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Quantifying Herbage Mass, Composition and Feed Value of Grass Land as Influenced by Altitude in Western Highlands of Ethiopia

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Abstract
Assement on the status of florisic composition, Biomass and Nutritive value of grass land was conducted in highland and mid altitude areas of Horro and Guduru districts with the objectives of assessing the present status of grazing lands interms of quality and quantity. The study was conducted during the last week of September to the first week October 2014 when much of herbs starts to flower. A total of 25 herbs were identified from grazing lands of the study area, of these 17 grass species (5 annuals and 12 perennial), 3 legume species, 2 sedges and 4 weeds species were identified in both agro ecologies except one grass (Eleusine africana) which was only observed in mid altitude area. Most of grass species were prennials. The herbage yield of grass lands of highland was 2.52 ton per hectare while, that of mid highland was 2.73 t/ha and these were not significantly different ($P>0.05$). The compositions of grasses, legumes and weed and or sedges were 69.6, 28.7 and 2.18 percent respectively for highland while in mid highland it was 73.6, 25.6 and 0.8 percent respectively. The ash content of mid altitude composite herbs (16.9±0.02) was significantly higher ($P<0.001$) than that of highland samples (9.21±0.1). There were no significant differences in crude protein (CP) content herbs harvested between the two agro ecologies.The neutral detergent fiber (NDF) content of mid altitude herb (61.7±.09) was significantly higher ($P<0.001$) than (54.8±0.07) percent reported for highland and Adltitude. The in vitro dry matter digestibility (IVDMD) and metabolisable energy (ME) content of harvested highland herbs were significantly higher ($P<0.01$) than that of mid altitude while there were no significant difference in digestible crude protein (DCP) of herbs between the two agro ecologies.The dry matter digestibilities (DDM) of highland herbs were significantly higher than the mid altitude herbs. Similarily estimated dry matter intake (DMI) and relative feed value (RFV) of samples of herbs of highland were significantly higher ($P<0.001$) than that of mid altitude. The nutritive value of herbage harvested at flowering stage in the present study agro ecology generally indicate well in supplying basic nutritional requierement of livestock but, the low potential yield of the grass lands should be the area of intervention in both highland and mid altitude.
Keywords: Annuals, Herbage yield, Nutrient composition, Prenials

Introduction

The population of livestock of Ethiopia is believed to be the largest in Africa (CSA, 2013). Inadequacy of feed interms of quality and quantity is considered to be critical among the constraints of livestock in the country (Alemayehu 2006, Adugna 2012).

Natural pasture, crop residues, improved pasture and forage and agro-industrial products and the fibrous agricultural residue are major feed resources (Alemayehu 2006, Adugna et al. 2012) in the country. Natural pasture contributes about 57.5 percent of the major feed resources available in the country (CSA, 2013).

The natural pasture which covers the largest portion of animal feed is characterized by seasonal fluctuation in total dry matter (DM) production and nutritional quality as a result of the distinct seasonal variation in plant growth, in relation to the annual rainfall pattern. The size of natural pasture in the country is severely decreasing as a result of expansion of cropping land, urbanization and industrial development, all of which results in proportional decrease in grazing land (Alemayehu, 2002; Zerihun, 2002). The primary productive capacity and pasture quality of native grasslands is low and this is partly attributed due to overgrazing, which results on defoliation, uprooting, trampling and desiccation of grasslands under high grazing presure.

Therefore, evaluation of herbage yield and quality of natural pasture helps to arrive at the correct carrying capacity and stocking rate of the ruminants. This will help in alleviating problems of over stocking. Estimation of yield and chemical composition will also give information to species composition and quality of pasture (Birnin-Yauri et al., 2012). Knowledge on quality of pasture is important as it affects the fibrolytic activity of rumen micro organisms which may be restricted when ruminant animals feed on poor quality forage (Fondevila et al., 1995). Palatability of forage may also be determined when the chemical composition is known because factors that relate to plant's palatability including its chemical composition, particularly the presence of secondary may be known.

Therefore, the present study was designed to assess the prevailing status of grazingland interms of quantity and quality in highland and mid highlands areas of Horro and Guduru districts; West Ethiopia.

