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Research Article

Herbaceous Species Composition, Diversity and Biomass of Communal Grazing Lands under Exclosure Management in Northwestern Tigray Region of Ethiopia

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ABSTRACT

A study was conducted in Tselemti district, which is found in the northwestern Tigray, Northern Ethiopia. The objectives of the study were to assess the herbaceous species composition, diversity and biomass under different grazing land management practices. Data on herbaceous species composition, species diversity, basal area, species richness and aboveground biomass were collected from 1 m^2 quadrat plot during the flowering stages of most herbaceous species in 2015. ANOVA was applied to test for differences in vegetation data using GLM procedures of SAS. Tukey Honesty Significance Difference test was used for mean comparison. Herbaceous species diversity and similarity indices among management practices were computed with Shannon-Weiner Index and Sørensen coefficient of similarity index, respectively. A total of 57 herbaceous species representing 21 families comprising of 41 non-grasses and 16 grasses were recorded. Poaceae took the highest percentage (28.1%) of the total families of herbaceous species sampled followed by Asteraceae (15.8%) and Fabaceae (15.8%). The diversity and richness of herbaceous species in ten year exclosure, five year exclosure and open grazing lands were 1.42, 1.57 and 1.54 and 8.42, 7.8 and 7.13 respectively whilst their corresponding evenness values were 0.54, 0.65 and 0.68, respectively. Species abundance, richness, density, basal cover of herbaceous species as well as aboveground biomass in ten years exclosure were significantly ($P < 0.05$) higher compared to five year exclosure and open grazing lands. Bare ground percentage, evenness and herbaceous species diversity decreases as the duration of protection increases. The establishment of exclosures for longer period on degraded grazing lands had positive effect in improving species composition and herbaceous vegetation biomass.

Key words: Herbaceous vegetation, Management practices, Open grazing lands, Richness

INTRODUCTION

In Ethiopia rangelands account for more than 62% of the country's total land surface (Alemayehu 1998). In Ethiopia, rangeland represents a valuable resource to the pastoralists and to the nation (Oba and Kotile, 2001). A Large part of the rangeland in Ethiopia is located in lowland arid and semi-arid regions with unreliable and erratic rainfall, and high temperature (Alemayehu 1998).

Rangeland contributes about 70% of the feed needs of ruminants worldwide and about 85% of the total feed needs of ruminants (cattle, sheep and goats) in African and South American countries (Holechek *et al.*, 2005). However, rangeland resources are facing intense degradation due to agricultural land expansion and heavy grazing (Mulugeta *et al* 2005; Mengistu *et al.*, 2005). In arid and semi-arid rangelands, heavy grazing is one of the most important destructive factors. Heavy grazing has negative effects on rangelands by destroying the most useful species in the plant mixture and losing density of the plant cover and biomass, thereby increasing the erosion hazard and reducing the nutritive value of the land (O'connor *et al.*, 2001; FAO, 2005).

The direct effect of livestock grazing includes consumption of the species and soil trampling which can destroy the structure and composition of plant communities. Proper distribution of livestock in rangeland is important issue in grazing management (Liang *et al* 2009). Moreover, herbaceous layer biomass, density and basal area percentage are reduced with increasing grazing intensity (Yayneshet *et al.*, 2009; Mekuria and Yami, 2013). Light grazing increases the aboveground biomass and basal area of the species, but from a long-term perspective, moderate grazing can help balance the production of different species and livestock production (Huang *et al* 2011). Intensive grazing of livestock reduced

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the herbaceous vegetation cover and changes species composition and it also endangered the stability of the rangeland ecosystem through negative changes in soil nutrients (Heidarian *et al.*, 2010).

Restoration of degraded communal grazing lands through establishing exclosures has become increasingly important in Tigray regional state, northern Ethiopia. Exclosures are areas closed from the interference of human and domestic animals, with the goal of promoting natural regeneration of plants and reducing land degradation of formerly degraded communal grazing lands (Mekuria *et al.*, 2011). Exclosures have been established on communal grazing lands in the semi-arid lowlands of Tigray for more than two decades.

