INDIGENOUS FORAGE SPECIES COMPOSITION, BIOMASS YIELD AND THEIR NUTRITIONAL QUALITY ACROSS GRAZING TYPES, IN NORTH SHEWA ZONE, ETHIOPIA

Asemahegn Mersha* and Abera Seyoum

Ethiopian Biodiversity Institute, P.O. Box 30726, Addis Ababa, Ethiopia.

ABSTRACT: This study was undertaken in Wachale district of North Shewa Zone with the aim to assess species composition, aboveground biomass production and nutritive values of indigenous forage species across three grazing types. Six free grazing, four controlled grazing and four enclosures areas were selected purposively from three kebeles. One transect with a length of 100 meters was laid on each management type from which forage samples were collected at every 25 m interval. Five plots of size 0.5m x 0.5m each were assigned along each transect. A total of 70 plots (30 plots for free grazing, 20 plots for controlled grazing and 20 plots for enclosure areas) were used throughout the study. A total of 16 indigenous herbaceous forage species were identified of which 11, 13 and 16 were found from free grazing, controlled grazing and enclosure areas, respectively. The highest relative frequency was obtained for *Andropogon abyssinicus*, 21.23% from free grazing, 20.82% from controlled grazing and 19% from enclosure. Dry matter yield was the highest ($P<0.001$) in enclosure followed by controlled grazing. The metabolizable energy (6.64 MJ/DM) and in vitro digestibility (44.29%) of *Sporobolus africanus* were lower ($P<0.05$) than *Andropogon abyssinicus, Pennisetum thunbergii, Eleusine floccifolia* and *Cyperus rotundus* values. The indigenous forage species in the study area were found to be poor in terms of diversity, composition yield and quality. It can be concluded that enclosures could be considered as better grazing management options in terms of maintaining species diversity, and dry matter yield.

Keywords: Dry matter yield, Grazing management types, Indigenous forage, Species composition

INTRODUCTION

Grasslands are found in all climatic zones except high mountains, extremely arid zones and the polar regions of the earth (Hedberg et al., 1995; Faber-Langendoen and Josse, 2010). The majority of grasslands are located in tropical developing countries where they are particularly important to the livelihoods of billions of poor people. Grasslands have many biodiversity values as they possess high species richness and provide

*Corresponding author: asemahegnm@gmail.com

numerous ecosystem functions and services (Faber-Langendoen and Josse, 2010). Grasslands provide feed for wild and domestic animals and they also play vital role in nonagricultural services, such as water supply, carbon storage, climate mitigation and offer natural habitats for both common and threatened species (Boval and Dixon, 2012; Bengtsson et al., 2019).

The grassland region of Ethiopia is found extensively in the central plateau, western, southern and southeastern semi-arid lowlands of the country (Hedberg et al., 1995; Mengistu, 2006). There are different types of grasslands that are used for livestock grazing in the highlands of Ethiopia. These include privately and communally owned, enclosures, riverside, lakeshore, and roadside grazing areas (Zewdu, 2005). The grassland harbors major feed resources in most of the highlands of Ethiopia (Keba et al., 2013; Yadessa et al., 2016; Abebaye et al., 2019), they are rich in indigenous forage species and mainly constitute grasses and various forb and shrub species (Kahurananga, 1986). According to CSA (2021) report, natural grazing land and hay accounts for 54.54% and 7.35% of the total feed utilized in Ethiopia, respectively.

However, the natural grazing lands in the highlands of Ethiopia are seriously overloaded with stocks beyond their optimum carrying capacity causing overgrazing, erosion and overall land degradation (Tolera and Abebe, 2007; Feyissa et al., 2015). Moreover, the current management and utilization of grazing lands have caused a reduction in biodiversity and the gradual replacement of better-quality indigenous forage species with unpalatable species; and caused rapid rates of genetic erosion on rare and endemic forage species and hampered germplasm exploration, collection, and conservation activities (Mengistu, 2004).

North Shoa zone of Oromia Regional State is one of the highlands of Ethiopia that occupies the central part of the country. The dominant feed resource for cattle in this area is natural pasture from communal grazing lands and enclosures which accounts for 49.8% of the basal feed (Brandsma et al., 2013). According to Feyissa et al. (2014), out of the total land owned and contracted in the area, 25% was used for hay production from indigenous and endemic forage species. From this area, substantial amount of hay was made available for sale each year and transported to other places. It was also reported that hay prices have increased significantly from year to year.

To conserve and sustain the present forage diversity in the natural grasslands, substantial identification of the driving factors and evaluation of their effects must be conducted. Therefore, assessment of the status of grassland resources is the key to putting in place a strategic plan for appropriate utilization of grassland ecosystem of the area, as there were gaps on the knowledge of indigenous forage diversity and the effects of grazing management of the district. The objective of the study was to assess endemic and indigenous forage species for their species composition, above ground biomass yield across grazing management types and their nutritional quality in the natural grassland of Wachale woreda of North Shewa zone.

