ASSESSMENT OF RANGELAND HERBACEOUS SPECIES BIODIVERSITY AND PRODUCTIVITY IN SHINILE AREA OF SOMALI REGIONAL STATE, ETHIOPIA

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Abstract: A study with the objectives of assessing on Rangeland Herbaceous Species Biodiversity and productivity was conducted in the grazing and browsing areas of the pastoral and agro-pastoral rangeland production systems in Shinile District of Somali Regional State. Plots were laid under two rangeland production systems (Pastoral Production System and Agro-pastoral Production System) with three grazing types (Riverside, Enclosure and Communal). The Statistical Analysis Software was used to analyze the vegetation and soil data. In the study district, a total of 27, 20, and 4 species of grasses, forbs and herbaceous legumes species were identified, respectively. There was a decreased in grass abundance and increased in non-grass species in the pastoral production system and an increased in grass abundance and decreased in non-grass species in the agro-pastoral rangeland production system. Herbaceous species abundance, species diversity, evenness and species richness were significantly higher in the Pastoral Production System than Agro-pastoral Production System. Herbaceous species abundance, species diversity and species richness were significantly higher in enclosure than riverside and communal grazing areas in Shinile district. The percentage of basal cover and bare ground for herbaceous species were significantly higher in the Pastoral Production System than Agro-pastoral Production System. There was an increased in the percentage of basal cover and decreased in bare ground cover in enclosure compared with other grazing land types. Potassium and sodium content of the soil were significantly higher in the Agro-pastoral Production System as compared to the Pastoral Production System. From the result, this study implies that a process of degradation maybe undergoing in the Pastoral Production System more than in the Agro-pastoral Production System, most likely due to poor grazing management practices and recurrent drought in the area. Therefore, this demands due attention on integrated management for the conservation of the soil, productivity of the rangeland and appropriate plan of biodiversity conservation such as establishing, designing and implementations of watershed management for physical and biological conservation should be planned to minimize loss of biodiversity, which also require the support of appropriate rangeland vegetation monitoring and evaluation systems based on the participation of the pastoral and agro-pastoral communities.

Keywords: Basal cover, biomass production, Plant species abundance, species composition, species diversity and soil characteristics.

1. INTRODUCTION

Different arid and semi-arid rangeland vegetation types, such as grasslands, open savannas (bush grassland) and closed savannas (bushland) are found in eastern Ethiopia, especially in the Somali Regional State (SoRPARI, 2005). These rangelands are rich in botanical resources, but at present they are subjected to human and natural influences (Gemedo-Dalleet al., 2006).The state of biodiversity in the Somali region is threatened by encroaching weeds and woody plants (EARO, 2003). According to the decrease in the production of the grass layer, difficulty in herding, wildlife attacks were the major problem associated with abundance of trees and shrubs in the rangelands (Abate et al., 2012).

Feed problem is one of the major factors that hinders the development and expansion of livestock production in Ethiopia (Ahmed et al., 2010; Solomon et al., 2010). Natural grazing land is predominant feed sources for livestock in lowland and crop residues represent a large proportion of feed resource in mixed crop livestock system of Ethiopia (Malede and Takele, 2014). The state and condition of the range vegetation and its dynamics over time, has witnessed to be an opportunity for better livestock production and better livelihood condition and/or challenge for survival to the existing pastoral production system in place (Muhidin, 2009).

Research studies undertaken in Somali National Regional State (SNRS) indicated that the current status of the rangelands is highly affected by the recurrent droughts, shortage of rainfall, overgrazing, population pressure, overstocking and soil erosion. Sites, which are found in agro-pastoral farming systems, have demonstrated higher level of rangeland degradation (Belayenesh, 2006). The rangeland condition has declined with increased grazing pressure (Lishan, 2007).

The Shinile zone is one of the zones in the SNRS, which is located in the northernmost part and the Government of Ethiopia classified this zone as susceptible to drought and suffering from chronic food deficit. The pastoral mode of life covers the largest area in the zone where pastoralists make up about 75-85% of the population.

In ShinileWereda, shortening of rainy seasons and associated replacement of valuable grazing species is worsening the already aggravated feed and water shortage in the area (Amaha, 2006; Lishan, 2007). Understanding the responses of vegetation to different grazing intensities is crucial to facilitate the management of these arid and semi-arid savannas for both biological conservation and sustainable use (Hoshino et al., 2009). It is very important to have basic information on biomass production dynamics and rangeland biodiversity, as these may facilitate the efficient and effective use of rangeland resources as livestock and wildlife feed. However, this research work is assessed to examine the effects of grazing land management and pastoral production systems on biomass production dynamics, rangeland biodiversity, identify the problems and propose effective range management practices.Therefore, this study was conducted with the general objective of assessing on rangelandherbaceous species biodiversity and productivity in the Shinile area and the specific objectives are as follows:

- To investigate the species composition, plant abundance and species diversity of the herbaceous vegetation of the rangeland.
- To investigaterangeland biomass production, soil characteristics and basal and bare ground cover of the study area

2. METHODOLOGY

2.1. Study Area

2.1.1. Location and Area Coverage

Shinile zone is one of the nine zones of the SNRS. It is located 460 km south-east of Addis Ababa and 179 km northwest of Jig-Jiga (capital city of SNRS) at 9°-10° N Latitude and 41°-42° E Longitude. Its altitude ranges from 950 to 1350 m a.s.l. and the zone has a total area of 30, 689 km². Shinile zone falls under the Hot to warm arid agro-ecological zone with 60 % arid, and 40 % semi-arid agro ecologies. The average temperature ranges from 28 to 38ºC. The rainfall pattern of the area is bimodal similar to Jig-Jiga zone, and the annual rainfall ranges from 300-600mm (SZARDO, 2013; Helen et al., 2015). There are two rainy seasons.