Some studies conducted in the northern highlands of Ethiopia (Yayneshet *et al.*, 2009) have shown that exclosures can be effective in enhancing composition, diversity, and density of vegetation. Due to the diverse agro-ecology, soil and topographic condition of Tigray, these studies are not sufficient to extrapolate the findings throughout the region. Besides, in the arid and semi-arid areas of the region, further research on grazing was not conducted. Therefore, the objectives of this study were (1) To determine the herbaceous species composition and abundance in protected and freely grazed areas; (2) To assess the species richness, diversity and similarities of herbaceous species in exclosures and freely grazed areas; (3) to determine the effect of area exclosures establishment on herbaceous vegetation biomass.

MATERIALS AND METHODS

Description of study area

The study sites for the present study were located in the semi-arid areas of Tselemti district in the northwestern Tigray of Ethiopia (Figure 1). Tselemti district is located in 13º 05'N latitude and 38º 08'E longitude. The landscape of the district is undulating of hills, flat plain plateau, mountains and valley with an altitude range of 800 to 2870 m. a. s. l. The mean maximum temperature varied between 33ºC in April to 41.7ºC in May, while the mean minimum temperature is between 15.8°C in December to 21.7°C in May. The dry season occurs between November to May whereas, the rainy season occurs between June to September, which follows a unimodal rainfall pattern with mean annual rainfall of 1,141.5 mm. The vegetation cover in the district includes Combretum-Terminalia and Acacia-Commiphora Woodlands which are characterized by small to moderate-sized drought resistant trees and shrubs with fairly large deciduous leaves. *Anogeissusleiocarpus* (DC) Guill & Perri, *Dichrostachy scinerea* (L.) Wight & Am, *Dovyalis abyssinica* (A. Rich) Warb, *Albizia amara*, *Oxythenanthera abyssinica*, *Boswellia papyrifera* (Del). Hochstand *Erytherina abyssinica* (A. Rich) Munro are some of the dominant woody species in the study area.