MATERIALS AND METHODS

Description of the study site

The study was conducted in Horro and Guduru districts of Horro Guduru Wollega Zone, Western Ethiopia. Horro district is located at 9º 34'N latitude and 37º 6'E longitude, at an altitude that ranges between 1800 – 2835 meters above sea level at 314 km from the capital city of Ethiopia, Addis Ababa. The district has one long rainy season that extends from March to mid October with mean annual precipitation of about 1800 mm (Olana, 2006). Annual average temprature of 13.3 ºC and the soil of the area is predominantly sandy loam (Ayantu et al., 2012). Guduru district is located at 09º 32'N latitude and 37º 30'E at an altitude that ranges between 1500-2296 meters above sea level. It had an annual rainfall ranging between 1350 -1400 mm, and annual average temprature of 20 ºC and the soil of the area is predominantly reddish brown Nitosol and generally clay dominated (Refissa et al., 2012).

Determination of grass biomass and composition

The study was carried out during the last week of September 2013 to mid of October 2013 on enclosed private grazing land, this time was selected as it was early flowering stage of the pasture (Crowder and Chheda, 1982), reach good stand for harvesting and time of paddock feeding practiced in the study areas. There was no controlling system over communal grazing land, as a result it was over grazed and was difficult to harvest. Therefore it was not included in this study. Twenty representative private enclosures, ten from highland and ten from mid altitude were selected by ealderly people and Development agents. Then three samples at quadrat size of 0.5 mx 0.5 m were taken from the selected grazing land from the diagonal at 10 meter difference for each of the two agro ecology by cutting at approximately 2 cm above the ground (Mannetje, 1978) and separated into grass, legume and sedges/weeds components. These samples were immediately weighed by sensetive balance on the field and placed in paper bags, taken to laboratory oven dried at 105 ºCfor 24 hours till constant weight is obtained. Then the dry matter (DM) obtained from different sites were used for extrapolation of total dry matter obtained from hectare of land and grass legume composition was calculated following the method described by Tothil et al (1978);

$$Tdw\ of\ grass\ or\ legume = \frac{Tfw\ of\ grass\ or\ legume}{Sfw\ of\ grass\ or\ legume} * Sdw$$

$$\%\ Composition\ of\ grass\ or\ legume = \frac{Tdw\ of\ grass\ or\ legume}{Gtdw\ of\ all\ the\ species} * 100$$

Where:

T_{fw} = total fresh weight
S_{fw} = sub- sample fresh weight
S_{dw} = sub- sample dry weight
T_{dw} = total dry weight
G_{tdw} = grand total dry weight

While harvesting samples for biomass estimation, encauntered species of grasses, legumes and sedges/weeds that are common and known were identified right on the field and those that were difficult to be identified with scientific name on the field were registered using vernacular name, collected and pressed with plant press and then taken to Addis Ababa University herbarium for identification.

Relative Feed Value (RFV)

RFV is calculated from the estimates of Digestible dry matter (DDM) and dry matter intake (DMI) as follows (Peter J., and Alvaro D. 2004)

1. % DDM = 88.8 – (0.779* %ADF)
2. DMI = 120 / %NDF
3. RFV = (% DDM * DMI)/1.29

Where; DDM = Digestible dry matter, DMI = Dry matter intake, ADF= acid detergent fiber, NDF = neutral detergent fiber

Analytical procedures

Representative feed samples were collected during subsequent visits and stratified based on type and location of harvest. Feed samples were oven-dried and ground to pass a one millimetre sieve size using Whiley mill and put in air tight plastic bag unil required for chemical analysis. Detemination of Dry matter (DM), crude protein (CP), and ash and Ether extract (EE) were determined by proximate analysis (AOAC, 1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined with ANKOM fiber analyzer sequentially by the method of Van Soest et al. (1991). Lignin (ADL) was determined by solubilization of cellulose with H_2SO_4. *In vitro* dry matter digestibilty (IVDMD) was determined using the ANKOM – DAISY procedure by the method of Van Soest and Robertson (1985). Metabolizable energy (ME) and digestible crude protein (DCP) content were estimated using the formula;

$$ME\ (MJ) = 0.17 * IVDMD\ (\%) - 2.0$$ (AAC 1990)

$$DCP\ (g) = 0.929 * CP\ (g) - 3.48$$ (Church and Pond 1982)

Data analysis

The data was first summarized using descriptives stastics for the whole samples. Data on herbage yield and chemical compostion were subjected to the general linear model (GLM) procedure of SAS (2002) statistical package. Means were separated by Tukey pair-wise comparison procedure. The following statistical model was used for data analysis.

$$Y_{ij} = m + L_j + e_{ij,}$$

Where

Y_{ij} = quality and composition of natural pasture

m = overall mean

L_j = the effect of j^{th} location

e_{ij} = random error

Result and Discusions

The type of herbs identified in the present study areas are listed in Table 1 below. A total of 25 herbs were identified from grazing lands of the study area, of these 17 grass species (5 annuals and 12 perennial), 3 legume species, 2 sedges and 4 weeds species were identified in both agro ecologies except one grass (Eleusine africana) which was only observed in mid altitude area.