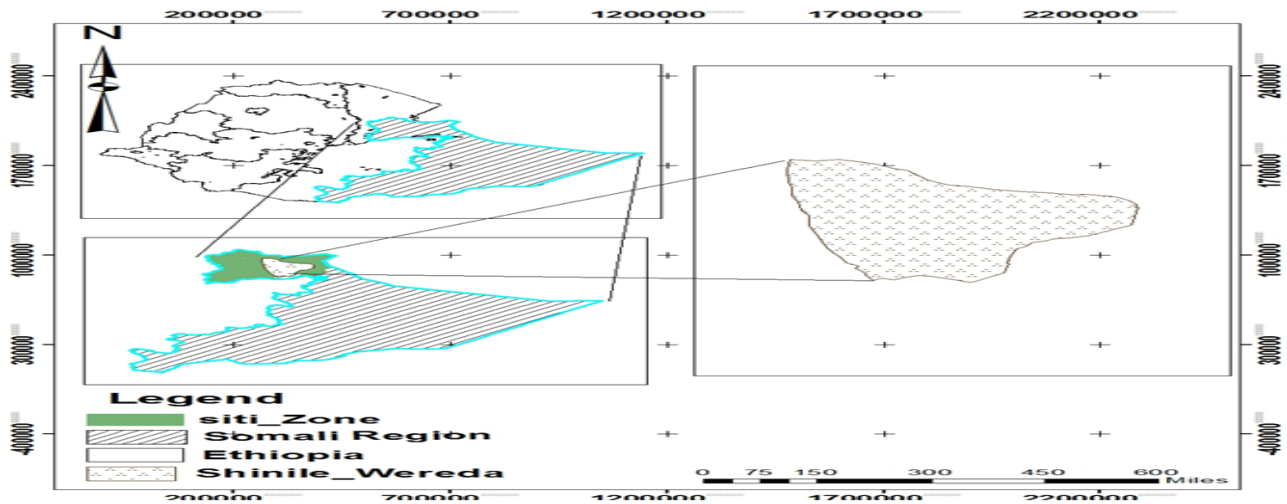
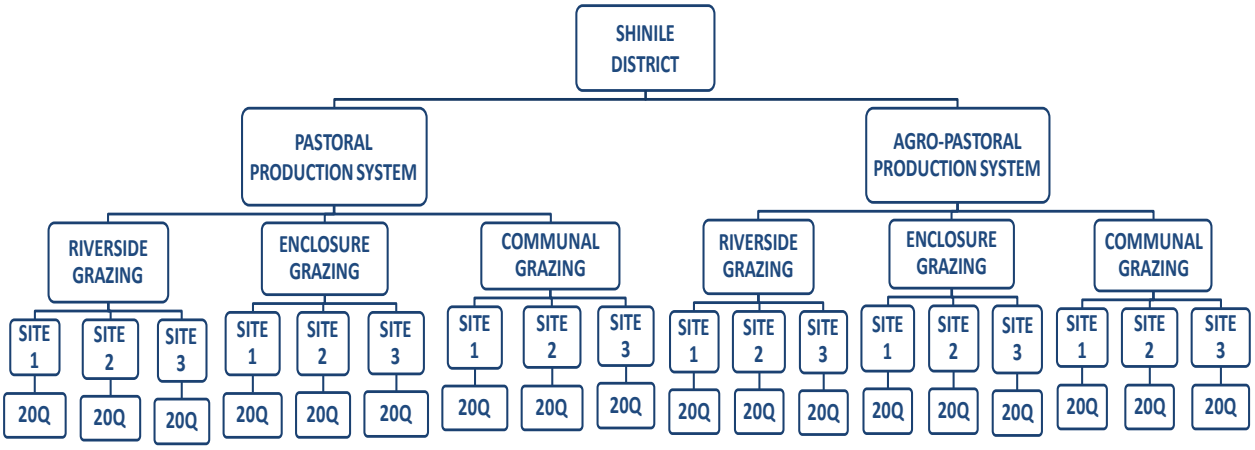


Figure 1 The location of Shinile district in Shinile Zone

2.2. Sampling Procedure

2.2.1. Selection of Sampling Sites

The study was conducted in the grazing and browsing areas of the pastoral and agro-pastoral rangeland production systems in Shinile area. For each rangeland production system, three different grazing types (i.e., communal, riversides/stream banks and enclosure grazing areas) were selected in the study district (2 rangeland production systems x 3 grazing types x 3 distance intervals (Figure 2)). For each grazing type, three study area sites with 1 km interval distances.