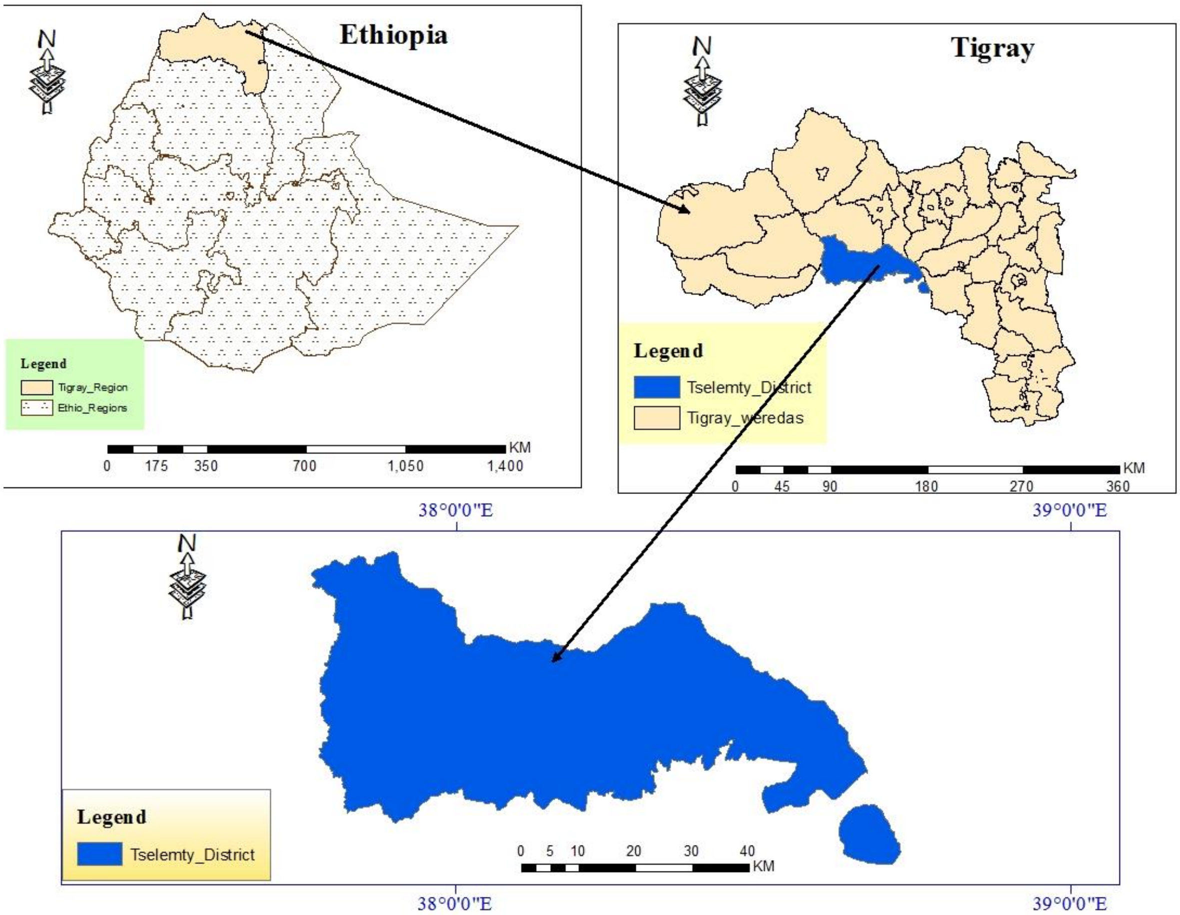

Fig. 1: Map of study area, Tselemti district of north western Tigray, Ethiopia. Site Selection and Sampling Designs.

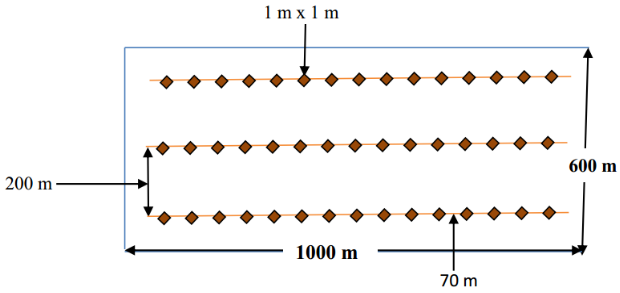

Fig. 2: Sampling design and plot layout of the experimental site.

Open grazing lands, 5-year old exclosures and 10-year old exclosures were selected for field data collection. The exclosures and open grazing lands were assumed to have been on similar conditions before the establishment of the exclosures. To cover the variability in soil and topography, we selected three replicates for each open grazing land and three replicates for each exclosure age throughout the study area. Exclosures with the same age and open grazing lands had to have a minimum distance of 1km from each other.

The topography (slope, presence of outcrops, elevation range) was recorded. The latitude, longitude and altitude of each study plots were recorded using GPS. Additional data for description of the study site, including climatic parameters such as rainfall and temperature were also collected from Tigray National Meteorological Agency.

The systematic transect sampling technique was employed to collect data from the study area. In order to eliminate any edge effects of the exclosure variables, the first and the last transect lines were laid at least 100 m inside from the margin of the adjacent grazing lands. Three parallel line transects each with 1000 m long at 200 m apart from the other were established for each exclosure age and open grazing land. The first sample plot was laid randomly and the others systematically at 70m interval along the line transect (Figure 2).

Sampling procedures

For all sampling sites, the herbaceous species composition (at species level), plant abundance, species richness, aboveground biomass, the percentage of basal and bare ground covers were quantified in $1m^2$ quadrat during the flowering stages of most herbaceous species in September to October, 2015. The species were classified into grasses (annual or perennial), herbaceous legumes and forbs within each quadrat to determine the contribution of each group according to (ILCA, 1990). After determining the species composition and plant functional groups in each quadrat, individual plants were counted to determine the abundance of each species. The percentage of basal cover and bare ground was recorded using visual estimation in each quadrat before the herbaceous stands were clipped.