MATERIALS AND METHODS

Study area

The study was conducted in Wachale woreda of North Shewa, Oromia Regional State, Ethiopia, which is located at 84 km North West of Addis Ababa (Figure 1). The district (woreda) is located between 9°25'2.13" to 9°48'44" North and 38°38'49.02" to 39°08'41" East. The altitude of the district ranges between 1200 and 2880 m.a.s.l. The mean annual rainfall of the area is about 1000 mm that ranges from 1000 to 1800 mm. The maximum and minimum annual temperature is 30^0C and 25^0C, respectively. In this district, livestock production is the most important agricultural activity next to crop production.

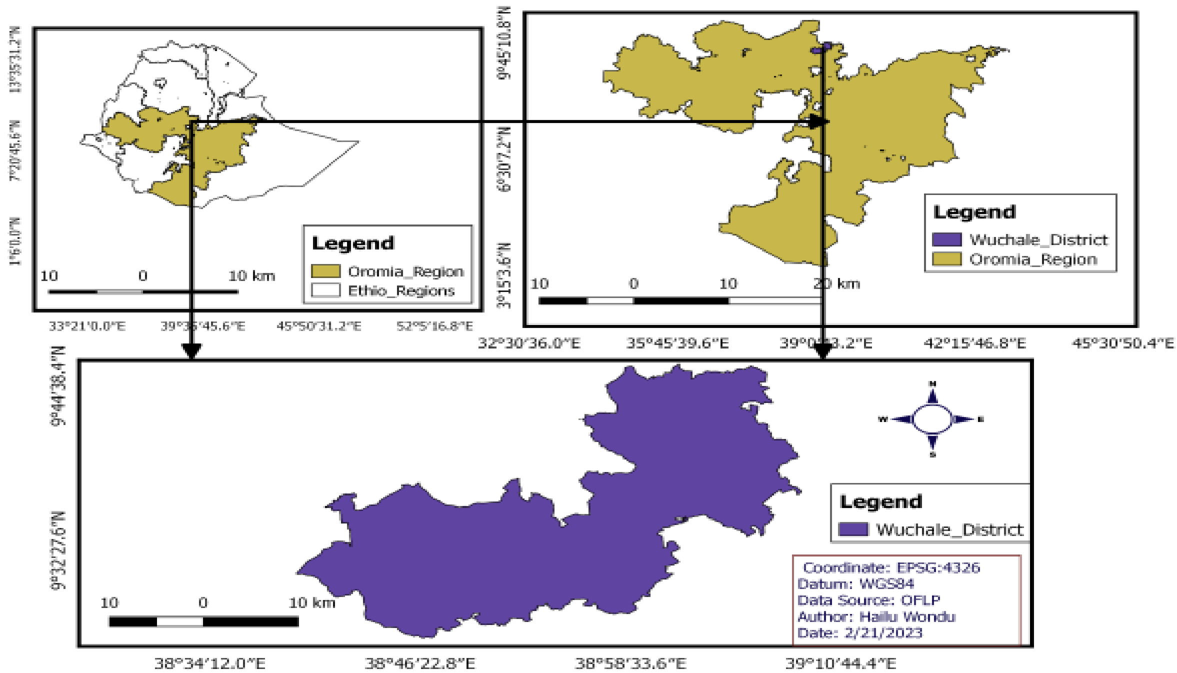

Figure 1. Maps showing the study area.

Sampling procedures

Sampling was conducted once both in wet and dry seasons at end of October and February, respectively. The study focused on communal, private free grazing, controlled grazing and enclosure grazing lands and comparing to each other with respect to herbaceous biomass production and nutritional qualities of the forage species. Kebeles were selected on their potential grazing types (free grazing, controlled grazing and enclosures). Thus, six free grazing, four controlled grazing and four enclosure areas were selected purposively from three kebeles: namely, Bosoke jate, Gora keteba and Wachala worto following discussions with district experts and knowledgeable community representatives.

One transect with a length of 100 meters was constructed on each grazing management and the forage samples were collected at every 25 m interval using 0.5m x 0.5m plots. Systematic sampling was used for the study (Kenkel et al., 1989). A total of 70 plots (30 plots for free grazing, 20 plots for controlled grazing and 20 plots for enclosure) were used throughout the study. The forage samples found inside the quadrats were clipped using a sickle at above 5 cm height. In each study quadrant, knowledgeable people were consulted to identify the local name of each herbaceous forage species. They were identified in the field and specimens were collected, pressed and dried properly using plant presses and transported to the herbarium of Ethiopian Biodiversity Institute for further identification and nomenclature. Nomenclature of the forage species followed the Flora of Ethiopia and Eritrea (Hedberg et al., 1995).

Thereafter, samples were hand-separated into different species, labeled, shade dried and then fresh weight of forage samples were measured in the field and kept in paper bags. Both fresh and dried weights were measured in grams using an electronic kitchen scale of 5000 g weighing capacity. Samples were subjected to air dry until transportation for laboratory analysis.