Q = Quadrat

Figure 2 The selection of the study areas in Shinile district

2.2.2. Sampling of Herbaceous Vegetation

The herbaceous vegetation sampling were conducted from the beginning of September up to the end of October 2014 at the time when most of the plants are at over 50% flowering which makes the identification of plants easy. Data that indicates the type of plant present at different study areas with their plant abundance was collected by using 1m x 1m. Twenty (20) $1m^2$ quadrat were randomly taken in each sample site of settled distance intervals. A total of 360 quadrats were used to assess the rangeland production by grazing type for species composition, biomass production and species diversity.

The herbaceous vegetation layer was studied for species diversity such as species richness, similarity and evenness/equitability in each quadrat. The herbaceous species was classified into grasses and non-grasses to determine their contribution of each group within the quadrat. In each quadrat, herbaceous plants were counted to determine plant abundance and species richness. The percentage of basal cover and bare ground were recorded using visual estimation in each quadrat. Aboveground dry matter biomass of the herbaceous vegetation was determined by harvesting the whole fresh biomass within each quadrat using hand shears, and the harvested herbaceous vegetation were identified into grass and non-grass. The samples were oven dried at 60°C for 72 hours and weighed at Haramaya University Animal Sciences Laboratory. The species diversity, as Shannon diversity and species evenness was calculated. Accordingly, the most appropriate parameter to determine species diversity was Shannon-Wiener diversity index (Magurran, 2004).

$H = - \Sigma (P_i) (\ln P_i)$
Evenness, $E = -\sum(Pi) (\ln Pi)/\ln S$
Species richness was represented by the number of species in each quadrant.

Herbaceous species composition similarity among grazing types was estimated by the model of Jaccard coefficient of similarity using the relative abundance of species in each sampling sites under each rangeland production systems and different grazing types.

$S_j = a/ a + b + c,$

2.2.3. Soil Sampling and Analysis

Five soil samples per sample plots with total soil samples of 90 quadrats were collected from each grazing type in the different rangeland areas of the Wereda in a zigzag pattern laid out plot of $1m^2$ using auger from a depth of 0 to 30cm. The soil samples at each distance interval of the grazing land were pooled to form one composite soil sample and the composite soil samples were divided into three equal parts and yield at total of 18 soil samples.

The samples were kept in plastic bags, labeled, sealed and transported to the soil laboratory of Haramaya University in Ethiopia for physical and chemical analysis. The pH and texture of the soil were determined in a 1:2.5 soil water ratio suspensions using the Bouyoucos hydrometer method (Bouyoucos, 1962), while electrical conductivity (EC) was determined using the sodium saturation ratio (Van Reeuwijk, 1992). The percentage organic carbon (OC) was determined according to the Walkley and Black (1934) method, and total N using the Kjeldahl procedure (Bermner and Mulvaney, 1982). Available phosphorus (P), exchangeable potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) were analyzed according to Olsen etal. (1954). Cation exchangeable capacity (CEC) was analyzed using the method of NRC (1996).

2.3. Statistical Analysis

Data collected from herbaceous vegetation composition, species diversity, plant abundance, basal and bare ground covers, soil characteristics and biomass production, a General Linear Model (GLM) was applied using SAS software (1999) in a randomized complete block design, with rangeland production system as a random block and grazing type as a fixed effect.

Moreover, Jaccard coefficient of similarity was used to test the differences on similarities in species compositions among rangeland production system and grazing types of the study area. Tukey multiple comparison was used to test significant differences among the means.

The following model was used to assess on total dry matter biomass production, biodiversity, soil characteristics and basal and bare ground cover of the rangeland during the study.

$$Y_{ijk} = \mu+PS_i+GT_j+(PS*GT)_{ij}+B_k+E_{ijk}$$

3. RESULTS AND DISCUSSION

3.1. Herbaceous Vegetation

3.1.1. Herbaceous Species Composition and Functional Groups

3.1.1.1. Herbaceous species composition and functional groups indifferent production systems

A total of 51 herbaceous species were identified in the pastoral and agro-pastoral rangelands of the study area. The number of grass, herbaceous legumes and forbs were 27 (52.94%), 4 (7.84%) and 20 (39.22%), respectively. Out of these 27 grass species 11 (21.57%) were identified as annual species whereas 16 (31.37%) were perennial grass species (**Table1**). There exist a higher number of perennials than the annual grasses, which imply the potential productive nature of the grassland. In contrast, the pastoral communities in the study area reported that the annual grasses are increasing and perennials decreasing by time, which might be a sign of deterioration. The higher composition of the perennial grasses may imply the potential productive nature of the rangeland for livestock production (Amaha, 2006).Herbaceous species identified in this study correspond partially with those reported in the earlier study (Selam, 2008).

The pastoral areas of the study district comprised 35 herbaceous species, of which 17 grass species (7 annual and 10 perennial), 1 legume and 17 species of forbs. Digitaria abyssinica, E. superba, E. tef, P. coloratum and T. beteronianuswere identified as common grass species in all grazing types; and their relative abundance increased with grazing level, from communal, to enclosure and then riverside. Atriplex semibaccata, B. persica, O. basilicum, P. hysterophorus, R. patula, S. carinensis, T. terrestris and X. strumarium were identified as common forbs species in all grazing types; and their relative abundance increased with grazing types, from communal to enclosure and

then riverside (**Table 1**).Out of the total grass species identified in the PPS, the percentage of perennial grass species was higher than that of the annual grass species. This result is in line with that reported by Amaha (2006) for Shinile rangelands, which exhibited that, the dominance of perennial grasses may indicate that the herbaceous layer is in good condition. According to the pastoralists, however, the trend in the annual grasses has been increasing over the past two decades and some useful perennial grasses have decreased in abundance.