Destructive sampling was used for herbaceous layer biomass estimation by harvesting the whole fresh biomass within each quadrat using hand shears. Fresh weight of all the undergrowth had been measured in the 1m*1m plot and small sample of known weight were taken for dry matter analysis. Sub-sample was separated and placed in a marked bag and taken to the laboratory to determine an oven-dry to wet mass ratio that is used to convert the total wet mass to oven dry mass. The sub sampled was air dried and latter oven-dried at Mekelle Soil Research Center with 80^0C for 48 hrs as described by Whalley and Hardy (2000) until a constant weight were achieved and finally re-weighed for their dry weight using a sensitive balance with a precision of 0.1g. The dry matter content of the undergrowth was determined after oven drying the fresh undergrowth sample and converting that proportionally to the 1mx1m quadrat and hectare.

All herbaceous plant species encountered in the plots were listed, recorded and identified at each plot. Plant species identification by their vernacular name was conducted through the support of the knowledge of local people particularly elders who have been living around the study area. Finally, vernacular names were crosschecked with their scientific names by using previous study of Solomon and Yayneshet (2014), Teame *et al.* (2014) and books of Ethiopian flora (Philips, 1995).

Diversity, evenness and similarity of herbaceous species

Indices that combine both richness and evenness into a single value are diversity indices. Species diversity indices in the area exclosure and openly-grazed land were calculated using Shannon-Wiener diversity Index (H’). The index takes into account the species richness and the proportion of each species in all sampled quadrats of each study site. The Shannon diversity index was calculated as

$$H' = -\sum_{i=1}^{s} P_i \ln(P_i) \qquad (1)$$

Where,
H = is Shannon diversity index
s = is the total number of species (species richness)
P_i = the proportional abundance of the i^{th}species = $\frac{ni}{N}$

ni = The number of individuals in species
N = the total number of all individuals
ln = log $base_e$
Evenness (J) or equitability, a measure of similarity of the abundances of the different species in the study sites was analyzed by using Shannon’s Evenness or Equitability Index (Krebs 1989; Magurran1988).

$$J = \frac{H'}{H_{Max}} = {}^{H'}\!/_{\ln(S)} \qquad (2)$$

Where: J = Evenness
H’ = Shannon-Wiener Diversity Index
H_{Max}= the maximum level of diversity possible within a given population, which equals Ln (number of species).
S = total number of species in the sample
To determine the species similarities of herbaceous species composition between exclosures and free grazing lands, Sørensen coefficient of similarity index (Sc) was used. The following formula was used to determine similarity of the herbaceous species in the study sites:

$$Sc = \frac{2a}{2a + b + c} \qquad (3)$$

Where, a = number of species common to both sites.
b = number of species present in the first site and absent from the second.
c = number of species present in the second site and absent from the first.

Statistical data analyses

All data were first checked for normality and equality of variance. General Linear Model (GLM) procedures of Statistical Analysis System (SAS) were used to analyze vegetation attribute data. One way analysis of variance (ANOVA) was used to test the effect of management practices on all data that were generated from vegetation (plant abundance, species richness, species composition and herbaceous layer biomass). The difference in these variables between the three management practices was assessed using treatment mean difference comparison Tukey Honesty Significance Difference (HSD) using SAS software at P<0.05.

RESULTS AND DISCUSSION

Herbaceous species vegetation composition

In the study area, a total of 57 herbaceous species comprising of 21 families were recorded. *Poaceae* took the highest percentage (28.1%) of the total families of herbaceous species sampled followed by *Asteraceae* (15.8%) and *Fabaceae* (15.8%). This finding was in line with the previous results from the Borana grazing lands which indicated that the Poaceae family took the lead of the herbaceous species sampled (Samuel 2009). Out of the 57 herbaceous species, 16 were different species of grasses while 41 were different non-grass species. Among the 41non-grass species, 29 species were forbs, 8 species were legumes and 4 were herbaceous climbers. In total, 10 annual grasses and 6 perennial grasses were identified (Table1).