Among the grass species identified, the major ones are: *pennisetum clandestinum, Eragrostis tenuifolia, Cynodon dactaylon, Digitaria abyssinica, Andropogon abyssinicus, eulisine jaegeri, pennisetum sphacelatum, pennisetum thunbergii,* and *Sporobolus pyramidalis* were the common. *Trifolium rueppellianum, Medicago polymorpha* and *Wiled Vicia sativm* were identified legumes. Two sedges; *Cyperus rotundus* and *Cyperus sesquiflorus* were also identified and the result resmbles that was reported for central plateau of Ethiopian highland and general report for highland Ethiopia (Alemayehu 2006).

Table 1. Species of herbs identified in the study area

Ref. no	Local name	Botanical name	Family name	Presence		Life form
				High land	Mid altitude	
A	**Grass species**					
1	Aganjira	*Eleusine africana*	*Poaceae*		✓	A
2	No name	*Eragrostis paniciforms*	*Poaceae*	✓	✓	P
3	No name	*Lolium multiflorum*	*Poaceae*	✓	✓	A
4	Chokorsa qala	*Cynodon dactylon*	*Poaceae*	✓	✓	P
5	Xaafii sinbirroo	*Eragrostis tenuifolia*	*Poaceae*	✓	✓	P
6	Guba (Migira)	*Pennisetum sphacelatum*	*Poaceae*	✓	✓	P
7	Mujja	*Snowdenia polystachya*	*Poaceae*	✓	✓	A
8	Marga qalla	*Digitaria abyssinica*	*Poaceae*	✓	✓	P
9	Warati	*Eleucine jagrie*	*Poaceae*	✓	✓	P
10	Daggo	*Eleusine floccifolia*	*Poaceae*	✓	✓	P
11	Muriyyi	*Sporobolus pyramidalis*	*Poaceae*	✓	✓	P
12	Sardo harre	*Eleusine indica*	*Poaceae*	✓	✓	A
13	Ballammi	*Andropogon abyssicus*	*Poaceae*	✓	✓	A
14	Migra saree adii	*Penniseturn sphacelaturn*	*Poaceae*	✓	✓	P
15	Migra saree diima	*Penniseturn thunbergi*	*Poaceae*	✓	✓	P
16	Sardoo	*Pennisetum clandestinum*	*Poaceae*	✓	✓	P
17	Daggala	*Hyperrhenia rufa*	*Poaceae*		✓	P
B	**Sedges**					
18	Qunni	*Cyperus rotundus*	*Cyperaceae*	✓	✓	P
19	NN	*Cyperus sesquiflorus*	*Cyperaceae*	✓	✓	P
C	**Legumes**					
20	Siddisa dhalaa	*Trifolium rueppellianum*	*Fabaceae*	✓	✓	A
21	Siddisa kormaa	*Medicago polymorpha*	*Fabaceae*	✓	✓	A
21	Atara quruphe	*Vicia sativa L.var.sativa*	*Fabaceae*	✓	✓	A
D	**Weeds**					
22	Tufo	*Guizotia scabra*	*Asteraceae*	✓	✓	P
23	Kello (Hadaa)	*Bidens biternata*	*Asteraceae*	✓	✓	A
24	Qortobbi	*Plantago lanceolata*	*Plantaginaceae*	✓	✓	P
25	Chukkalla	*Uebelinia abyssinica*	*Caryophyllaceae*	✓	✓	A