The agro-pastoral areas of the study district comprised 46 herbaceous species, of which 24 grass species (11 annual and 13 perennial), 4 legumes and 18 species of forbs. Cynodondactylon, D. aegypticum, E. tef, L. nutans, P. coloratum, Panicum sp. and T. beteronianuswere identified as common grass species in all grazing types; and their relative abundance increased with grazing types, from riverside, to communal and then enclosure. Atriplex semibaccata, B. persica O. basilicum, P. hysterophorus, R. patula, T. terrestris and X. strumarium identified as common forbs species in all grazing types; and their relative abundance increased with grazing types, from communal, to enclosure and then riverside (**Table 1**).

In the pastoral and agro-pastoral rangelands, many of the grass species recorded were perennials and their relative abundance was high in comparison with annual grass species. In fact, some species might have a different relative abundance in different topographic units as well as between edaphic factors within a unit (Snyman, 1998). The dominance of some species in certain area than others could be related to their high adaptation in response to changes in environmental circumstances, such as land use/land cover, rainfall and soil patterns (Getachew, 2006).

Grasses dominate the herbaceous vegetation in arid and semi-arid African rangelands, but these rangelands are often highly degraded due to heavy grazing by pastoral communities (Abuleet al., 2005; Angassa and Oba, 2007). However, we poorly understand the interplay between grazing impacts and vegetation and soil properties (Bilottaet al., 2007; Moussaet al., 2009), and especially the impacts of grazing on soil nutrients (Han et al., 2008), thereby affecting the relative abundance of different plant functional groups, and plant species richness (Tessemaet al., 2011).

3.1.1.2. Herbaceous Species Composition in different grazing types

The riverside grazing areas comprised 39 herbaceous species; 19 grass species; of which 8 were annual and 11 were perennials, 3 legumes and 17 species of forbs. Dactyloctenium aegypticum, D. abyssinica, E. superb, E. tef, L. nutans and T. beteronianus were identified the most dominant grass species in the riverside grazing. Parthenium hysterophorus, R. patula, T. terrestris and X. strumarium, were identified the most dominant forbs species in the riverside grazing areas of the pastoral production system whereas, Dactyloctenium aegypticum, D. abyssinica, E. tef, S. microprotus and T. beteronianus were identified the most dominant grass species in the riverside grazing. Belpharis persica, P. hysterophorus, T. terrestris and X. strumarium were identified the most dominant forbs species in the riverside grazing areas of the agro-pastoral production (**Table 1**).

Enclosure grazing areashad40 herbaceous species; 22 grass species; of which 10 were annual and 12 were perennials, 1 legume and 17 species of forbs. Cenchrus ciliaris, E. superba, E. tef, S. verticilata and S. microprotus were identified the most dominant grass species in the enclosure grazing areas.Atriplex semibaccata, O. basilicum, R. patula, S. carinensis and X. strumarium were identified the most dominant forbs species in the enclosure grazing areas of the pastoral production system.However, Bothriochloa insculpta, D. aegypticum, D. abyssinica, E. tef, and S. microprotus were identified the most dominant grass species in the enclosure grazing areas. Parthenium hysterophorus, S. nigrum and X. strumarium were identified the most dominant forbs species in the enclosure grazing areas of the agro-pastoral production system (**Table 1**).

Communal grazing areas comprised 24 herbaceous species; 13 grass species; of which 6 were annual and 7 were perennials and 11 species of forbs. Digitaria abyssinica, E. superba, E. tef, P. coloratum and T. beteronianus were identified the most dominant grass species in the communal grazing areas. Ocimum basilicum, P. hysterophorus, R. patula, T. terrestris and X. strumarium were identified the most dominant forbs species in the communal grazing areas of the pastoral production system, whereasDactyloctenium aegypticum, E. superba, E.tef, P. coloratum and T. beteronianus were identified the most dominant grass species in the communal grazing areas. Belpharis persica, R. patula, T. terrestris and X. strumarium were identified the most dominant forbs species in the communal grazing areas of the agro-pastoral production system (**Table 1**).