In open grazing lands, five year exclosure and ten year enclosure in total 24, 33 and 47 types of herbaceous species composition were recorded with species richness of 10, 11 and 12 grass species respectively accounted for perennials and annuals. Accordingly, a total of 2, 3 and 5 perennial grass species was recorded in open grazing lands, five year exclosure and ten year exclosure, respectively. The remaining counts of herbaceous species were covered by non-grass species i.e. herbaceous forbs, herbaceous legumes and herbaceous climbers. The result of vegetation composition analysis indicated that exclosures are far more enriched with herbaceous vegetation composition than open grazing lands (Table1).Ten years exclosure demonstrated the highest numbers of grass and non-grass species composition than five years exclosure followed by open grazing lands which had less number of grasses and non-grass species composition.

The lowest species composition in open grazing lands was due to the existence of continued heavy grazing pressures throughout the year and human interferences. A study in eastern Tigray, Ethiopia (Gebrewahd 2014) demonstrated that free grazing resulted lower species composition when compared to closed areas due to the high grazing intensity throughout the year. Hence, this finding supports the results of (Tessema *et al* 2011) who reported that lightly grazed sites had a higher herbaceous species richness compared with heavily grazed sites.

Herbaceous species density and basal cover

Management practices and age of exclosure had a significant effect on the density and ground cover of the herbaceous species in the present study. The mean herbaceous species density was significantly (P<0.001) higher in the grazing areas that were excluded for ten years (206.73 individuals m^{-2}) followed by five years exclosure (115.69 individuals m^{-2}) and open grazing lands (95.36 individuals m^{-2}). The lower mean herbaceous species density in the open grazing lands might be due to disturbance of animals through heavy grazing and trampling.

There was a variation (P<0.001) in terms of herbaceous vegetation basal cover percentage among open grazing lands, five year exclosure and ten year exclosures. The basal cover percentage of open grazing land, five years exclosure and ten years exclosure was 23.24%, 49.77% and 61.64%, respectively (Table 2). The higher basal cover percentage in both exclosures might be due to the exclusion of livestock grazing. This result is similar to (Bradd Witt *et al* 2011) who reported almost double herbaceous basal cover inside the enclosures compared to outside areas.

Species diversity, evenness and similarity

Shannon diversity index of herbaceous species encountered in open grazing land, five years exclosure and ten years exclosure were 1.54, 1.57 and 1.42, respectively (Table 3). The finding of this result is in agreement with (Cavalcanti and Larrazabal 2004) who stated that the Shannon diversity index is high when it is above 3.0, medium when it is between 2.0 and 3.0, low between 1.0 and 2.0, and very low when it is smaller than 1.0. Accordingly, the findings of the study show that Shannon diversity index for herbaceous plant species was low for both exclosures and open grazing lands. Within exclosures, the areas closed for ten years had lower herbaceous species diversity. The highest herbaceous species diversity at five years exclosure might be related to the low density of woody species as well as the removal of animal disturbances. Ten years exclosure had the lowest herbaceous species diversity due to the effect of high woody density that suppresses the growth of herbaceous vegetation through competitive and shading effect. This result advocates the reports of (Yayneshet *et al* 2009; Ayana *et al* 2010) who indicated that herbaceous/grass diversity decreased while woody species abundances increased with exclosure age. However, the results for herbaceous species diversity, contrast with results reported where herbaceous species diversity was higher in exclosures than in the adjacent grazed areas (Yayneshet 2011).

Species richness of herbaceous vegetation recorded in the open grazing land, five years exclosure and ten years exclosure were 7.13, 7.8 and 8.42, respectively, while their corresponding evenness values were 0.68, 0.65 and 0.54, respectively. Herbaceous species richness was significantly (P<0.05) affected by grazing land exclusion practices. The herbaceous species was relatively evenly (P<0.001) distributed in open grazing land (0.68) and five years exclosure (0.65) than ten years exclosure (0.54). Areas protected for ten years showed lowest herbaceous species evenness than five year exclosures and open grazing lands.

