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Effect of growth stages and systems on range vegetation characteristics in el Rosa, north Kordofan, Sudan

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A B S T R A C T

The range vegetation characteristics were studied in closed and open systems at flowering and seeding in (El Rosa) El khuwei locality at September and November 2009. Sampling was using 2Km^2 plots in a radiating manner from the centre of plot. CRD was used to analyses all parameters. Results of biomass, plant density and plant cover in the closed systems at the flowering were significantly ($P < 0.0001$) higher. These parameters were significantly lower in the open system at seeding. Bare soil and litter were significantly ($P < 0.0001$) higher in the open system at seeding. Total forage productivity kg/ha was significantly ($P < 0.05$) higher in the closed system at the flowering and least in the open system at seeding. Carrying capacity was significantly ($P < 0.0001$) higher in closed system at seeding and leas in open at flowering. Stoking rates in the closed system at flowering were significantly ($P < 0.0001$) higher and least in the open system at seeding. Plant frequencies were higher in the closed system at the two growth stages than open system like Huskneet *(Cenchrus biflorus*) Bano (*Eragrostis tremula*) Gaw (*Aristida* sp) Difra (*Echinocloa colonum*) Aboelrakhus (*Andropogon gayanus*) Fisiya (*Fimbristyls hispidula)* and Tmrfar (*Oldenlandia senegalensis*) had higher frequencies. However leflef (*Luffa aegyptiaca)* and Himeira

(*Hymenocardia acida)* had lower frequencies. Simeima (*Sesamum alatum*) Buid (*Commelinia subulata*) Abodaib (*Ceraotheca sesamoid*) Shuleny (*Zornia glochidiata)* and Rabaa (*Zalea* sp) were found only in the closed system at flowering. Nuida (*Sida cordofolia)* were only found in the open system at the two growth stages. It was concluded that the closed system had higher plant density and cover, biomass, plant frequencies and forage production. Bare soil and litter were higher in open system at seeding. Carrying capacity was higher in the closed system at seeding. Stoking rates in the closed system at flowering were higher. Indicate that direct effects on different system vegetation characteristics, productivity, caring capacity and stocking rates.

1. Introduction

Animal production is mainly traditional in the Sudan based on rangeland and nomadic nutrition in the country, rangelands about 279.4 million Fadden, (Darag and Suleiman 1988; RPA 1996), Producing 86.6% of the national animal feed requirements (MAW 2005). Arid and semi-arid lands comprise approximately 60% of the country's total area and include the most important rangelands (Darag and Suleiman 1988). Vegetation cover in these zones has changed qualitatively and quantitatively dues too many factors including low rainfall, overstocking and wind and water erosion (Darag 1996). These factors reduced total area available for grazing decreased highly palatable disappeared of plants (Darag and Suleiman 1988). Improved land management is likely to improve pasture and livestock performance. The north Kordofan area is about 25 million ha of; 14.5 million ha are rangeland (AFRICOVER 2004). It is among the leading in the Sudan in animal and range resources, more than 13 million heads of sheep, goats, camels and cattle (RPA 2005). Animal production in the State is mainly traditional depending on natural rangeland (Cook and Fadlalla 1987). Cattle dominate the southern part of the State and sheep, goats and camels are dominated in the northern drier part (El-Hag 1993). About 90% of livestock it's in traditional pastoral systems, mainly in the western states. Average annual rainfall is about 300 mm- between July and September with a peak in August. The main objective of this paper was to investigate effect of growth stages and systems on range vegetation characteristics.