Table 1. List of herbaceous species with their relative abundance (nm^{-2}), life forms (LF) and functional group (FG) under two rangeland production systems (pastoral and agro-pastoral), three grazing types (communal, enclosure and riverside) in Shinile area, Somali Regional State, Ethiopia

Herbaceous Species	Rangeland Production System							
	Pastoral			Agro-Pastoral				
	R	E	C	R	E	C	LF	FG
Achyranthesaspara	2.5	0	0	18.06	29.45	0	F	P
Aristidaadoensis	0	0	12.70	7.26	2.78	0	G	A
Atriplexsemibaccata	51.11	61.66	25.20	99.64	26.11	23.71	F	A
Belpharispersica	20.83	5.56	7.22	82.46	51.92	125.04	F	A
Bothriochloainsculpta	5.56	0	19.20	14.762	153.998	0	G	P
Brachiariacomata	0	0	0	16.67	0	0	G	P
Bruceaantidysenterica	2.22	0	0	0	29.91	10.32	F	P
Cassia obovota	10	0	0	4.17	15.28	0	F	P
Cenchrusciliaris	0	6.67	0	0	0	0	G	P
Chenopoddiummoralle	52.78	25.52	0	0	2	0	F	A
Commicorpusafricanus	0	0	0	0	8.33	0	F	P
Crotolariapycnostachya	67.06	0	0	16.67	0	0	L	-
Crotolariarosenii	0	0	0	20	0	0	L	-
Croton menyhartii	47.5	0	41.79	0	0	0	F	A
Cymbopogongiganteus	0	0	6.25	13.93	0	0	G	A
Cynodondactylon	3.33	8.33	0	135.34	138.37	20	G	P
Dactylocteniumaegypticum	100.16	0	0	320.95	277.19	112.05	G	A
Digitariaabyssinica	341.65	894.76	684.90	167.26	127.91	0	G	P
Eleusinejaegeri	11.11	0	0	0	0	0	G	P
Eragrostisaspera	0	0	0	0	10	0	G	A
Eragrostisbiflora	0	0	0	2.5	3.57	0	G	A
Table 1 (continued)								
Eragrostissuperba	119.40	45.24	26.85	28.25	28.73	108.93	G	P
Eragrostistef	572.58	359.92	166.25	96.31	137.84	330.17	G	A
Helitropiumcineraceas	0	0	0	41.67	6.67	0	F	P
Hyparrheniahirta	0	0	0	0	2.22	0	G	P
Hypheanathebaica	3.33	0	0	0	54.42	0	G	A
Indigoferaspicata	0	0	0	0	20	0	L	-
Lintonianutans	154.11	0	15.39	24.76	11.34	102.32	G	P
Medicago spp.	37.33	15.56	0	67.22	77.39	0	F	A
Ocimumbasilicum	27.09	81.46	40.74	69.48	9.37	62.18	F	P
Ocimumurticifolim	0	0	0	0	28.57	0	F	P
Panicum coloratum	29.76	87.5	170.377	25.20	17.29	311.13	G	P
Panicum sp.	0	0	0	117.74	142.10	41.74	G	A
Parteniumhysterophorus	212.371	214.3452	118.7599	193.1151	295.4339	27.77778	F	A
Pennisetum sp.	0	0	0	0	33.33	0	G	A
Polypogonmonspliensis	0	0	0	6.25	0	0	G	P
Ruelliapatula	214.99	292.64	301.78	70.42	38.82	359.60	F	A
Sericompsispallidis	0	0	3.89	0	2.5	0	F	A
Setariaverticilata	0	35.40	0	0	5	0	G	A
Solanumcarinensis	72.5	53.02	68.93	6.67	1.67	100.46	F	A
Solanumnigrum	20.83	0	0	86.30952	125.6832	0	F	P
Sporobolusiclados	3.33	0	0	0	0	0	G	P
Sporobolusagrostidae	0	0	0	131.90	94.49	0	G	P
Sporobolusmicroprotus	0	84.40	3.33	519.37	252.08	0	G	P
Sporoboluspyramidlis	0	0	0	0	18.06	0	G	P
Sylvia somalensis	7.5	0	0	0	0	0	F	P
Tephrosiavogelii	0	0	0	36.67	0	0	L	-

Tetrapogonvillosa	0	0	0	0	5	0	G	P
Tragus beteronianus	377.42	578.25	793.17	261.07	73.38	633.42	G	A
Tribulusterrestris	243.41	219.36	264.36	74.17	72.96	108.02	F	A
Xanthium strumarium	70.52	112.81	105.71	178.06	104.20	133.61	F	A
Grasses Species	12	9	10	17	21	8	-	-
Annual Grasses	4	3	4	7	10	4	-	-
Perennial Grasses	8	6	6	10	11	4	-	-
Legumes	1	0	0	3	1	0	-	-
Forbs	16	10	10	13	18	9	-	-
Total Number of Species	29	19	20	33	40	17	-	-
Percentage of Species								
Grasses Species	41.38	47.37	50.00	51.52	52.50	47.06	-	-
Annual Grasses	13.79	15.79	20.00	21.21	25	23.53	-	-
Perennial Grasses	27.59	31.58	30.00	30.30	27.5	23.53	-	-
Legumes	3.45	0.00	0.00	9.09	2.5	0.00	-	-
Forbs	55.17	52.63	50.00	39.39	45	52.94	-	-
Total Percentage Species	100.0	100.0	100.0	100.0	100.0	100.0	-	-

C = communal; E = enclosure; R = riverside; A = annual; P= perennial; F = forbs; G = grass; L = legumes; LF = life form; FG = functional group

3.1.2. Herbaceous Species Diversity and Plant Abundance

3.1.2.1. Herbaceous species diversity and plant abundance in differentproduction systems

Herbaceous species abundance (**Table 2**; $F_{1, 354} = 19.56$, $P < 0.001$), species diversity (**Table 2**; $F_{1, 354} = 15.35$, $P < 0.001$), evenness (**Table 2**; $F_{1, 354} = 14.51$, $P < 0.001$) and species richness (**Table 2**; $F_{1, 354} = 6.94$, $P = 0.009$) in the pastoral rangeland production system had significantly higher than agro-pastoral production system (**Table 2**). This may be related to the presence of high animal grazing pressures due to the presence of high number of livestock. This result also indicates that in the pastoral production system, herbaceous vegetations were equally distributed.