The average number of herbaceous species per plot also increases as the duration of exclusion increases. Exclosures had a higher herbaceous species richness compared to open grazing lands due to the negative impact of heavy grazing intensity on most herbaceous species. This finding is similar to the results of (Aynekulu, 2011;

Table 1: List of herbaceous species with their family, relative abundance (nm^{-2}), life forms (LF) and functional group (FG) under two exclosure age categories and open grazing lands

Scientific name	Family	Management practices			LF	FG
		Open grazing land	Five years exclosure	Ten years exclosure		
Acanthospermumhispidum	Asteraceae	3	2.7	4.5	A	F
Ageratum conyzoides	Asteraceae	0	0	17	A	F
Albucaabyssinica	Asparagaceae	0	0	1.5	P	F
Alysicarpusrugosus	Fabaceae	5.9	4.8	5.4	A	L
Amaranthusspp	Amaranthaceae	0	0	1.5	A	F
Arisaemaenneaphyllum	Araceae	0	0	1	P	F
Bidensmacroptera	Asteraceae	0	10.4	31.2	A	F
Bidenspachyloma	Asteraceae	0	6	7.9	A	F
Bidenspilosa	Asteraceae	13.3	4	5.8	A	F
Bidensspp	Asteraceae	8.8	18.7	15.5	A	F
Chamaecristahochstetteri	Fabaceae	0	1	10	A	L
Chamaecristamimosoides	Fabaceae	3.9	4.6	2.5	A	L
Cicercuneatum	Fabaceae	0	5.3	0	A	L
Clematis simensis	Ranunculaceae	0	0	2	P	HC
Commelinabenphalensis	Commelinaceae	2.2	3.5	6.1	A	F
Commelinalatifolia	Commelinaceae	0	0	1	A	F
Commicarpusplumbagineus	Nyctaginaceae	0	0	1	P	F
Corchorustrilocularis	Tiliaceae	0	0	2.8	A	F
Cynodondactylon	Poaceae	23.8	0	0	P	G
Cyperusrotundus	Cyperaceae	0	0	8	P	F
Cyphostemmaadenocaule	Vitaceae	0	0	1	P	HC
Dactylocteniumaegyptium	Poaceae	17.4	18.9	0	A	G
Digitaria ternate	Poaceae	12.9	13.2	25.7	A	G
Digitariavelutina	Poaceae	24.4	10.9	27.0	A	G
Eleusineindica	Poaceae	8.4	0	0	A	G
Eragrostiscilianensis	Poaceae	11.8	27.1	51.1	A	G
Euphorbia hirta	Euphorbiaceae	8.8	13	0	A	F
Euphorbia scordifolia	Euphorbiaceae	8.6	5.1	8.5	A	F
Exothecaabyssinica	Poaceae	0	3	7.9	P	G
Galinsogaparviflora	Asteraceae	0	2	0	A	F
Hyparrheniaanthistirioides	Poaceae	52.8	78.3	0	A	G
Hyparrheniarufa	Poaceae	0	5.7	15.9	P	G
Hypoestesforskaolii	Acanthaceae	0	1	2	P	F
Ipomoea purprea	Convolvulaceae	0	5	2.7	A	F
Leucasmartinicensis	Lamiaceae	0	0	6	A	F
Medicagopolymorpha	Fabaceae	0	0	3.3	A	L
Nicandraphysalodes	Solanaceae	0	0	1.7	A	F
Oxygonumsinuatum	Polygonaceae	10.9	4	17.5	A	F
Panicum maximum	Poaceae	0	0	4	P	G
Pennisetumpedicellatum	Poaceae	0	36.8	89.4	A	G
Pennisetumpolystachion	Poaceae	16	18.9	15	P	G
Plectranthuslanuginosus	Lamiaceae	0	3	3.8	P	F
Rhaynochosia minima	Fabaceae	0	0	2.8	P	HC
Rottboeliacochinchinensis	Poaceae	16.2	19.6	31.5	A	G
Sennaobtusifolia	Fabaceae	8.4	2.6	1.6	A	L
Sennaoccidentalis	Fabaceae	2.8	0	0	A	L
Setariapumila	Poaceae	20.4	24	47.6	A	G
Sidarhombifolia	Malvaceae	1.9	2.4	1.5	P	F
Solanumincanum	Solanaceae	0	1	0	P	F
Strigahermonthica	Scrophulariaceae	15	0	0	A	F
Tagetesminuta	Asteraceae	0	4	3	A	F
Themedatriandria	Poaceae	0	0	68.8	P	G
Tragiacinerea	Euphorbiaceae	0	0	1.7	P	F
Tricholaenateneriffae	Poaceae	0	0	1	A	G
Trifoliumschemperi	Fabaceae	0	0	2	P	L
Xanthium strumarium	Asteraceae	5	1.7	2.7	A	F
Zehneriascabra	Cucurbitaceae	0	0	1	P	HC
Number of species					-	-
Grass species	-	10	11	12	-	-
perennial grass	-	2	3	5	-	-
Annual grass	-	8	8	7	-	-
Herbaceous legumes	-	4	5	6	-	-
Herbaceous forbs	-	10	17	25	-	-
Herbaceous climbers	-	0	0	4	-	-
Total number of species	-	24	33	47	-	-
Percentage of species						
Grass species	-	41.7	33.3	25.5	-	-
perennial grass	-	8.34	9.1	10.7	-	-
Annual grass	-	33.4	24.2	14.9	-	-
Herbaceous legumes	-	16.7	15.2	12.8	-	-
Herbaceous forbs	-	41.7	51.5	53.2	-	-
Herbaceous climbers	-	0	0	8.5	-	-
Total percentage of species		100	100	100		

