dry matter yield and which was 5.4 tones ha^{-1} in northwest lowlands of Ethiopia.

However the current study was against, Yadessa *et al*. (2016), who reported that 2ton per hectare dry matter yield in each altitudinal gradients and Alemu (2015), who reported that the biomass from higher altitude was higher than both mid and lower altitude.

The current study indicated that the trend of dry matter and increased as results grazing intensity is decreasing with decreasing altitude because the altitude where higher biomass was recorded an area where not suitable for livestock grazing than mid and upper (Table 2)

Conclusions

The major findings of this study were the altitudinal variation had affected both botanical composition and total dry matter yield of the herbaceous species. And more species diversity and total forage biomass production were observed at lower altitudes where is the topography of the grassland rouged and un suitable for grazing animals around valleys.

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