Dry matter (DM) weights obtained from sample sites, the percent composition of each species of grasses, legumes, Cyperus and Sedge, and forbs of herbaceous species for each quadrant were calculated and the total biomass production capacities of the area were obtained following Tothil et al. (1978), as cited in Ayele et al. (2022).

$$\text{TDW of individual species} = \text{TFW of a species} \times \text{SDW of species x SFW of a species}$$

$$\text{\% Composition of each species at a site} = \frac{\text{TDW of species x 100}}{\text{GTDW of all the species}}$$

Where TDW is total dry weight, TFW is the total fresh weight of individual species, SDW is sub-sample dry weight, SFW is sub-sample fresh weight, and GTDW is the total dry weight of all species.

Dry matter yield (DMY) and crude protein yield (CPY) were calculated according to Mengistu and Mekasha, (2007).

$$\text{Dry matter yield (t/ha} = \frac{\text{Green forage yield (t/ha) X dry matter content (\%)}}{100}$$

$$\text{Crude protein yield} = \frac{\text{Dry matter yield } \left(\frac{\text{t}}{\text{ha}}\right) \text{X crude protein (\%)}}{100}$$

Laboratory analysis

The samples were analyzed using Near Infrared Reflectance Spectroscopy (NIRS) at the Animal Nutrition laboratory of the International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia. The NIRS instrument, Foss Forage Analyzer 5000 with the software package WinISI II in the 1108-2492 nm spectra range was used to scan dry forage samples and a good-of-fitness NIRS equation was used for the prediction of dry matter (DM), total ash (Ash), nitrogen, neutral detergent fiber (NDF), acid detergent fiber, metabolizable energy (ME) and in vitro digestibility (IVOMD).

Statistical analysis

The proportion of the different forage species were calculated using percentage. The data obtained from the dry matter production were subjected to ANOVA using the General Linear Model procedure of Statistical Analytical System (SAS) computer software (Wicklin, 2010). Grazing management and species were considered independent variables. Grass species' nutritive values, crude protein yields, dry matter yield, fresh weight and their dry weight were considered response variables. General Linear Model procedure of statistical analysis system (SAS) version 9.1 (Wicklin, 2010) was used to conduct statistical analysis. Duncan was used to determine mean differences at $P \leq 0.05$.

The model used was; $Yijk = \mu + Ai + Bj + (AB)ij + eij$

Where Y is the response variable,

μ is the overall mean,

Ai is the forage species effect,

Bj is the grazing management effect,

(AB)ij is the interaction between species and grazing management and

eijk is the random residual error assumed to be normally and independently distributed.

RESULTS

Species composition and biomass production

A total of sixteen indigenous herbaceous forage species were obtained from the study area, of them 10 were grasses (62.50%), 4 forbs (25%) and different Cyperus and sedges species (12.5%). The total percent frequencies of occurrence were as follows: 15.66 % *Pennisetum thunbergii*, 6.63% *Trifolium cryptopodium*, 1.81% *Pennisetum riparium*, 3.01% *Cynodon dactylon*, 0.06% *Chloris gayana*, 20.48% *Andropogon abyssinicus*, 9.04% *Alchemilla abyssinica*, 3.61% *Trifolium* sp., 0.06% *Medicago ploymorpha*, 0.6 % *Pennisetum longistylum*, 5.42% *Cyperus rotundus*, 16.27% Cyperus and Sedge sps., 1.81% *Eragrostis botryodes*, 7.83% *Sporobolus africanus*, 5.42% *Eleusine floccifolia*, and 1.2% *Hyparrhenia* sp.

From sixteen identified forage species, 11 (68.75%) were recorded from free grazing, 13 (81.25%) from controlled grazing and 16 (100%) from enclosure (Table 1). The most frequent herbaceous forage species in the study areas, across the three grazing management types, were *Andropogon abyssinicus, Pennisetum thunbergii* and *Cyperus* and sedge sps. In the present study the forage species *Chloris gayana, Medicago polymorpha* and *Pennisetum longistylum* were not encountered in both free and controlled grazing management types, while *Pennisetum riparium* and *Hyparrhenia* sp. were not observed in free grazing management type. In free gazing management type, the highest relative frequency was recorded for *Andropogon abyssinicus* (21.23%), followed by *Pennisetum thunbergii* (15.14%) and Cyperus and sedge sps. (12.12%), while the rest had values below 10%.

Table 1. Compositions (%) based on frequencies of occurrence forage species found in three grazing managements types.

Species	Relative frequency of each species		
	Free grazing (communal)	Controlled grazing (private)	enclosure
Alchimella abyssinica	9.10%	8.33%	8.41%
Andropogon abyssinicus	21.23%	20.82%	19.00%
Cyperus and *sedge sps*.	12.12%	13.59%	16.83%
Chloris gayana	0.00%	0.00%	1.17%
Cynodon dactylon	3.02%	2.07%	2.54%
Cyperus rotundus	7.10%	5.26%	5.54%
Eleusine floccifolia	9.10%	6.26%	5.54%
Eragrostis botryodes	5.02%	5.07%	5.17%
Hyperrhia sp.	0.00%	2.07%	1.17%
Medicago polymorpha	0.00%	0.00%	1.17%
Pennisetum longistylum	0.00%	0.00%	1.17%
Pennisetum riparium	0.00%	2.07%	2.34%
Pennisetum thunbergii	15.14%	16.60%	15.29%
Sporobolus africanus	6.04%	8.33%	5.20%
Trifolium sp.	3.02%	4.15%	3.54%
Trfolium cryptopodium	9.10%	6.26%	5.88%

