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Seasonal Dynamics in Botanical Composition of the Rangelands of Gambella, Southwestern Ethiopia

Ketema Tilahun[1,*], Ashenafi Mengistu[2] and Solomon Mengistu[3]

[1]Department of Animal Sciences, Gambella ATVET College, Gambella, Ethiopia
[2]Department of Animal Production Studies, Addis Ababa University, College of Veterinary Medicine and Agriculture, Debre Zeit, Ethiopia
[3]Debre Zeit Agricultural Research Centre, Ethiopian Institute of Agricultural Research (EIAR), Debre Zeit, Ethiopia

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Corresponding Author:
Ketema Tilahun
ketema.tilahun@yahoo.com

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ABSTRACT

Systematic assessment on seasonal dynamics in botanical composition of the herbaceous and woody layers of Gambella rangelands of southern Ethiopia was undertaken. The study was conducted during the consecutive wet and dry seasons of 2013/14 in the two districts (Itang and Jikawo). The representative sites per district were three wet season and one dry season grazing areas. A total of 38 herbaceous species belong to 12 families were identified, of which 36.84%, 15.79%, 36.84% and 10.53% grasses, legumes, forb and sedges botanical group respectively. There were a significant variation between seasons, species and their interaction at $p<0.01$ of the herbaceous layer. This suggests that there is great seasonal dynamism of semi-arid vegetation communities, especially of the grass cover. The dominant grass species were *Brachiariasemiundulata*, *Cynodon dactylon*, *Echinochloa colona*, *Echinochloa pyramidalis*, *Eriochloa fatmensis*, *Panicum maximum*, *Rottboellia cochinchinensis* and *Setaria incrassate* which are known as the key forage species by the Neur pastoralists. The botanical group of the herbaceous layer differed significantly at $p<0.05$ and their proportion across season showed a highly significant difference at $p<0.01$. However, their interaction with season did not show a marked variation ($p>0.05$).The woody layer was consisted of 12 species, which included species of 6 trees and 6 shrubs, contributing each 50% of the botanical group. Botanical composition and related parameters of the woody layer did not show a marked variations ($p>0.05$) between seasons. This is due to the dominance of evergreen browse species *Acacia hockii*, *Acacia seyal* and *Balanites aegyptiaca*. Accordingly, suggesting that evergreen trees and shrubs play a vital role as a source of fodder in the tropics when the herbaceous layer dried up and deteriorate.

Keywords: botanical group, dry season, grazing areas, herbaceous layer, wet season, woody layer.

INTRODUCTION

Range resources are heterogeneous and dispersed, tied with seasonal rainfall patterns, differing through time and characterized by overall erratic climatic patterns. The net productivity of arid rangelands is low and the animal and plant populations that it can sustain fluctuate unpredictably, depending on a number of variables among which rainfall patterns play a major role (Nori *et al.*, 2008). The availability and quality of the different browse and grass species is believed to vary from season to season due to marked seasonality in rainfall distribution that affects the growth and development of the plant species, particularly that of the grasses and other herbaceous species (Abebe *et al.*, 2012). Botanical composition is one of the means of studying ecological changes in the development of a rangeland (Malan and Niekerk, 2005). The seasonal dynamics of vegetation is related to inter-specific and intra-specific plant species competition, carrying capacity of rangeland and land use management (Shuyskaya *et al.*, 2012). Botanical and chemical composition and season of growth affect the digestibility of grasses, and the nature and quantities of products of digestion (Dohme *et al.*, 2006).The changes in the composition of plant species in savanna ecosystems have a significant influence on the sustainability of livestock production (Sankaran *et al.*, 2005).

The pastoral environment in East Africa is typified by semi-arid lands (Homewood, 2008). The pastoral regions of Ethiopia, as elsewhere in Africa, have a fragile environment and unpredictable weather (PFE, IIRR and DF, 2010). Like other pastoral areas of Ethiopia, in Gambella, extensive pastoral production system is experienced, predominantly in areas where the Nuer Pastoral communities inhabit (Tilahun, 2007). The Region is endowed with a huge number of livestock and supports the livelihood of a larger segment of the society (GPNRS, 2011). Grazing land is an important and key resource in the region. Major sources of livestock feed are the open woodlands, riverine forest and woodland during the wet season, and the savanna grassland during the dry season. No other feed is provided to livestock (ACORD, 1998; Tilahun, 2007).

Various range research and development works were conducted exhaustively in the rest rangelands of Ethiopia. However, in the Gambella Regional State in general and the Nuer pastoral areas in particular, research and development interventions have never been done (Tilahun, 2007). As baseline description of the flora (Kelbessa *et al.*, 1992; Friis, 1992; Tadesse, 1992), an ecological study of the vegetation (Awas *et al.*, 2001) and information regarding biomass production, utilization practices and range condition in Nuer Zone (Tilahun, 2007) of the region have been conducted. However, studies on variations in botanical composition across season have not been done that would contribute to decision making regarding optimal utilization of the range resources. Therefore, the objective of this study was to undertake systematic assessments of the seasonal dynamics in botanical composition of the herbaceous and woody layers of the rangeland of Gambella, Southwestern Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

This study was conducted in rangelands of Gambella from the two districts, Itang and Jikawo located between 06°10'70" to 08°21'59" N and 034°66'25" to 093°47'49" E with an altitude of 391 to 438 m.a.s.l. The annual rain fall of the region ranges between 800-1200 mm with uni- modal distribution (Woube, 1999) and the average annual temperature is 27.5°^{0}C (Kassahun and Asfaw, 2008). Fertile but poorly drained Vertisols (47%), relatively infertile well-drained orthic Acrisols (14%), relatively fertile eutric Fluvisols (27%) occasionally with high water tables and deep well drained dystric Nitosols of moderate fertility (11%) are the four major soil types found in the entire region. The existing land cover (vegetation) types of

the region are identified as cultivated land, forest land, wood land, bush land, shrub land, grass land, bamboo, wet (marsh land) (GPNRS, 2011).