A = annual; P = perennial; F = forbs; G = grass; L = herbaceous legumes; HC= herbaceous climber; OGL = open grazing land; FYE = five years exclosure; TYE = ten years exclosure; LF= functional group; nm^{-2}= Number per 1m^2.

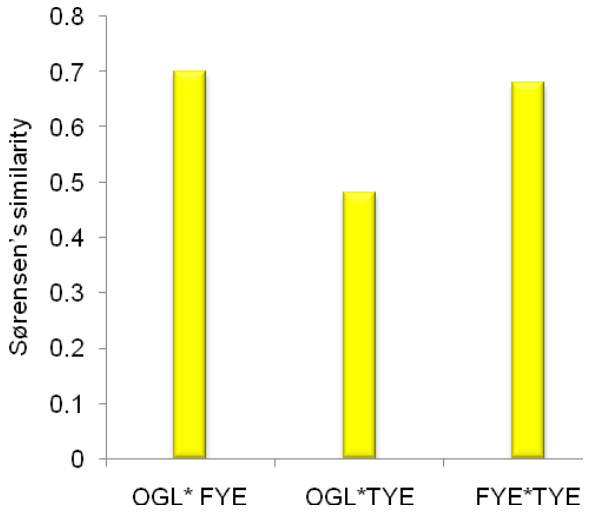

Fig. 3: Sørensen's similarity coefficient for the interactions among three management practices.

Table 1: Basal cover, bare ground, and density of herbaceous plant species

Management practice	Basal cover	Bare ground	Density
Open grazing land	23.2^c	76.8^a	95.4^b
Five years exclosure	49.8^b	50.2^b	116^b
Ten years exclosure	61.6^a	38.4^c	207^a
SEM	0.98	0.98	8
p value	0.0001	0.0001	0.0001

Means with the same letter superscripts along columns are not significantly different at P<0.05 level of significance. Basal cover and bare area in percentage and density in individual count per m^2.

Table 2: Comparison of herbaceous species richness, Shannon Weiner diversity and evenness indices under area exclosures and open grazing lands

Management practices	Richness	Diversity	Evenness
Open grazing land	7.13^b	1.54	0.68^a
Five years exclosure	7.80^{ab}	1.57	0.65^a
Ten years exclosure	8.42^a	1.42	0.54^b
SEM	0.193	-	0.0142
p value	0.016	-	0.0001

Means with the same letter superscripts along columns are not significantly different at p < 0.05 level of significance.