The dry matter biomass yield of seven forage species, namely, *Andropogon abyssinicus* (31.81%), *Pennisetum thunbergii* (25%), *Alchimella abyssinica* (5.18%), *Sporobolus africanus* (5.16%), *Eleusine floccifolia* (5.21%), *Trifolium cryptopodium* (5.11%) and *Cyperus rotundus* (5.1%) had 82.57% contribution of the total identified forage species (Figure 2). Therefore, the highest dry matter biomass production was recorded by *Andropogon abyssinicus*, followed by *Pennisetum thunbergii* (25%). However, the most preferred forage species by the communities with their quality feed, *Pennisetum riparium*, *Trifolium sp.* and *Pennisetum longistylum*, had low % biomass dry matter production in the study area.

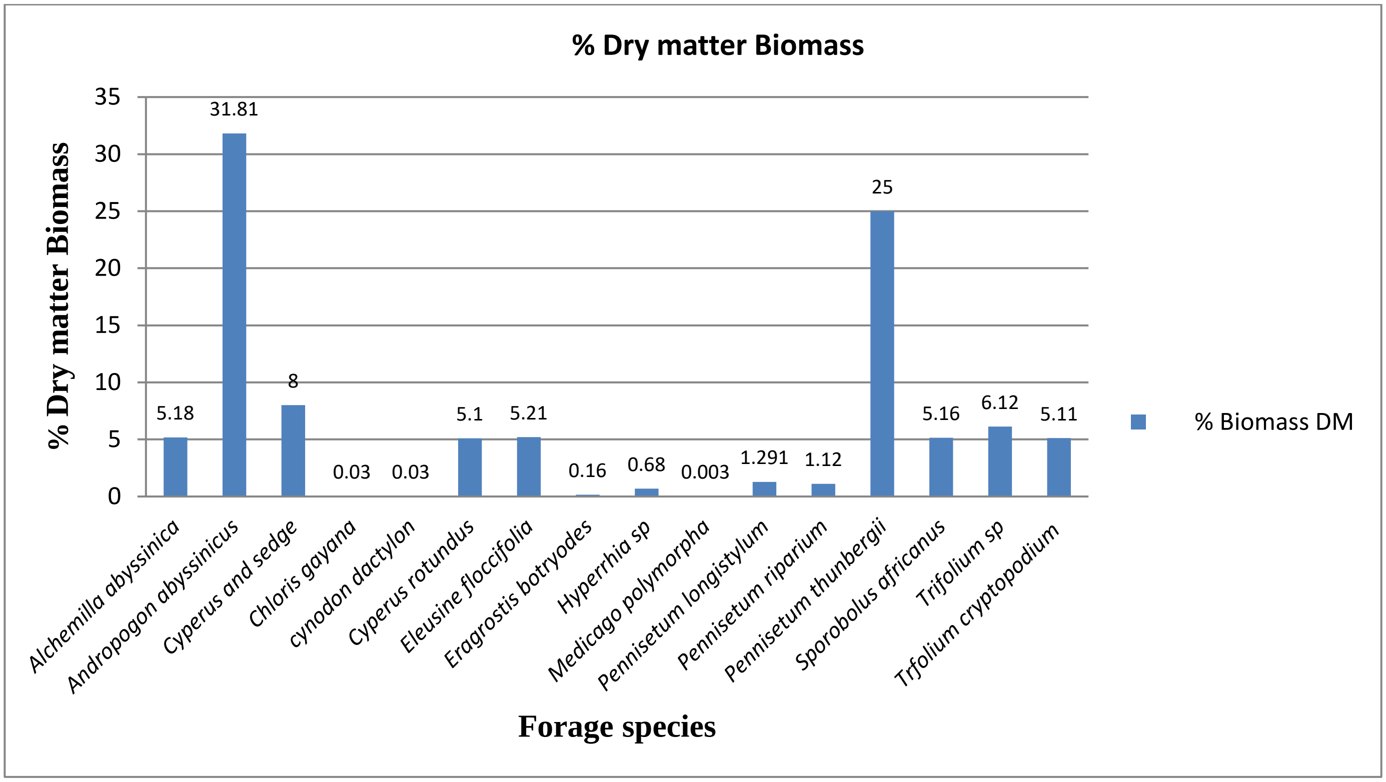

Figure 2. Percent dry matter biomass yield of indigenous forage species obtained in the study area.

Forage production

Analysis of variance (Table 2) showed that species and grazing management had highly significant (P<0.001) effects on dry matter yield (DMY), crude protein yield (CPY), fresh weight and dry weight of the forage species studied. Similarly, the interaction between species and grazing management had also significant effects (P≤0.05) on DMY, CPY, fresh weight and dry weight of selected forage species.