Selection of the Study Sites and Field Layout

A reconnaissance survey was conducted to select the study site. The grazing areas were systematically selected in such a way that they represent pastoralists' seasonal grazing locations. In establishing the sampling plots, a combination of stratification and systematic sampling were used. Four representative sites were selected from each districts which included three wet season grazing areas (open woodlands, riverine forests and woodlands) and one dry season grazing area (savanna grassland). Totally four transects, which are 100 m in length and 15 m apart, used to collect vegetation and soil samples. Each transect position were marked by Global Positioning System (GPS).

Vegetation Survey

Vegetation survey was carried out once in each of the two major seasons, dry and wet seasons. Quadrat method was employed to determine botanical composition of the rangeland. The herbaceous species was determined by examining 1×1 m^2 quadrats. For shrubs and trees above 2 m height, 10 m × 10 m quadrats were used. The species occurred in each quadrat were counted and recorded. The leaves of the selected browse species were hand plucked when available along transects, while grass samples were harvested at about five cm above the ground. These were further used for chemical analysis. Samples of same species within transects were bulked for analysis. Harvested materials of each quadrat were sorted out into herbaceous species (grasses, legumes, forbs and sedges) and woody species (shrubs and trees) on the basis of their botanical group.

The herbaceous layer was classified based on the succession theory described by Dyksterhuis (1949); on the ecological information for the arid to semi-arid regions of South Africa (Tainton *et al.*, 1980; Vorster, 1982) and on their ecological status determined by their perceived acceptability to animals and response to grazing (Amsalu and Baars, 2002; Van Oudtshoon, 1992) into: (i) highly desirable species (decreasers), (ii) desirable species (increaser IIa), and (iii) less desirable and undesirable species (increasers IIb and IIc). In addition, species were grouped into annuals and perennials in terms of their life form as well as by their abundance into (dominant, common and present). The grouping of species was also subjectively supported by the opinions of the pastoralists. The dormant browse species with no foliage were considered non-available (Hussain and Durrani, 2009) particularly those of deciduous species.

Statistical Analysis

A two-way ANOVA was carried out using General Linear Model procedure of Statistical Package for the Social Science (IBM SPSS Statistics, 2011) to test differences in the effects of season on botanical composition and related parameters of the herbaceous and woody layer. For data that did not require analysis, simple descriptive statistics were employed where appropriate.

RESULTS

Seasonal Dynamics in Botanical Composition and Related Parameters of The Herbaceous Layer

A total of 38 herbaceous species belong to 12 families were identified, of which 14 (36.84%), 6 (15.79%), 14 (36.84%) and 4 (10.53%) grasses, legumes, forb and sedges botanical group respectively. In terms of the life forms, 23(60.53%) were annuals and 15(39.47%) perennials. Based on their desirability, 6 species (15.79%) were highly desirable, 9 species (23.68%) were desirable, 12 species (31.58%) were less desirable and 11species

(28.95%) undesirable. In terms of their ecological index, 6(15.79%), 4(10.53%), 10(26.32%) and 18(47.37%) species were Decreasers, Increaser IIa, Increaser IIb and Increaser IIc, respectively (Table 1).

Table 1: Species identifed and related parameters of herbaceous layer in the Gambella rangelands of southwestern Ethiopia