Table 4: Means of herbaceous vegetation biomass under exclosures and open grazing lands (DM t/ha)

Management practices	DMY t/ha
Open grazing land	0.638±.05^c
Five years exclosure	2.35±.06^b
Ten years exclosure	3.10±.08^a
p value	< 0.0001

DMY t/ha = dry biomass yield in ton per hectare.

Mekuria and Yami, 2013) who reported that exclosure have higher plant species richness compared to the adjacent grazing lands. According to (Tessema *et al.*, 2011) lightly grazed areas had higher herbaceous species richness than heavily grazed areas.

The three sites shared 17 of the 57 herbaceous species in common. Open grazing land shared 20 and 17 of the herbaceous species with five and ten year exclosure, respectively, while five years exclosure shared 27 of the herbaceous species with ten year exclosure. Sørensen's index of community similarity in herbaceous species composition was highest between open grazing lands and five years exclosure (70%), and the lowest between open grazing lands and ten years exclosure (48%).The results of our finding showed that herbaceous species compositions were 70% similar between open grazing lands and five years exclosure and 48% similar between open grazing lands and ten year exclosures (Figure 3).

Herbaceous Species Biomass

Herbaceous vegetation biomass was highly significantly (P<0.001) affected by management practices. The mean aboveground herbaceous biomass production in ten years exclosure was higher than the five year exclosure and open grazing lands (Table 4). The mean herbaceous dry biomass yield measured in area exclosures was more than four times greater than open grazing lands. Accordingly, Lowest herbaceous dry biomass was recorded for open grazing land (0.64 DM tha^{-1}) while the highest biomass was for ten year exclosure (3.10 DM tha^{-1}) (Table 4). Age of exclusion also significantly affected biomass production where five years closed areas had significant (P<0.001) lower mean biomass production compared to the ten years closed areas. The reason for the significant difference between the three areas might be due to the difference in total herbaceous species richness and density of herb and grass stock.

In open grazing lands, the low biomass is a result of continuous grazing by grazers and browsers that may cause in severe heavy grazing, which affects growth of plant species negatively. This finding is in line with (Yayneshet *et al* 2009) who stated that significantly more than double aboveground biomass has been produced at exclosures than open grazing lands. Besides, (Snyman 2005) also reported that aboveground biomass accumulation declined with grazing land degradation, due to several factors like reduced soil cover, changed species composition and decreased root biomass.

Conclusions

The objectives of this study were to determine the role of area exclosures on herbaceous species composition, biomass, richness, diversity and similarities of grazing lands after short and long term exclusion from livestock grazing. Accordingly, areas exposed to heavy grazing pressure, i.e. open grazing lands, grazing lands protected from human and animal disturbances for five years (five-year old exclosures) and for ten years (ten-year old exclosures) were selected for field data collection.

Vegetation data, such as herbaceous vegetation composition, abundance, biomass, basal area and bare ground percentage, species diversity, density, frequency were collected during the flowering stages of most herbaceous species. Analysis of Variance (ANOVA) was applied to test for differences in herbaceous vegetation data using a General Linear Model (GLM) procedure of Statistical Analysis System (SAS). Tukey Honesty Significance Difference (HSD) test was used for mean comparison between the different management practices.

A total of 57 herbaceous species comprising of 41 non-grasses and 16 grasses were identified from the study area. In open grazing lands, five year exclusion and ten year enclosure 24, 33 and 47 herbaceous species were recorded with species richness of 10, 11 and 12 grass species, respectively. *Poaceae* took the highest percentage (28.1%)

of the total families of herbaceous species sampled followed by *Asteraceae* (15.8%) and *Fabaceae* (15.8%) throughout the study site. Ten year exclosures had higher plant species composition followed by five year exclosures and open grazing lands. The lowest species composition in open grazing lands was due to the existence of continued heavy grazing pressures and human interferences throughout the year. The establishment of exclosures for longer period on degraded grazing lands had positive effect in improving species composition and herbaceous vegetation biomass.

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