The value of dry matter yield was the highest (P<0.001) in enclosure followed by controlled grazing, but free grazing management system had the lowest dry matter yield (0.40 t/ha). When the crude protein yields of the three grazing managements were compared, there were no significant difference (P<0.05) between controlled grazing and enclosure.

Considering fresh and dry weight of selected forage species, enclosure had very high significant (P<0.001) difference from free and controlled grazing managements (Table 3).

Table 2. Combined analysis of variance for dry matter yield, crude protein yield, fresh weight and dry weight of selected indigenous forage species.

S.O.V	DF	Variables (kg/ha)			
		DM	CPY	Fresh wt.	Dry wt.
		F-value			
Species	6	27.84***	4.70***	17.73***	17.73***
Grazing management	2	31.39***	8.91***	20.63***	20.63***
Species x grazing management	12	2.95**	2.20*	2.54**	2.5**

S.O.V= Source of variation; DMY=dry matter yield; CPY=crude protein yield; wt= weight; *******= (P<0.001); ******= (P<0.01); *****= (P<0.05)

Table 3. Mean comparisons of fresh weight and dry weight of selected forage species across grazing management.

Grazing management type	Fresh weight (kg/ha)	Dry weight (kg/ha)
Free grazing	1650[b]	460[b]
Controlled grazing	1880[b]	530[b]
Enclosure	4870[a]	1360[a]
Significant level	***	***

Kg/ha= kilogram per hectare, means with different letters within rows are significantly different at P<0.001

Dry matter and crude protein yields

The dry matter yields of *Andropogon abyssinicus, Pennisetum thunbergii* and *Eleusine floccifolia* were significantly higher (P<0.001) than *Alchemilla abyssinica*, *Cyperus rotundus*, *Sporobolus africanus* and *Trifolium crypsopodium*, in the three grazing management systems. The highest dry matter yield was obtained from *Andropogon abyssinicus* in free (830 kg/ha) and controlled (1220 kg/ha) grazing systems, while the highest dry matter yield was obtained from *Pennisetum thunbergii* (2130 kg/ha) harvested from enclosure. On the other hand, the dry matter yield of *Trifolium crypsopodium*, *Cyperus rotundus, Alchemilla abyssinica* and *Sporobolus africanus* was not significantly (P<0.05) different among each other in the free grazing, controlled grazing and enclosed grassland. Crude protein yields (CPY) of all selected forage species collected from free grazing and enclosed grasslands had statistically similar values (P≤0.05), while in controlled grazing land the values of CPY in *Sporobolus africanus, Alchemilla abyssinica, Cyperus rotundus, Trifolium crypsopodium* and *Eleusine floccifolia* had similar results (Table 4). In the present study, the highest mean dry matter and crude protein yields were obtained from enclosure followed by controlled grazing. The crude protein yield of selected forage species harvested from free grazing and enclosure were not significantly different between each other (p≤0.05). The highest % biomass was obtained from *Andropogon abyssinicus* in free grazing and enclosure grasslands followed by *Pennisetum thunbergii* even though no significant difference was observed between them (P≤0.05).

Table 4. Mean comparisons of dry matter production (kg/ha), crude protein yields (kg/ha) %, dry matter biomass of selected forage species in the three grazing management systems.

Study parameters	Forage species						
	Sporobols africanus	*Alchemilla abyssinica*	*Cyperus rotundus*	*Trifolium crypsopodium*	*Eluesine floccifolia*	*Pennisetum thunbergii*	*Andropogon abyssinica*
Free grazing							
DMY (kg/ha)	30[b]	110[b]	110[b]	80[b]	380[a]	690[a]	830[a]
CPY (kg/ha)	196[a]	9.8[a]	58.9[a]	9.1[a]	20.20[a]	148.5[a]	37.1[a]
% Biomass	1.38c	1.79c	5.57b	0.32c	1.06c	36.51[a]	53.41[a]
Controlled grazing							
DMY (kg/ha)	170[b]	200[b]	350[b]	210[b]	970[a]	997[a]	1220[a]
CPY (kg/ha)	21[b]	22[b]	223[b]	129[b]	47[b]	600[a]	540[a]
% Biomass	4[bc]	5[bc]	3[c]	5[bc]	10[b]	41[a]	32[a]
Enclosure grassland							
DMY (kg/ha)	750[b]	180[b]	320[b]	520[b]	1640[a]	2130[a]	1790[a]
CPY (kg/ha)	111[a]	34[a]	81[a]	326[a]	79[a]	640[a]	563[a]
% Biomass	3.17[c]	2.72[c]	2.5[c]	5.20[b]	6.13[b]	35.25[a]	45.04[a]

Means with different letters within rows are significantly different at P ≤0.05, DMY; dry matter yield, CPY; crude protein yield and % dry matter biomass yield.