Scientific Name	Vernacular Name	Family	Botanical Group	Life Forms	Desirability	Ecological Group
***Achyranthes aspera* L.**	*Gar*	Amaranthaceae	Forb	A	L	IncIIc
***Aeschynomene indica* L.**	*Keck*	Fabaceae	Legume	A	L	IncIIc
***Brachiariasemiundulata* (A. Rich.) Stapf.**	*Dit*	Poeceae	Grass	A	H	Dec
***Centrostachys aquatic* (R.Br.) Wall ex Moq**	*Kowkow*	Amaranthaceae	Forb	A	U	IncIIc
***Chloris gayana* Kunth**	*Bok*	Poeceae	Grass	P	D	IncIIa
***Commelina benghalensis* L.**	*Gnock*	Commelinaceae	Forb	A	H	Dec
***Corchorus fascicularis* Lam.**	*GnangJang*	Tiliaceae	Forb	A	L	IncIIc
***Corchorus trilocularis* Lam.**	*GnangJang*	Tiliaceae	Forb	A	U	IncIIc
***Cucumis pustulatus* Naud ex Hook.f.**	*Peet*	Cucurbitaceae	Forb	P	U	IncIIc
***Cynodon dactylon* (L)**	*Moth*	Poeceae	Grass	P	D	IncIIa
***Cyperus aethiops* Ridley**	*Gnyal*	Cyperaceae	Sedge	P	U	IncIIc
***Cyperus distans* L.f.**	*Gode*	Cyperaceae	Sedge	P	U	IncIIc
***Cyperus pauper* Hochst. Ex A. Rich.**	*Duck*	Cyperaceae	Sedge	A	U	IncIIc
***Cyperusrotundus* L.**	*Kuiling*	Cyperaceae	Sedge	P	L	IncIIc
***Desmodiumuncinatum* (Jacq.) DC.**	*Unkown2*	Fabaceae	Legume	P	D	IncIIb
***Dichondra repens* JR. & G. Forst.**	*Kuded*	Convolvulaceae	Forb	A	U	IncIIc
***Diplocyclos palmatus* (L.) C Jefji-en**	*Botbot*	Cucurbitaceae	Forb	P	U	IncIIc
***Echinochloa colona* (L.)Link.**	*Kut*	Poeceae	Grass	A	D	IncIIa
***Echinochloa pyramidalis* (Lam.) Hitchc. & Chase**	*Bor*	Poeceae	Grass	A	H	Dec
***Eriochloa fatmensis* (Hochst. & Steud.) Clayton**	*Wawich*	Poeceae	Grass	A	L	Inc IIb
***Ethulia gracilis* Del**	*Gnier*	Asteraceae	Forb	P	U	IncIIc
***Hygrophila schulli* (Hamilt.) MR. & S.M Almeida**	*Theil*	Acanthaceae	Forb	P	L	IncIIc
***Indigofera arrecta* Hochst. ex A.Rich.**	*ThiathJang*	Fabaceae	Legume	A	L	IncIIc
***Ipomea aquatica* Forsk**	*Thech*	Convolvulaceae	Forb	A	D	IncIIb
***Ipomoea purpurea* (L.) Roth**	*Naynay*	Convolvulaceae	Forb	A	D	IncIIb
***Oryza longistaminata* A. Chev. & Roehr**	*Pon*	Poeceae	Grass	P	H	Dec
***Panicum maximum* Jacq.**	*Gaw*	Poeceae	Grass	P	H	Dec
***Paspalum scrobiculatum* L.**	*Gok*	Poeceae	Grass	A	H	Dec
***Pennisetum polystachion* (L.) Schult.**	*Chumear*	Poeceae	Grass	P	L	Inc IIb
Phyllanthus guineensis	*Waak*	Euphorbiaceae	Forb	A	L	IncIIc
***Rhynchosiastipulosa* A. Rich.**	*Unkown1*	Fabaceae	Legume	A	U	IncIIc
***Rottboellia cochinchinensis* (Lour.) Clayton**	*Pon2*	Poeceae	Grass	A	L	Inc IIb
***Senna obtusifolia* (L.) Irwin & Barneby**	*Reir*	Fabaceae	Legume	A	D	IncIIa
***Setaria incrassata* (Hochst.) Hack.**	*Hol*	Poeceae	Grass	P	L	Inc IIb
***Setaria pumila* (Poir.) Roem. & Schult.**	*JualJoack*	Poeceae	Grass	A	D	Inc IIb
***Solanum incanum* L.**	*Tanglor*	Solanaceae	Forb	P	U	IncIIc
***Sporobolus pyramidalis* P. Beauv.**	*Thoath*	Poeceae	Grass	A	L	Inc IIb
***Vigna membranacea* A. Rich**	*Reim*	Fabaceae	Legume	A	D	IncIIb

A= annual, P = perennial; H= highly desirable, D = desirable, L= less desirable, U=undesirable, Dec= decreaser, IncIIa = increaser IIa, IncIIb = increaser IIb, IncIIc = increaser IIc.

There were a significant variation between seasons, species and their interaction at p<0.01(Table 2).

Table 2: Mean± SD and level of variation of seasonal dynamics in botanical composition of the herbaceous layer

Species	Wet		Dry		Significance
	N	Mean±SD	N	Mean±SD	
Achyranthes aspera	2	10.84±5.89			
Aeschynomene indica	3	7.08±2.05			
Brachiariasemiundulata	4	26.23±11.34			
Centrostachys aquatic	2	6.28±0.56			
Chloris gayana	3	13.63±10.06	1	20.00	
Commelina benghalensis	9	11.04±4.28			
Corchorus fascicularis	4	6.69±1.63			
Corchorus trilocularis	2	8.34±2.35			
Cucumis pustulatus	6	16.41±12.56	3	25.60±11.62	
Cynodon dactylon	24	44.17±31.95	14	63.61±28.33	
Cyperus aethiops	2	8.49±3.69	1	11.11	
Cyperus distans	3	11.55±7.53			
Cyperus pauper	1	5.56			
Cyperusrotundus	19	27.22±27.9	10	39.95±33.48	
Desmodiumuncinatum	4	11.72±6.08	2	16.25±5.3	
Dichondra repens	1	5.88			
Diplocyclos palmatus	1	10.00			
Echinochloa colona	8	22.52±6.62			
Echinochloa pyramidalis	6	21.59±11.52			
Eriochloa fatmensis	4	30.44±10.16			
Ethulia gracilis	10	25.30±27.68	5	39.67±34.16	
Hygrophila schulli	36	30.47±21.90	20	43.14±21.96	
Indigofera arrecta	3	13.33±5.77			
Ipomea aquatica	16	24.71±13.02			
Ipomoea purpurea	3	11.11±1.92			
Oryza longistaminata	15	13.77±8.52	7	19.44±8.93	
Panicum maximum	14	22.27±12.98	3	13.23±1.84	
Paspalum scrobiculatum	2	7.18±0.72			
Pennisetum polystachion	5	17.72±4.45	2	20.84±5.89	
Phyllanthus guineensis	3	5.71±0.64			
Rhynchosiastipulosa	4	10.03±4.54			
Rottboellia cochinchinensis	8	26.33±16.73			
Senna obtusifolia	13	16.21±8.92			
Setaria incrassata	17	46.86±32.05	9	60.49±33.06	
Setaria pumila	3	6.61±1.81			
Solanum incanum	5	39.76±30.12	3	60.71±12.88	
Sporobolus pyramidalis	11	27.53±26.89	6	41.98±29.46	
Vigna membranacea	5	12.00±5.70			
Season					**
Species					**
Season*Species					**