3.1.2.2. Herbaceous species diversity and plant abundance in different grazing types

Herbaceous species abundance (**Table 2**; $F_{2, 354} = 9.00$, $P < 0.001$), species diversity (**Table 2**; $F_{2, 354} = 9.06$, $P < 0.001$) and species richness (**Table 2**; $F_{2, 354} = 17.02$, $P = 0.001$) were significantly increased from communal to riverside and then enclosure grazing areas in the rangeland production systems (**Table 2**). This result might be related to the damage of herbaceous species by heavy grazing and human activities and it could be related to soil degradation which is caused to the poor quality of soils fertility and soil compacted in the communal and riverside grazing areas. There was no significant difference in species evenness in all grazing areas which indicated that the relatively species distributions was similar through all grazing areas of the rangeland.

3.1.2.3. Interaction Effect of production systems and Grazing on herbaceous species diversity and plant abundance

The pastoral production system, enclosure grazing had significantly lower in species diversity and species richness but significantly higher in plant abundance than the other two grazing areas (**Table 2**; $F_{1, 354} = 4.18$, $P = 0.016$). This was in relation to the Digitaria abyssinica grass species which were highly dominated species in enclosure grazing areas (**Table 1**). Herbaceous plants diversity was significantly increased from communal to enclosure and then riverside grazing (**Table 2**; $F_{1, 354} = 8.39$, $P < 0.0001$) and species richness was significantly increased from enclosure to communal and then riverside grazing areas (**Table 2**; $F_{1, 354} = 19.57$, $P = 0.009$).

The agro-pastoral production system, herbaceous species diversity (**Table 2**; $F_{1, 354} = 9.06$, $P = 0.001$), relative plant abundance (**Table 2**; $F_{1, 354} = 4.18$, $P = 0.016$) and richness (**Table 2**; $F_{1, 354} = 19.57$, $P = 0.001$) were significantly higherin enclosuregrazing than the other two grazing areas of the rangelands. This might be related to the reduced her baceous species damage by heavy grazing pressures and human activities in enclosure grazing areas and it could be related with reduced soil degradation in this area.

Table 2.Effect of production system on herbaceous species diversity, species evenness, total plant abundance (Nm^{-2}) and species richness at different types of grazing in Shinile Area, Somali Regional State, Ethiopia

Factor Levels and interaction effect		Shannon diversity	Species Evenness	Plant abundance	Species richness
Pastoral Production System (PPS)		Mean			
	R	1.51[a]	0.88[a]	260.0[c]	5.68[a]
	E	1.48[b]	0.88[a]	285.0[a]	5.55[c]
	C	1.43[c]	0.81[b]	275.0[b]	5.62[b]
Agro-pastoral Production System (APPS)					
	R	1.12[c]	0.72[b]	226.7[b]	4.18[b]
	E	1.57[a]	0.81[a]	275.0[a]	6.90[a]
	C	1.16[b]	0.73[b]	205.0[c]	4.05[c]
Production System (PS)					
	F (df = 1,354)	15.35	14.51	19.56	6.94
	P	0.001	0.001	0.001	0.009
	Lsd	0.096	0.051	16.80	0.430
Grazing Type(GT)					
	F (df = 2,354)	9.06	2.76	9.00	17.02
	P	0.001	0.065	0.001	0.001
	Lsd	0.118	NS	20.57	0.523
PS*GT (interaction)					
	F (df = 2,354)	8.39	1.15	4.18	19.57
	P	0.001	0.318	0.016	0.001
	Lsd	0.167	NS	29.10	0.740

Df = degree of freedom, F-ratio = F test value, P = probability value, NS = non significant, PPS = Pastoral Production System; APPS = Agro-pastoral Production System; GT = Grazing Type; R = Riverside; E = Enclosure; C = Communal. Means with the same letter in columns within each production system (PS) are not significantly different at $P \leq 0.05$.

3.1.3. Biomass Production of Herbaceous Species

3.1.3.1. Biomass production of herbaceous species in different production systems

Herbaceous grass biomass (**Table 3**; $F_{1, 354} = 0.48$, $P = 0.492$), and non-grass biomass (**Table 3**; $F_{1, 354} = 0.66$, $P = 0.420$) showed no significant differencein both production systems. This might be due to similarities in climate and grazing pressure, lack of variations in the basal cover, and the grass species composition values among the grazing types. This is also reported in the study area for previous studies, the possible reason for the non-significant difference for grass biomass among the study areas might be the influence of the frequent drought that occurred in the Shinile zone (Lishan, 2007).