Nutritive quality of forage species

Grasses and Cyprus

The DM contents of *Eleusine floccifolia* (90.80%), *Sporobolus africanus* (90.42%), and *Cyperus rotundus* (90.53%) were significantly higher than *Pennisetum thunbergii* (89.99%) (P<0.05) (Table 5). The crude protein (CP) contents of the four species of grass and *Cyperus rotundus* had statistically similar values

(P<0.05). Metabolizable energy (ME) (6.64MJ/DM) and Invitro organic Matter Digestibility (IVOMD) (44.29%) of *Sporobolus africanus* were lower (P<0.05) than *Andropogon abyssinicus, Pennisetum thunbergii*, *Eleusine floccifolia* and *Cyperus rotundus* values. Neutral Detergent Fiber (NDF) value of *Sporobolus africanus* (77.54%) also had higher (P<0.05) than *Andropogon abyssinicus* (72.59%), *Pennisetum thunbergii* (72.35%) and *Cyperus rotundu*s (70.63%) except *Eleusine floccifolia* (74.52%).

Table 5. Overall mean comparisons of chemical composition and nutritional values of collected forage species

Forage types	DM (%)	Ash % DM	CP % DM	NDF % DM	ADF % DM	ME MJ/kg DM	IVOMD (%)
Gasses and Cyperus							
Andropogon abyssinicus	90.25^{ab}	11.01^{ab}	5.21^{a}	72.59^{bc}	40.24^{bc}	7.07^{a}	47.86^{a}
Pennisetum thunbergii	89.99^{b}	11.78^{a}	5.48^{a}	72.35^{bc}	39.70^{b}	7.20^{a}	48.94^{a}
Eleusine floccifolia	90.80^{a}	10.44^{b}	4.80^{a}	74.52^{ab}	44.04^{a}	7.15^{a}	47.98^{a}
Cyperus rotundus	90.53^{a}	10.27^{ab}	5.62^{a}	70.63^{bc}	38.32^{c}	7.38^{a}	50.20^{a}
Sporobolus africanus	90.42^{a}	9.66^{c}	5.36^{a}	77.54^{a}	44.32^{a}	6.64^{b}	44.29^{b}
Forb and legume							
Trifolium cryptopodium	91.48^{a}	7.99^{b}	9.84^{a}	47.54^{b}	34.70^{a}	8.77^{a}	60.83^{a}
Alchimella abyssinica	88.32^{b}	12.88^{a}	9.77^{a}	62.05^{a}	28.38^{b}	8.59^{a}	59.89^{a}
Combined forage							
Mixed green forage	90.09^{a}	12.23^{a}	6.63^{a}	68.56^{b}	37.57^{b}	7.29^{a}	49.90^{a}
Mixed dry forage	89.96^{a}	12.07^{a}	4.94^{b}	76.20^{a}	48.91^{a}	6.16^{b}	41.54^{b}

Means within column followed by the same letter (s) are not significantly different at P<0.05 significant level of Duncan multiple tests. CP; crude protein, NDF; Neutral detergent fiber, ADF; acid detergent fiber, ADL; Acid detergent lignin, ME; metabolizable energy (MJ/kg DM), TIVOMD; true in vitro organic matter digestibility (gm/kg DM).

Forb and legume

Trifolium cryptopodium had (P<0.05) higher Dry Matter (DM) and Acid Detergent Fiber (ADF) contents than *Alchimella abyssinica*, on the other hand, *Alchimella abyssinica* had higher (P<0.05) Ash and NDF values than *Trifolium cryptopodium.* Crude protein, ME and IVOMD values of *Trifolium cryptopodium* and *Alchimella abyssinica* were not significantly different (P<0.05).

Combined forage species

Dry matter and Ash contents of mixed green forage and mixed dry forage were not significantly differed with each other (P<0.05). CP, ME and IVOMD values of mixed green forages were significantly higher than mixed dry forages (P<0.05). However, mixed dry forages had higher NDF and ADF values than mixed green forages (P<0.05).

Nutritional values across functional groups

The nutritional values of the families of the identified forage species (Table 6), has shown that the highest (12.88%) Ash value was obtained from Rosaceae, which was significantly higher (P<0.05) than Cyperaceae (10.72%) and Fabaceae (7.99%); but was not significantly different from Poaceae (11.13%) (P<0.05). Poaceae, Cyperaceae and Fabaceae had statistically similar values (P<0.05) in terms of CP; while Rosaceae had shown higher CP value than Cyperaceae and Poaceae. NDF and ADF contents of Poaceae obtained from the present study were the highest (P<0.05) of the rest three families. The NDF value of Fabaceae and Rosaceae were the lowest, while the ADF values of Cyperaceae and Fabaceae had similar values (P<0.05). The ME and IVOMD values were high (P<0.05) in Fabaceae and Rosaceae the lowest value being from Poaceae.

Table 6. Analysis of chemical composition and nutritional values based on families

	% of DM					
Family	Ash	CP	NDF	ADF	ME MJ/kg DM	IVOMD % of DM
Poaceae	11.13[ab]	7.55[b]	73.24[a]	40.81[a]	7.09[c]	48.02[c]
Cyperaceae	10.72[b]	7.59[b]	67.64[b]	33.73[b]	7.67[b]	52.18[b]
Fabaceae	7.99[c]	9.84[ab]	47.54[c]	34.70[b]	8.77[a]	60.74[a]
Rosaceae	12.88[a]	10.86[a]	62.38[c]	27.56[c]	8.67[a]	60.10[a]

Means within column followed by the same letter (s) are not significantly different at P <0.05 significant level of Duncan multiple tests CP; Crude protein, NDF; Neutral detergent fiber, ADF; acid detergent fiber, ADL; Acid detergent lignin, ME; metabolizable energy (MJ/kg DM), TIVOMD; true in vitro organic matter digestibility (gm/kg DM).