*N= Number of observations, **=Highly significant (p<0.01), SD= Standard deviation*

Of the total herbaceous species identified, 12 and 14 species were classified as dominantly and commonly distributed over the major grazing areas of the two districts in wet season (Table 3). Of the dominant species 8 (66.67%) were grasses, 2(25%) were forbs, 1(8.33%) each were legume and sedge. The dominant grass species were *Brachiariasemiundulata, Cynodon dactylon, Echinochloa colona, Echinochloa pyramidalis, Eriochloa fatmensis, Panicum maximum, Rottboellia cochinchinensis* and *Setaria incrassate.* These species are known as the key forage species by the Nuer pastoralists in the Gambella rangelands of southwestern Ethiopia. *Echinochloa colona* was dominantly occurring in woodlands and riverine forests of Itang district whereas *Panicum maximum* was distributed in the woodlands and open woodlands of Jikawo. *Cynodon dactylon* and *Echinochloa pyramidalis* were the dominant grass species of grassland savanna of Itang.Of the commonly distributed

herbaceous species 4 (14.29%) were grasses (*Chloris gayana, Oryza longistaminata, Pennisetum polystachion* and *Sporobolus pyramidalis*), 6 (42.86%) were forbs (*Achyranthes aspera, Corchorus fascicularis, Cucumis pustulatus, Ethulia gracilis, Hygrophila schulli* and *Ipomoea purpurea*) 3 (21.43%) were legumes (*Indigofera arrecta, Rhynchosiastipulosa* and *Vigna membranacea*) and 1(7.14%) was sedge (*Cyperus distans*).

Table 3: Seasonal dynamics in Species composition (%) based on frequency of occurrence of the herbaceous layer in the Gambella rangelands of southwestern Ethiopia

Species/Season, Grazing Areas	Wet								Dry							
	JW	JR	JO	JS	IW	IR	IO	IS	JW	JR	JO	JS	IW	IR	IO	IS
Achyranthes aspera	-	-	*C*	-	-	-	-	-	-	-	-	-	-	-	-	-
Aeschynomene indica	-	*P*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brachiariasemiundulata	-	*D*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Centrostachys aquatic	-	-	-	-	-	*P*	*P*	-	-	-	-	-	-	-	-	-
Chloris gayana	*C*	-	-	-	-	-	-	-	*C*	-	-	-	-	-	-	-
Commelina benghalensis	*C*	*P*	*P*	-	-	-	*C*	*D*	-	-	-	-	-	-	-	-
Corchorus fascicularis	-	-	-	-	*P*	*C*	-	-	-	-	-	-	-	-	-	-
Corchorus trilocularis	-	-	*P*	-	-	-	-	-	-	-	-	-	-	-	-	-
Cucumis pustulatus	-	-	*C*	-	-	-	-	-	-	-	*D*	-	-	-	-	-
Cynodon dactylon	-	-	-	*C*	-	*P*	-	*D*	-	-	-	*D*	-	*C*	-	*D*
Cyperus aethiops	*P*	-	-	-	-	-	-	-	*P*	-	-	-	-	-	-	-
Cyperus distans	-	*C*	-	-	-	*P*	-	-	-	-	-	-	-	-	-	-
Cyperus pauper	-	-	-	-	*P*	-	-	-	-	-	-	-	-	-	-	-
Cyperusrotundus	*C*	*D*	*P*	-	-	-	-	-	*D*	*D*	*D*	-	-	-	-	-
Desmodiumuncinatum	-	-	-	-	-	-	*P*	-	-	-	-	-	-	-	*C*	-
Dichondra repens	*P*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diplocyclos palmatus	-	-	*P*	-	-	-	-	-	-	-	-	-	-	-	-	-
Echinochloa colona	-	-	-	-	*D*	*D*	-	-	-	-	-	-	-	-	-	-
Echinochloa pyramidalis	-	-	*P*	-	-	-	-	*D*	-	-	-	-	-	-	-	-
Eriochloa fatmensis	-	-	-	-	-	*D*	-	-	-	-	-	-	-	-	-	-
Ethulia gracilis	*P*	*P*	-	-	*C*	-	-	-	*C*	*P*	-	-	*D*	-	-	-
Hygrophila schulli	*C*	*C*	-	-	*C*	*C*	-	*C*	*D*	*D*	-	-	*D*	*D*	-	*D*
Indigofera arrecta	-	-	*C*	-	-	-	-	-	-	-	-	-	-	-	-	-
Ipomea aquatic	-	*P*	-	*D*	*D*	*P*	*P*	-	-	-	-	-	-	-	-	-
Ipomoea purpurea	-	-	*C*	-	-	-	-	-	-	-	-	-	-	-	-	-
Oryza longistaminata	-	-	*C*	-	-	*P*	-	*C*	-	-	*P*	-	-	*P*	-	*P*
Panicum maximum	*D*	*P*	*D*	-	-	-	*P*	-	*P*	*P*	*P*	-	-	-	-	-
Paspalum scrobiculatum	-	-	-	-	-	-	*P*	-	-	-	-	-	-	-	-	-
Pennisetum polystachion	-	-	-	-	-	-	*C*	-	-	-	-	-	-	-	*P*	-
Phyllanthus guineensis	*P*	-	*P*	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhynchosiastipulosa	-	-	-	-	-	-	*C*	-	-	-	-	-	-	-	-	-
Rottboellia cochinchinensis	*P*	*C*	-	*D*	-	-	-	-	-	-	-	-	-	*D*	-	-
Senna obtusifolia	-	*P*	*P*	-	*D*	*D*	*P*	*P*	-	-	-	-	-	-	-	-
Setaria incrassata	*C*	-	-	-	-	-	*D*	-	*D*	-	-	-	-	-	*D*	-
Setaria pumila	-	-	-	-	*P*	-	-	-	-	-	-	-	-	-	-	-
Solanum incanum	-	-	*P*	-	-	-	-	-	-	-	*D*	-	-	-	-	-
Sporobolus pyramidalis	-	*C*	-	-	-	*C*	*C*	-	-	*D*	-	-	*D*	-	-	-
Vigna membranacea	-	*P*	*C*	-	-	-	-	-	-	-	-	-	-	-	-	-