3.1.3.2. Effect of production system and grazing on basal and bareground cover of herbaceous species

In all rangeland production systems, the percentage of basal cover (**Table 3**; $F_{1, 354} = 14.35$, $P < 0.001$), significantly increased from communal, riverside and then enclosure grazing areas; whereas the bare ground (**Table 3**; $F_{1, 354} = 14.35$, $P < 0.001$), was significantly decreased fromcommunal, riverside and then enclosure grazing areas. Production system and grazing had highly significant effect on the percentage of basal cover and bare ground for herbaceous species. Percentage of basal cover (**Table 3**; $F_{1, 354} = 8.32$, $P = 0.004$)of the pastoral had significantly higher than agro-pastoral production system, and the percentage of basal cover in the pastoral and agro-pastoral production systems of the study districts were 50.31 and 42.94%, respectively (**Table 3**).Whereas bare ground cover of the pastoral had significantly lower than agro-pastoral production system (**Table 3**; $F_{1, 354} = 8.32$, $P = 0.004$). This might be related to the reduced species damage soil degradation from communal, riverside and then enclosure grazing areas. This result was similar to the previous finding of the resource assessment potential study of the SNRS which revealed that large rangeland areas in Shinile zone had turned into bare lands as a result of the over usage and lack

of soil moisture to support vegetation growth. A similar finding was also reported by Gemedo (2004) for range sites around water points (ponds) and Foora (grazing land traditionally allocated by Borana pastorals for dry livestock) areas, which are closely associated with bare soil.

Table 3. Effect of production system and different types of grazing on herbaceous dry matter biomass (kg ha^{-1}), basal cover and bare ground (%) in Shinile Area, Somali Regional State, Ethiopia

Factor Levels and interaction effect		GB	NGB	BC	BG
Pastoral Production System (PPS)		Mean			
	R	922.10	955.00	52.72^{b}	47.28^{b}
	E	936.50	1027.00	57.33^{a}	42.67^{c}
	C	753.80	725.00	45.75^{c}	54.25^{a}
Agro-pastoral Production system (APPS)					
	R	839.10	881.00	38.53^{b}	61.47^{b}
	E	965.40	964.00	70.57^{a}	29.43^{c}
	C	953.70	1039.00	20.67^{c}	79.33^{a}
Production System (PS)					
	F (df = 1,354)	0.48	0.66	8.32	8.32
	P	0.492	0.420	0.004	0.004
	Lsd	NS	NS	5.920	5.920
Grazing Type(GT)					
	F (df = 2,354)	0.68	0.840	35.23	35.23
	P	0.511	0.434	0.001	0.001
	Lsd	NS	NS	7.250	7.250
PS*GT (interaction)					
	F (df = 2,354)	1.36	3.06	14.35	14.35
	P	0.262	0.052	0.001	0.001
	Lsd	NS	NS	10.250	10.250

Df = degree of freedom, F-ratio = F test value, P = probability value, NS = non significant, PPS = Pastoral Production System; APPS = Agro-pastoral Production System; GT = Grazing Type; R = Riverside; E = Enclosure; C = Communal;GB = Grass biomass; NGB = Non-grass biomass; BC = Basal Cover; BG = Bare ground. Means with the same letter in columns within each production system (PS) are not significantly different at P ≤ 0.05.

3.1.4. Herbaceous Species Similarity

The highest two Jaccard coefficient similarity index (0.57 and 0.50) for herbaceous species composition was recorded between the communal grazing areas of the pastoral and agro-pastoral production systems; and enclosure and communal grazing areas of the pastoral and agro-pastoral production system, respectively. The lowest two Jaccard coefficient of similarity index (0.13 and 0.18) was obtained between the enclosure and riverside grazing areas of the pastoral and agro-pastoral production systems; and riverside and enclosure grazing areas of the pastoral and agro-pastoral production system, respectively (**Table 4**). This result indicated that community species similarity was high between communal and enclosure grazing areas in both production systems. Less species similarity was recorded between pastoral and agro-pastoral production systems of the riverside and enclosure grazing areas. This result could be related to the variation of species communities between the pastoral and agro-pastoral production systems grazing types.

Table 4. Jaccard coefficient of similarity for herbaceous species under two rangeland production system and three grazing types in the rangelands of Shinile area, Somali Regional State, Ethiopia

		Rangeland Production System					
		Pastoral			Agro-pastoral		
		R	E	C	R	E	C
Pastoral							
	R	-					

	E	0.25	-				
	C	0.20	0.43	-			
Agro-pastoral							
	R	0.38	0.13	0.38	-		
	E	0.18	0.22	0.30	0.20	-	
	C	0.22	0.50	0.57	0.25	0.20	-

3.2. Soil Parametersin Different Production Systems

Potassium (**Table 5**; $F_{1, 12} = 5.68$, P = 0.035), and sodium (**Table 5**; $F_{1, 12} = 5.69$, P = 0.034) content of the soil are significantly higher in agro-pastoral production as compared to the pastoral production system. This result is in agreement with those reported by in Erer district (Selam, 2008).