DISCUSSION

Species composition and Biomass contribution of forage species

The highest proportion of forage species in the present study was observed by grass species, which may be related to the management and utilization aspects of grasslands. It also could be a result of their ecological competitiveness and resilience to various adverse conditions (Linder et al., 2018). The present result is similar to the finding reported by Getachew (2005) and Bekele et al. (2010). In the present study among the forage species, *Andropogon abyssinicus, Pennisetum thunbergii* and Cyperus and sedge sps. were recorded as dominant with frequency percentage value of >15% and *Alchemilla abyssinica*, *Sporobolus africanus*, *Cyperus rotundus* and *Eleusine floccifolia* were commonly occurring species as their frequency of percentage was between 5% and 15%; while all the rest were recorded as rare species (Beyene and Mlambo, 2012). On the other hand, better quality forage species like mixture of *Trifolium* sp, *Trifolium cryptopodium, Alchemilla abyssinica, Pennisetum riparium, Pennisetum longistylum* and *Medicago ploymorpha* with lower percent frequency and biomass yield might indicate the poor forage quality and availability of the grassland in the district (Bekele et al., 2010). Indigenous forage species composition occupied by a few species made up the bulk of biomass yield and high values of relative frequency. This is because of the fact that in grassland community one or a few species are able to tolerate the multidimensional environmental factors of the area that they are spatially stable (Abule et al., 2007). Increased abundance of these species in this study area may be due to response to disturbance such as moderate to heavy grazing, competition, and water logging tendency of the area which is especially favored by Cyperus and sedge sps. (Edwards et al., 1997). Moreover, Asrat et al. (2015) reported that the composition and abundance of herbaceous species were influenced by increased grazing pressure. In the present study, the identified herbaceous forage species were lower than previously reported in various parts of Ethiopia (Zewdu, 2005), which may be due to water logging status of the area and acidity of the soil and small sampling area. It may also be attributed to high altitude of the study area, since higher altitudes have lower vegetation diversity according to Aynekulu et al. (2012) and Gebrewahid and Abrehe (2019).

Out of sixteen indigenous forage species identified from the study area, 11 and 13 were available in free grazing and controlled grazing management types, respectively; while all the sixteen species were present in enclosure. This is an indication that grazing regime can influence botanical composition of herb species. High herbaceous biomass in enclosures could be linked with low grazing disturbance by livestock (Mengistu et al., 2005). Previous studies also indicated that grazing intensity is one of the most primary factors that result in reducing forage composition and diversity over time (Mengistu, 2006). The intensity of grazing can cause difference in botanical composition and relative abundance of important forage species. Moreover, Sternberg et al. (2000) and Keba et al. (2013) also stated that overgrazing affects the botanical composition and species diversity and causes strong influence on the structure and organization of forage species in different ways. This result coincides with the report of (Angassa, 2014) and Ayele et al. (2022), as they indicated that frequent and heavy grazing pressure may cause a reduction in herbaceous forage species composition, diversity and basal cover. Skornik et al. (2010) also suggested that heavy and long-term grazing caused both decline in floristic richness and above-ground biomass yield, ultimately altering species composition.

Determination of forage yield

The variation in mean DMY, CPY, Fresh weight and Dry weight were highly significant ($P<0.001$) due to species composition, biomass yield of the different forage species collected and grazing management types. The variation in DMY, CPY, fresh weight and dry weight were significant ($P\leq0.05$) due to the interaction effect between species and grazing management types. This indicated that forage production can be influenced by forage species and grazing management practices (Bekele et al., 2010). The effect of grazing type on DMY, CPY, Fresh weight and Dry weight depends on the available forage species of the grassland.

This indicated that forage yield can be influenced by different grazing management practices and species of forage available in the specific grassland.

Forage dry weight recorded from enclosure in the present study was similar with the results of Ayele et al. (2022) from private grazing, communal grazing, and fallow land and roadside. Moreover, fresh weight (4.87 t/ha) of forage species collected from enclosure grassland had similar value with the report of communal grazing land. Dry matter yield of grazing land increased as grazing intensity decreased. Moreover, growing under a condition without cattle grazing and human disturbances, the plants were able to complete a normal life cycle of growth, flowering, setting seeds and the likes (Wang et al., 2018; Liu et al., 2020).

Andropogon abyssinicus, Pennisetum thunbergii and *Eleusine floccifolia* resulted in higher dry matter yield than *Alchemilla abyssinica, Cyperus rotundus, Sporobolus africanus* and *Trifolium cryptopodium*, in the three grazing management systems. This could be due to high frequency, availability and distribution of these species in the study area. Even though, the sampling time was at full flowering stage the mean dry matter yields in the three grazing types were below the values of previously reported results (Mengistu, 1987; Agza et al., 2013; Zewdie and Yoseph, 2014), which may be due to species composition, interactions within and among species and increased degree of degradation, but comparable with Abule et al. (2007).