JW=Woodland at Jikawo district, IW=Woodland at Itang district, JR=Riverine Forest at Jikawo district, IR=Riverine Forest at Itang district, JO=Open Woodland at Jikawo district, IO=Open Woodland at Itang district, JG=Grassland Savanna at Jikawo district, IG=Grassland Savanna at Itang district, D = dominant (>15%), C= common (>5-15%), P= present (<5%), -=not present

In the dry season, of the total herbaceous species identified 9 and 2 species were classified respectively as dominantly and commonly distributed over the major grazing areas of the two districts (Table 3). Four (44.44%) grass species (*Cynodon dactylon, Rottboellia cochinchinensis, Setaria incrassate* and *Sporobolus pyramidalis*), 4 (44.44%) forbs (*Cucumis pustulatus, Ethulia gracilis, Hygrophila schulli* and *Solanum incanum*) and 1(11.11%) sedge

(*Cyperusrotundus*) were the dominant ones. Of the commonly distributed herbaceous species 1 (50%) was grass species (*Chloris gayana*) and 1(50%) was legume (*Desmodiumuncinatum*).

The botanical group of the herbaceous layer differed significantly at $p<0.05$ and their proportion across season showed a highly significant difference at $p<0.01$. However, their interaction with season did not show a marked variation ($p>0.05$). The proportion of desirability and ecological group of the herbaceous layer across seasons, between them and their interaction with season showed a marked variations ($p<0.01$) (Table 4).

Table 4: Mean± SD and level of variation of seasonal dynamics in botanical group, desirability and ecological group of the herbaceous layer

Parameter	Wet		Dry		Significance
	N	Mean±SD	N	Mean±SD	
Botanical group					
Grass	83	20.29±13.69	42	45.81±31.41	
Legume	1	25.00	2	16.25±5.30	
Forb	69	13.99±9.57	31	42.58±23.33	
Sedge	14	11.69±7.38	11	37.33±32.93	
Season					**
Botanical Group					*
*Season*Botanical Group*					ns
Desirability					
Desirable	67	18.59±10.55	17	55.47±31.35	
Highly desirable	40	17.27±11.72	10	17.58±7.93	
Less desirable	64	16.24±13.39	47	44.69±28.00	
Undesirable	25	8.97±4.39	12	39.03±26.97	
Season					**
Desirability					**
*Season*Desirability*					**
Ecological Group					
Decreaser	40	17.27±11.72	10	17.58±7.93	
Increaser IIa	34	17.68±7.95	15	60.7±29.53	
Increaser IIb	57	21.13±15.42	19	45.82±31.77	
Increaser IIc	65	10.81±5.68	42	41.21±25.85	
Season					**
Ecological Group					**
*Season*Ecological Group*					**

*N= Number of observations, **=Highly significant (p<0.01), *=Significant (p<0.05), ns= Not significnt (p>0.05),SD= Standard deviation*

Generally, the proportion of highly desirable and desirable species decreased in dry season, while those of less desirable and undesirable ones tended to increase (Figure 1).

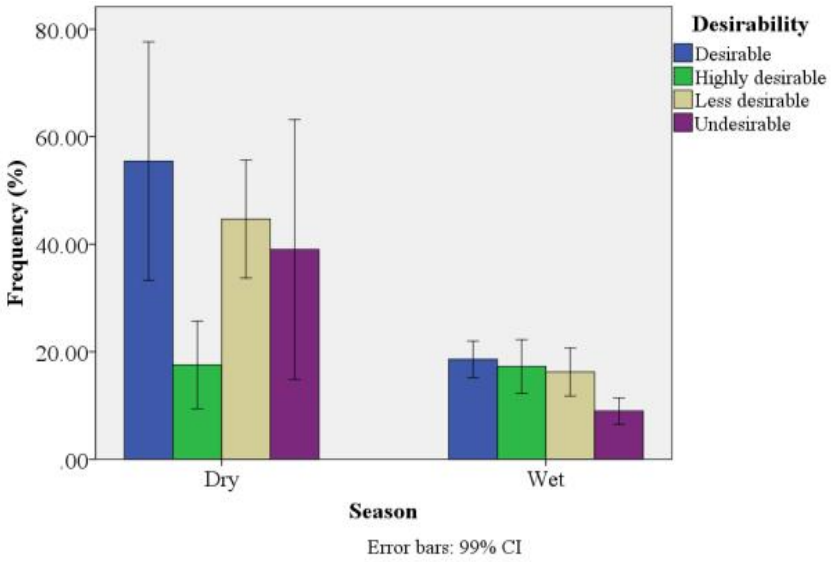

Figure 1: Seasonal Dynamics in the desirability of herbaceous layer

The proportion of Increasers (IIa, IIb and IIc) showed an increased trend following the dry season (Figure 2).