Where, P = perennial, A = annuals, NN = no name

Herbage yield and Composition grazing land

Decline of areas and dwindling of biomass productivity of grazing lands in the study areas are some of the major concerns of the society. The estimated average herbage yield of enclosure was 2.52 tons per hactare in highland, while it was 2.73 tons per hactare in mid altitude. These results as shown in Table 2 indicate, relative higher herbage yield in mid altitude agro-ecology than of highland. The difference in herbage yield seen between the two agro-ecologies of present study areas were insignificant (P>0.05). Similar species composition and similar livestock management system prevailing in the two agro-ecologies could be reason for similar herbage yield. The overall estimated mean herbage yield for the two agro-ecologies of the present study area was 2.62 ton per hactare. This result was similar with herbage yield 1.7 -2.4 ton/ha observed in Menesibu districts of western Ethiopia (Dirriba et al., 2012) and lower than 3.54, 3.4, 5.67 tonns of herbage yield per hectare reporeted for Digga, Jeld and Fogera districts of Ethiopia respectively (Bedassa et al., 2012) and it was also less than 5.4 t/ha reported for North West lowlands of Ethiopia (Bilatu A., 2013).

Both productivity and species composition of pasture land impacts the feed quantity and quality. The composition of private grass land of present study areas are dipicted in the following table. About 69.7 percentage of private enclosed grass land of highland composed of grass species, while about 73.6 percent was grass in mid altitude. Wild trifolium sppecies dominates the grazing land and with few legume speices it covers about 28.7 percent of herbage yield of grass land in highland and 25.6 percent in mid altitude. The higher proportion of legumes observed conforms to the idea that the composition of legumes increase with the increase in altitude (Alemayehu 2006). In these areas, during the wet season, grazing lands contain a significant proportion of *Trifolium* species which is grazed prior to full blooming causing problem of bloating and subsequently death of animals. The proportion of weeds and sedges as shown in the Table below, about 2.8 percent of herbage yield of highland and 0.8 percent of Mid altitude herbage yield composes less palatable species like sedges and weeds. The higher percentage of trifolium species and weeds and sedges in highland could be 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 grass land.

Table 2. Herbge yield and composition of sampled grazing land

Agro-ecology	Herbage yield ton/ha	Species composition (percentage)		
		Grass	Legume (Trifolim)	Weeds and sedges
Highland	2.52	69.6	28.7	2.18
Mid-highland	2.73	73.6	25.6	0.8
Average	2.62	71.3	27.1	1.5
Se	0.14	1.8	1.7	0.6

Se = standard error, ha = hectare

Herbage nutrient composition

The chemical composition of the composite samples collected from the two agro-ecologies is presented in Table 3. The difference in mean DM content of herbage samples collected from highland and mid altitude (93.4 and 94.2) percent respectivelly was not wide (P>0.05). The mean ash content of herbs harvested between the two agro-ecologies have shown significant difference (P<0.001). This difference could be resulted due to differnce in soil factor`.

Crude protein (CP) content of the herbage have not shown significant difference in between the two agro-ecologies (P>0.05), but slight higher CP was obtained from highland area, this probably resulted due to higher proportion of legume species and cooler temprature which allows plants to remain vegetative and less lignified for a long time (Van Soest 1982). Therefore, the relatively higher environmental temperature in mid altitude areas of the present study might have promoted rapid physiological development leading to the dilution of CP content and lignification of the cell wall fibers that could reduce the digestibility of the natural pasture harvested from mid-altitude as compared to that harvested in highland.The ovrall mean CP contents of herbage (11.75 %) observed in the presnt study areas was comparable with (12.1 %) CP of forage harvested during the end of wet season (Zinash and Seyoum, 1991) and below 13.1 % reported for Sinana district harvested in September (Solomon 2008) and higher than previousily reported CP value of 5.03- 8.07 for natural pasture harvested in similar season in Menesibu districts of western Ethiopia (Diriba et al., 2012). The overall mean CP of the two agro ecologies falls with in the normal threshold of grasses (8-18 %) and it was reported that forages with CP content of below 8 % are categorized under poor quality forages (Leng, 1990) resulting in less feed intake, less digestibility and poor utilization of feed.

Neutral detergent fiber consists of the slowly digested hemicellulose and cellulose as well as indigestible lignin in the plant. Its estimate is important in ruminant nutrition to estimate feed intake and predict the susceptibility of the cattle fed the diet to stomach upset. The mean NDF contents of pasture harvested from mid altitude was significantly higher (P<0.001) than that of harvested from high land. The NDF value (53-60 %)

observed in this study was with in the threshold level (45 – 65 %) reported for grass hay (Lemus R., 2009). feeds with more than 65% NDF content were classified as low quality roughages (Singh and Oosting 1992), and the natural pasture in the study area falls in good category, but the present result was lower than NDF content of 72.7-77.8 percent reported for western Ethiopia harvested at the similar season and age of growth in Menesibu district (Diriba et la., 2012). The higher NDF percentage observed in mid altitude areas of the present study could be due to the prevailing higher temprature in mid altitude than that of highland which initiate early maturation of grasses and relative higher grass species composition of grazing lands of mid altitude.