Nutritional values

Forage quality can be affected by a variety of biological and environmental factors. In general, the nutritional value of forages is the highest when the plant is young, have actively growing leaves but declines as the plant nears maturity. Good quality forage is associated with high CP and low fiber, the CP values of grass species in the present study ranged from 4.80-5.62% which is below some findings elsewhere (Teklu et al. 2010; Gebremariam and Belay, 2021), but comparable to the values of natural mix hay and maize straw reported by Gebremariam and Belay (2021). The crude protein contents of grasses, Cyperus, mixed green and mixed dry forages were below the minimum (7%) requirements for optimum microbial growth and maintenance (Van Soest et al., 1991). Moreover, the chemical composition of selected forage species was below the results of earlier studies (Keba et al., 2013; Asrat et al., 2015). The CP decreased because of the accumulation of structural carbohydrates. According to Feyissa et al. (2014), CP content, IVOMD and ME content significantly declined with delaying harvesting from mid-October to late October.

The NDF values of grasses, Cyperus, mixed green forage and mixed dry forage were higher and categorized in the range of low-quality forage (>65%), while forbs (*Trifolium cryptopodium* and *Alchimella abyssinica*) had medium forage quality (45-65%). The ADF values of the studied forage types were within the medium quality (31-45%) with the exception of mixed dry forage which had a value within the range of low quality (Singh and Oosting, 1992). Similarly, Leng (1990) indicated that forage species of CP and digestibility lower than 8% and 55% are categorized under low-quality forages. The ME and IVOMD values of all the analyzed forage species were below the records of native hay (Geleti et al., 2013) with the exception of IVOMD of *Trifolium cryptopodium* (60.83%). The mean ME for the selected grass, Cyperus, mixed green and mixed dry forages were below the critical threshold levels (7.5 MJ/kg DM). Moreover, the IVOMD values of all the studied grasses and mixed dry forages were below the critical threshold level (50%) required for feed digestibility (Owen and Jayasuriyat, 1989). The present study generally demonstrated that grasses, Cyperus, mixed green and mixed dry forages that are widely used as roughage feeds for dairy animals in the study area are of inferior quality containing high fiber fractions, low CP, ME and IVOMD.

Nutritional values across functional groups

The CP, ME and IVOMD values of Fabaceae and Rosaceae were comparable. But the chemical and nutritional composition of Cyperaceae was higher than the values of Poaceae, that may be due to seasonal water logging tendency of the study area. The mean values of CP in Poaceae, Cyperaceae and Fabaceae in the present study were lower than the mean values reported by Keba et al. (2013) and Mosisa et al. (2021), but higher than the values of NDF and ADF obtained by the same authors. Moreover, ME and IVOMD values of the studies function group were lower than the values of native hay and herbaceous legumes (Geleti et al., 2013). Generally, the feed quality of Fabaceae and Rosaceae were comparable. Likewise, the chemical composition and nutritional values of Cyperaceae and Fabaceae were also comparable in the major nutritional parameters. Generally, as the forage sampling was conducted during hay harvesting time the relative quality of hay produced in the study area has been assessed to be of poor quality.

CONCLUSIONS

The study gave information on botanical composition, above ground biomass and nutritional profiles of main forage species available in the Wahcale district of North Shewa zone, Oromia regional state. The result showed that the botanical composition of indigenous forage species was dominated by a few species, but with high biomass yield and high values of relative frequency. Comparison with previous studies revealed low diversity and compositions in the present study area. There were variations among the forage species, grazing types in terms of species composition, biomass yield and nutritional qualities. Some forage species with varied occurrence belonging to different families were identified from the three grazing management types. Wide variations were not recognized between the nutritive values of most indigenous forage species, especially on grasses, Cyperus, and mixed green and mixed dry forages. The CP contents of grasses, Cyprus, mixed green and mixed dry forages were found to be below the critical level required for maintenance, optimum rumen function and feed intake, resulting in low livestock productivity. Even though, the mean DM yield of indigenous forage species in study area was high and comparable with most of earlier reports, the feed quality tested according to the current result was very poor. Moreover, the nutritive values of most of the forage species during wet and dry season in the present study were below the requirement of ruminant livestock. Few forage grass species were dominant; therefore, to improve diversity, composition and availability of other crucial indigenous forage species, proper grazing land management has to be conducted. In addition, collection, conservation and multiplication of rarely available forage species should be widely undertaken. Overall, the indigenous forage species in the study area were found to be poor in terms of diversity, composition, yield and quality, while enclosures could be considered as better grazing management option in terms of maintaining species diversity and DM yield.

ACKNOWLEDGEMENTS

The study was fully sponsored by the Ethiopian Biodiversity Institute and we highly acknowledge the financial support we received. The authors would also like to acknowledge the International Livestock Research Institute (ILRI) for sponsoring laboratory services. Individuals involved directly or indirectly for the work of this study are highly recognized by the authors.

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