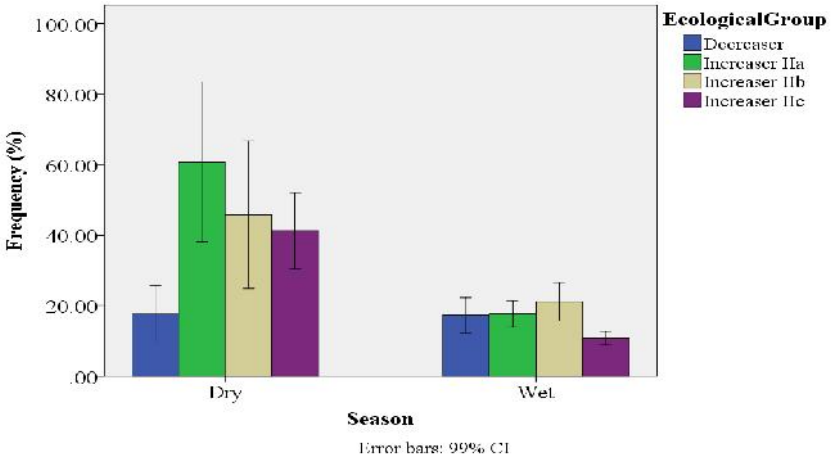

Figure 2: Seasonal dynamics in ecological group of the herbaceous layer

Seasonal Dynamics in Botanical Composition and Related Parameters of the Woody Layer

Botanical composition of the woody layer was consisted of 12 species, which included species of 6 trees and 6 shrubs, contributing each 50% of the botanical group. In terms of their life forms, 58.33% were evergreen and 41.67% were decisuous. Of the total woody species on the other hand, 4 species (33.33%) were highly desirable, 5 species (41.67%) were desirable, and 2 species (16.67%) were less desirable and 1species (8.33%) undesirable (Table 5).

Table 5: Species identified and related parameters of woody layer in the Gambella rangelands of southwestern Ethiopia

Scientific Name	Vernacular Name	Family	Botanical Group	Life form	Desirability
Acacia hockii De Wild.	*Lor*	Fabaceae	Tree	EG	D
Acacia senegal (L.) Wild.	*Chidock*	Fabaceae	Tree	EG	H
Acacia seyal Del.	*Theap*	Fabaceae	Tree	EG	H
Azadirachta indica A. Juss.	*ByBy*	Meliaceae	Tree	EG	U
Balanites aegyptiaca (L.) Del.	*Thow*	Balanitaceae	Tree	EG	D
Cadaba farinosa Forsk	*Neth*	Capparaceae	Shrub	EG	H
Catunaregam nilotica (Stapf) Tirveng.	*Koech*	Rubiaceae	Shrub	DC	D
Harrisonia abyssinica Oliv.	*Kom*	Simaroubaceae	Shrub	DC	L
Hibiscus calyphyllus	*Pour*	Malvaceae	Shrub	DC	L
Piliostigma thonningii (Schumach.) Milne-Redh.	*Goany*	Fabaceae	Shrub	DC	D
Tamarindus indica L.	*Koat*	Fabaceae	Tree	EG	D
Ziziphus mauritiana Oliv.	Bow	Simaroubaceae	Shrub	DC	H

DC = Deciduous, EG= Evergreen, D= Desirable, H= Highly desirable, L= Less desirable, U= Undesirable

Botanical composition and related parameters of the woody layer (botanical group, life forms and desirability) did not show a marked variations ($p>0.05$) between seasons (Table 6). This is due to the dominance of evergreen browse species like *Acacia hockii, Acacia seyal and Balanites aegyptiaca* (Table 7).

Of the total woody species identified, 5 species were classified as dominantly and/or commonly distributed over the major grazing areas of the two districts across the seasons (Table 7).

Table 6: Mean± SD and level of variation of seasonal dynamics in botanical composition of the woody layer

Species	Wet		Dry		Significance
	N	Mean±SD	N	Mean±SD	
Acacia hockii	23	38.69±17.04	23	44.41±18.72	
Acacia senegal	5	7.19±7.31	5	7.68±7.42	
Acacia seyal	20	25.99±18.06	20	29.05±17.93	
Azadirachta indica	4	25.5±10.82	4	25.5±10.82	
Balanites aegyptiaca	19	26.32±13.93	19	31.41±15.76	
Cadaba farinosa	5	8.4±6.06	5	9.43±6.59	
Catunaregam nilotica	6	9.54±8.46	1	3.45	
Harrisonia abyssinica	6	8.13±2.95			
Hibiscus calyphyllus	3	6.71±3.08			
Piliostigma thonningii	2	3.88±1.95			
Tamarindus indica	3	3.09±1.3	3	3.48±1.04	
Ziziphus mauritiana	10	16.13±16.98			
Season					ns
Species					*
*Season*Species*					ns

*N= Number of observations, *= Significant (p<0.05), ns= Not significnt, SD= Standard deviation*

Table 7: Seasonal dynamics in species composition (%) based on density of the woody layer in the Gambella rangelands of southwestern Ethiopia