Even if, soil chemical properties (excluding potassium and sodium minerals) did not show significant difference over all rangeland production systems and grazing types were generally low and differed non-significantly in all the study sites (**Table 5**). All the findings in the chemical analysis of soil nutrients may indicate that the data are notable for their lack of variability within the given soil type of the Shinile rangelands. This is supported by the finding of Teferaetal.(2007) in Borana rangelands, Ethiopia. This finding is partially, related to a study conducted in Awash National Park and Abernosa Cattle Breading Range (Tessemaet al., 2011). Complex spatial patterns of soil nutrients have been commonly presumed to develop over time as a result of the interactions of climate, parental material, vegetation type and topography (Wang et al., 2001). Overall, the rangelands of east Africa are regarded as having a low fertility. This principally was attributed to the very old age of common parental material (Pratt and Gwynne, 1977).

Table 5. Effect of production systems and grazing types on physical and chemical soil Parameters in Shinile area, Somali Regional State, Ethiopia

Soil Parameters	Pastoral Production System (PPS)			Agro-pastoral Production (APPS)			System Production System (PS)			Grazing Type (GT)			PS*GT		
	R	E	C	R	E	C	F(df=1,18)	P	Lsd	F(df=2,18)	P	Lsd	F(df=2,18)	P	Lsd
	Mean														
pH	7.810	7.983	7.777	7.743	7.793	7.953	0.12	0.740	NS	0.75	0.492	NS	1.89	0.194	NS
EC(mmhos/cm)	0.060	0.028	0.129	0.035	0.039	0.039	2.50	0.140	NS	1.89	0.194	NS	1.82	0.203	NS
OC (%)	1.047	1.155	0.737	0.924	1.271	1.163	0.69	0.424	NS	0.95	0.412	NS	0.89	0.437	NS
OM (%)	1.805	1.992	1.27	1.593	2.191	2.005	0.68	0.425	NS	0.95	0.412	NS	0.89	0.438	NS
AVP.ppm	9.427	13.37	9.39	6.847	7.527	9.717	0.73	0.410	NS	0.18	0.837	NS	0.32	0.734	NS
K(Cmol(+)/Kg.Soil)	2.183[b]	2.170[b]	2.343[a]	2.547[a]	2.347[b]	2.523[a]	5.68	0.035	0.219	1.02	0.389	NS	0.38	0.695	NS
Mg(Cmol(+)/Kg.Soil)	6.623	6.640	6.643	6.703	6.687	6.54	0.04	0.841	NS	1.58	0.245	NS	2.20	0.153	NS
Na(Cmol(+)/Kg.Soil)	2.910[b]	2.897[b]	3.123[a]	3.393[a]	3.13[b]	3.367[a]	5.69	0.034	0.292	1.01	0.394	NS	0.37	0.698	NS
Ca(Cmol(+)/Kg.Sol)	27.98	27.74	24.89	27.12	28.77	23.45	0.03	0.865	NS	1.06	0.377	NS	0.09	0.911	NS
Total N (%)	0.090	0.0997	0.064	0.0797	0.109	0.100	0.67	0.429	NS	0.94	0.416	NS	0.89	0.436	NS
CEC (meq/100g.soil)	39.70	39.44	37.00	39.76	40.93	35.87	0.00	0.957	NS	0.90	0.432	NS	0.09	0.913	NS
Sand (%)	53.31	54.92	59.64	46.64	52.97	61.31	0.45	0.514	NS	3.17	0.079	NS	0.49	0.623	NS
Silt (%)	20.67	22.05	18.33	27.00	20.67	19.33	1.09	0.317	NS	2.31	0.141	NS	1.45	0.274	NS
Clay (%)	26.03	23.03	22.03	26.36	26.36	19.36	0.02	0.885	NS	2.11	0.164	NS	0.59	0.571	NS

Ca = calcium; CEC = cation exchange capacity; EC = electrical conductance; Mg = magnesium; K = potassium; Na = sodium; N = nitrogen; OC = organic carbon; P = phosphorus; Df = degree of freedom, F-ratio = F test value, P = probability value; NS = non significant, PPS = Pastoral Production System; APPS = Agro-pastoral Production System; GT = Grazing Type; R = Riverside; E = Enclosure; C = Communal. Means with the same letter in rows within each production system (PS) are not significantly different at $P \leq 0.05$.

4. CONCLUSION AND RECOMMENDATIONS

In the study districts, a total of 27, 20and 4 species of grasses, forbs and herbaceous legumes species were identified respectively. Percentages of perennial herbaceous species were higher than annuals. In the pastoral production system, Digitaria abyssinica, E. superba, E. tef, P. coloratum and T. beteronianuswere identified as common grass species in all grazing types; and their relative abundance increased with grazing types, from communal, to enclosure and then riverside. While in the agro-pastoral production system, Cynodondactylon, D. aegypticum, E. tef, L. nutans, P. coloratum, Panicum sp. and T. beteronianuswere identified as common grass species for all grazing types; and their relative abundance were increased with grazingtypes, from riverside, to communal and then enclosure. The pastoral production system, enclosure grazing had significantly lower in species diversity and species richness but significantly higher in plant abundance than the other two grazing areas. Herbaceous plants diversity was significantly increased from communal to enclosure and then riverside grazing and species richness was significantly increased from enclosure to communal and then riverside grazing areas.Potassium and sodium content of the soil are significantly higher in agro-pastoral production as compared to the pastoral production system.Research related to rehabilitation and possible restoration strategies through soil seed bank and aboveground dynamics under rangeland production systems and grazing should be considered.

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