Acid detergent fiber (ADF) is a sub-fraction of NDF, but only consists of cellulose and lignin and knowing of it helps for prediction of energy value of forages. The ADF composition of 28.9 for highland and 26.9 percent of mid altitude falls below the normal range of ADF content of grasses (30's to mid 40's). The difference in ADF content of herbs were significant ($P<0.05$) between the two agro-ecologies (Table 3).

Acid detergent lignin (ADL) contents of present study result (5.62% in highland and 8.7 % in mid altitude) was significantly different ($P< 0.01$) which could also be resulted with difference in species composition and temprature difference between the two areas. This has a limiting effect on feed utilization since an increase in ADL content from 5-6% may reduce cellulose digestibility by 20% (McDonald et al 2002).

There was significant difference in invitro dry matter digestiblity (IVDMD) value between the two agro-ecologies. The IVDMD 78.65 % of highland and 74.54 % of mid-land were higher than that was previously reported (42.89-52.95) for herbage harvested from Menesibu (Diriba 2012), 71.4 -71.5 % for Sinan district and 65.7-70.8 % in Dinsho district harvested from September to October (Solomon et al., 2008). The significant difference in IVDMD observed in present study could be due to difference in temprature and soil of the area. Metabolizable energy content of natural pasture of highland was higher ($P<0.01$) than that of mid altitude areas.

Table 3. Descriptive stastics for the chemical compositions of herbage harvested

Composition	Agr-ecology			
	Highland (Mean ±S.E)	Mid-land (Mean ±S.E)	Total (Mean ±S.E)	P-value
DM	93.4±0.01	94.2±0.001	94.8±0.004	NS
Ash	9.21±0.10	16.90±0.02	13.05±2.22	***
CP	12.69±0.80	10.82±0.31	11.75±0.64	NS
NDF	54.8±0.07	61.7±.09	58.2±2.0	***
ADF	28.86±0.28	26.93±0.27	27.90±0.58	*
ADL	5.62±0.27	8.65±0.18	7.14±0.88	**
IVDMD	78.65±0.15	74.54±0.34	76.60±1.20	**
ME	13.35±0.03	12.65±0.06	13.002±0.20	**
DCP	8.80±0.74	6.57±0.28	7.68±0.72	NS
DDM	66.42±0.22	67.92±0.21	67.17±0.45	**
DMI	2.19±0.007	1.95±0.003	2.07±0.07	***
RFV	112.70±0.23	102.47±0.16	107.58±2.95	***

DM = dry matter, CP = crude protein, IVDMD = invitro dry matter digestibility, ME, metabolisable energy, DDM= Digestibility of dry matter, DMI = dry matter intake, RFV = relative feed value, Se = standard error

The digestible crude protein contents of samples of herbs of the two agro ecologies were comparably similar, but the digestible dry matter (DDM) of highland herbs has shown significant difference ($P<0.01$) over that of mid altitude. This could be due to difference fiber contents herbs harvested from the two agro ecologies. The difference in dry matter intake (DMI) and relative feed values (RFV) of highland herbs was significantly higher ($P<0.001$) than that of mid altitude. The higher DMI and RFV observed in highland could be resulted due to lower fiber contents of herbs of highlands than mid altitude.

CONCLUSION

Overall, 25 species of hersbs were identified from the grazing lands of the study areas. Most of the identified species were found in both agro ecologies. 17 species of grasses (5 annuals 12 perennials), 3 legume species, 4 weeds and 2 sedges/forbs were identified. Differences in altitude didin't have shown significant difference in herbage yield and composition. The expansion of trifolium species on grazing lands is becoming a series problem in the study areas. But the quality of herbs harvested at flowering stage was well in supplying basic nutritional requierement of livestock. The estimated amounts of herbage yield from the two agro ecologies were very low; therefore increasing the herbage yield and controlling the invasive plant on grass land should be intervention area in the future.

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