Species/Season, Grazing Areas	Wet								Dry							
	JW	JR	JO	JS	IW	IR	IO	IS	JW	JR	JO	JS	IW	IR	IO	IS
Acacia hockii	*D*	*D*	*C*	-	*D*	*D*	*D*	-	*D*	*D*	*C*	-	*D*	*D*	*D*	-
Acacia senegal	-	-	-	-	*P*	*P*	-	-	-	-	-	-	*P*	*P*	-	-
Acacia seyal	*C*	*D*	*D*	-	*P*	*P*	*D*	-	*D*	*D*	*D*	-	*P*	*P*	*D*	-
Azadirachta indica	-	-	-	-	-	-	*D*	-	-	-	-	-	-	-	*D*	-
Balanites aegyptiaca	*C*	*C*	*D*	-	*D*	*C*	-	-	*D*	*C*	*D*	-	*D*	*C*	-	-
Cadaba farinosa	-	-	-	-	*P*	*P*	-	-	-	-	-	-	*P*	*C*	-	-
Catunaregam nilotica	-	-	*C*	-	-	*P*	-	-	-	-	*P*	-	-	-	-	-
Harrisonia abyssinica	*P*	-	-	-	*P*	*P*	-	-	-	-	-	-	-	-	-	-
Hibiscus calyphyllus	-	-	-	-	-	*P*	-	-	-	-	-	-	-	-	-	-
Piliostigma thonningii	*P*	*P*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tamarindus indica	-	*P*	-	-	-	*P*	-	-	-	*P*	-	-	-	*P*	-	-
Ziziphus mauritiana	*D*	-	-	-	*P*	*P*	-	-	-	-	-	-	-	-	-	-

JW=Woodland at Jikawo district, IW=Woodland at Itang district, JR=Riverine Forest at Jikawo district, IR=Riverine Forest at Itang district, JO=Open Woodland at Jikawo district, IO=Open Woodland at Itang district, JG=Grassland Savanna at Jikawo district, IG=Grassland Savanna at Itang district, D = Dominant (>20% of density), C= Common (>10-20% of density), P= Present (<10% of density),-=Not present

DISCUSSION

The composition of the herbaceous layer in this study (Table 1) agrees with the terminology used byAllen *et al.* (2011) who defined the indigenous vegetation in grazing land is predominantly grass, grass-like plants, forbs or shrubs those are grazed or have potential to be grazed, and which is used as a natural ecosystem for the production of grazing herds of wild or domestic ungulates. Significant variation between seasons, species and their interaction at p<0.01 (Table 2) suggests that there is great seasonal dynamism of semi-arid vegetation communities, especially of the grass cover (Trodd and Dougill, 1998). The present study result agrees with the conclusion of Keba *et al.*, (2013) that production of herbaceous biomass is primarily determined by the amount, distribution and duration of rainfall.

During the wet season the present finding showed (Table 3) in contrast to the suggestions of(O'Connor and Roux, 1995; Treydte *et al.*, 2006; Haftay *et al.*, 2013)who stated that the rare presence of highly desirable and nutrient-rich species, such as *Cynodon dactylon*, in areas where grazing pressure was high might be related to its prostrate and short stature growth. In agreement with Van der Westhuizen *et al.*, (2005) and Tefera *et al.*, (2007) *Cynodon dactylon* is rather the dominant key species in rangelands that are severely overgrazed. It also occurred in grassland savannas of both districts which are the communal grazing areas of the Nuer pastoral communities.

Most savannas are degraded and dominated by unpalatable and annual herbaceous plant species (Abule *et al.*, 2005). Similarly the grassland savannas of Jikawo are degraded and the less palatable annual forb *Hygrophila schulli* is commonly and dominantly distributed throughout the seasons. Thehighly desirablegrass species such as *Brachiariasemiundulata*, *Echinochloa pyramidalis* and *Paspalum scrobiculatum* were distributed in few grazing areas of the districts (Table 3). Besides their annual form of life, as indicated by Gemedo-Dalle *et al.*, (2006) and Haftay *et al.*, (2013) such limited spatial distribution might be related with grazing pressure and be indicator of the rangeland deterioration. Overgrazing affect the botanical composition and species diversity by depressing the vigour and presence of dominant species, which then enables colonization by less competitive, but grazing tolerant plant species (Sternberg *et al.*, 2000). Most grasses in savanna ecosystems are fairly tolerant to grazing, however, prolonged intense grazing eventually lead to shift in species composition (Skarpe, 1992).

The only dominant grass species during the wet season in the open woodlands of Itang and grassland savanna of Jikawo were *Setaria incrassate* and *Rottboellia cochinchinensis* respectively. *Setaria incrassate* was distributed in Jikawo woodlands and Itang open woodlands. *Sporobolus pyramidalis* was occurred in riverine forests of Jikawo and woodlands of Itang (Table 3). In accordance with the reports of Haftay *et al.*, (2013) who noted that less desirable grass species, such as *Setariaverticillata* and*Sporobolus marginatus*, were found only in the open-access grazed areas due to their low preference by grazing livestock.

In wet season*Ipomea aquatica* and *Commelina benghalensis*were the dominant forbs. *Ipomea aquatica* was occurred in grassland savanna of Jikawo and woodlands of Itang whereas *Commelina benghalensis* was occurred in grassland savannas of Itang (Table 3). Species of the plant family, *Commelinaceae*, have not been investigated extensively for their potential as fodder crops in ruminant nutrition, particularly not in the tropics where different species grow abundantly (Lanyasunya *et al.*, 2006). The only dominant legume and sedge were *Senna obtusifolia* in woodlands and riverine forests of Itangand *Cyperusrotundus* in reverine forests of Jikaworespectively. *Cyperus rotundus* is one of the most serious weed problems in many parts of the world (Travlos *et al.*, 2009).

In line with the findings of Amsalu and Baars (2002); Adane (2003) and Admasu *et al.* (2010) in other rangelands of the country, *Cynodon dactylon*, which are drought and heavy grazing tolerant, also occurred during the dry season in grassland savannas of both districts which are the communal grazing areas of the Nuer pastoral communities. *Setaria incrassate* was distributed in Jikawo woodlands and Itang open woodlands. *Sporobolus pyramidalis* was occurred in riverine forests of Jikawo and woodlands of Itang. In accordance with the reports of Haftay *et al.* (2013) who noted that less desirable grass species, such as *Setariaverticillata* and*Sporobolus marginatus*, were found only in the open-access grazed areas due to their low preference by grazing livestock. *Hygrophila schulli* was dominant in woodlands and riverine forests of the two districts as well as grassland savanna of Itang. *Cyperusrotundus* was occurred in woodlands, riverine forests and open woodlands of Jikawo. The undesirable perennial forb *Solanum incanum* was dominant in the open woodlands of Jikawo. According to Coppock (1994) Solanum species are indicators of a change in the condition of the rangeland towards deterioration and are also considered as poisonous plants species in

Ethiopia. The only common grass specie in Jikawo woodlands and legume species in open woodlands of Itang were *Chloris gayana* and *Desmodiumuncinatum* respectively (Table 3).

A declining proportion of perennial grasses (Table 3) definitely contribute to reduced composition of desirable and highly desirable species in the herbaceous layer during dry season (Table 4) (Figure 1). *Oryza longistaminata* and *Panicum maximum* were the only perennial highly desirable grass species present in dry season along some of the major grazing areas (Table 3). This shows that the importance of palatable perennial plant species composition for rangeland productivity has highly emphasized (James *et al.*, 1999). In line withHussain and Durrani (2009) who noted that seasonal availability of palatable fodder species depended upon the phenological stage, which in turn depended upon the climate. On the other handsTefera *et al.*, (2007) indicated that classifications of species into desirability groups relied most importantly on the merits of species with respect to their life forms and palatability. However, under the high grazing pressures experienced in the communal land, such classification may not be valid in some cases, particularly when palatability is taken as criteria and under such situations, even less palatable species may be heavily grazed and be relatively palatable.

Following the dry season the proportion of Increasers (IIa, IIb and IIc) showed an increases trend (Figure 2). Similarly, Kirkman (1999) observed that the vigour of preferred (palatable) grasses declined during the season following grazing, while vigour of unpreferred (unpalatable) grasses increased during the following season, probably due to reduced competition from the regularly defoliated preferred grasses with livestock type having a significant impact on species response. In recent years alternative paradigms have been argued that rangeland is more heavily utilized during the wet season where herbivores are sustained by key resource areas than rangeland where there are no key resource areas utilized during the dry season. This implies that the impact of herbivores on vegetation is important even where intra- and inter-seasonal climatic fluctuations are significant (Kirkman and de Faccio Carvalho 2003).

The marked variation not shown in botanical composition and related parameters of the woody layer (Table 6) is due to the dominance of evergreen browse species like *Acacia hockii, Acacia seyal and Balanites aegyptiaca* (Table 7). In agreement with Tolera *et al.*, (1997); Hussain and Durrani (2009) and Cavalcante *et al.*, (2014) in arid and semi-arid regions most perennial browse species were found maintaining their greenness and nutritive value throughout the dry season when grasses dry up and deteriorate both in quality and quantity. Trees and shrubs are important sources of fodder for livestock in the tropics and dry environments and withstand harsh climatic conditions better than herbaceous species (Silanikove *et al.*, 1996).They provide green forage for grazing animals throughout the year (evergreen species) or at specific critical periods of the year (deciduous species) (Kokten *et al.*, 2012) (Table 5).

Over the major grazing areas of the two districts across the seasons *Acacia hockii*were dominant followed by *Acacia seyal*, *Balanites aegyptiaca* and *Azadirachta indica* (Table 7). Acacia woodlands represent one of the most widespread vegetation types of dry lands in Africa (Traoré *et al.*, 2012). *Acacia hockii* whichis native too many dry areas in tropical Africa south of the Sahel, to eastern and southern Africa (ILDIS, 2013) is dominant in woodlands and riverine forests of the two districts and in open woodlands of Itang district. *Acacia seyal* is widely distributed in the African savannas and considered as one of the most common trees on clay plains that flood during the rainy season (McAllan, 1993) is dominant in open woodlands of the two districts and riverine forest of Jikawo. The highly desirable tree, *Acacia senegal*ispresent in woodlands and riverine forests of Itang. It is a widespread leguminous tree (Raddad, 2006) distributed in the drier parts of tropical Africa (Wekesa *et al.*, 2009).

*Balanites aegyptiaca*is one of the most widely distributed trees in the dry-lands of Africa and Sudan (Sands, 2001). It is dominantly and/or commonly distributed in woodlands and

riverine forests of the two districts as well as in the open woodlands of Jikawo. The tree is a drought resistant species and cannot be damaged by grass fires (Elfeel *et al.*, 2007) where grassland burning is a common practice in Nuer pastoral community (Tilahun, 2007). Tamarind has a wide geographical distribution in the subtropics and semiarid tropics(El-Siddib *et al.*, 2006) and *Tamarindus indica* is present in riverine forests of the study area.*Cadaba farinosa* is distributed throughout the word mostly tropical and sub-tropical regions (Telrandhe and Uplanchiwar 2013) and common in riverine forests of Itang during dry season. Therefore, this indicated that the woody layer vegetation composition in tropical and sub-tropical savanna ecosystem shows widespread distribution trends particularly of Acacia.

CONCLUSION

The present finding indicated seasonal dynamics in the botanical composition of semi-arid rangelands. The effect of season on the botanical composition of the herbaceous layer was highly pronounced. Moreover, botanical group, desirability and ecological group of the herbaceous layer showed a significant seasonal dynamics. On the other hands the woody layers did not show a marked variation in terms of their botanical compositions and related vegetation parameters. Therefore, it can be suggested that, for sustainable rangeland resource management and utilization understanding and quantifying seasonal dynamics of the available feed is of great importance.

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