2. Materials and methods

2.1. Study area

This study was conducted in (El Rosa) El-khuwei locality north Kordofan State, Sudan. It lies between longitudes 28˚:33' - 28˚:30'N and latitudes 12˚:14' - 14˚:12'E and is about 105 Km west of El Obeid. The closed system was established in 2007 in about 500 ha; at El-khuwei locality has a large livestock export market (Hamari sheep). Average monthly temperature according to Nimer (2000) in I987-2002 in El Obeid was (34.6°C). It is the sand dune area "Goz". The site is naturally dominated by grasses namely Huskneet (*Cenchrus biflorus),* Shilini (*Zornia glochidiata*), Bigail (*Blepharis linarifolia*) and Aborakhus (*Andropogon gayanus*). The trees included Humied (*Sclerocarya birrea*), Higlig (*Balanites aegyptiaca*) and Sider (*Zizuphus spina- Christi).* The Shrubs include Kursan (*Boscia senegalensis*), Usher (*Calotropis*), Mereikh (*Leptadenia pyrotechnica*) and Arad (*Leptadenia pyrotechnica)* according to MAR (2009).

2.2. Layout of the experiment

Sampling was done by locating 2Km^2 sample plots in closed and open systems at two different growth stages flowering and seeding, at each plot eight transects of 500m length were located in a radiating manner from the center of the sample plot (Fadlalla and Cook 1985). Completely Randomized Design (CRD) was used to analyses all parameters.

2.3. Measurements of vegetation attribute

2.3.1. Measuring cover

The traditional loop method was used to measure cover, litter and bare soil according to Parker and Harris (1959). Sixteen transects readings were made within the selected plot and each transect was 100m long. Measurements were taken along each transect using a 100m plastic tape. Litter and cover and bare soil were recorded at 10 meter intervals using 3/4'' loop to obtain 100 observations. The data was recorded in special sheets.

2.3.2. Biomass

The double sampling procedure was used to measure biomass. Eight transect 500m long were taken within the selected plot in a radiating mater, at ten quadrates ($1m^2$) were placed each transect and at 50m intervals. Three replicate observers together estimated the weight of the 10 quadrates in the plot, only the 3rd, 7th and 10th quadrates were used. The samples were oven dried at 80^{o}C for 24 hours and dry weights recorded according to (Wilm *et al* 1944).

2.3.3. Density and frequency of pasture

Density and frequency readings were obtained from the double sampling procedure quadrates. Samples selected within closed and open system 80 quadrates. Eight transect 500m long were taken within the selected plot in a radiating mater, at ten quadrates ($1m^2$) were placed each transect and at 50m intervals. Density was determined by counting the number of plants rooted within each quadrate. Frequencies was determined by counting the number of quadrates that containing the species and divide that number by the total number of quadrate used as a percentage individual of a given species according to(Morrison *et al* 1995; Kira *et al* 1953).

2.3.4. Available browse of shrubs

The Adelaide technique (Andrew *et al* 1979) was used to obtain browse of shrubs. Three observers were used and five calibrations or standard shrubs were selected at different height classes not exceeding 1.5m. These shrubs were tagged with masking taped. Hand- held production unit for each shrub was used to estimate the unit equivalent in each shrub, and the available shrubs production units were visually estimated. Twigs (2mm) in diameter) were cut, oven dried at 105˚C for to determine actual weight of available browse.

2.4. Assessment of carrying capacity and stocking rates

2.4.1. Carrying capacity

Carrying capacity can be used equation:

$$\text{Carrying capacity} = \frac{\text{Annual forage consumption}}{\text{Available forage productivity (kg/ha)}}$$

Carrying capacity was calculated by the following:

Forage productivity (kg/ha)

1- Forage requirement per animal unit/ month/ year
2- Proper use factor % to obtain available forage for proper use 50%
3- Duration of grazing month/ year

2.4.2. Stocking rate

For stocking rate in this case is gussets use carrying capacity and area of the range system in the closed and open range and used the following equation AUM/ year:

$$\text{Stocking rate} = \frac{\text{Area (closed and open)}}{\text{Carrying capacity}}$$

2.4.3. Statistical analysis

Completely Randomized Design (CRD) and Duncan Multiple Range test was used for mean separation (Steel and Torrie 1960). SPSS (Statistical Package for Social Sciences) was used for the statistical analyses.

3. Results and discussion

3.1. Vegetation characteristics

3.1.1. Biomass

The closed system at flowering was significantly ($P < 0.0001$) higher biomass productivity that than open system. Highly significant ($P < 0.0001$) system x growth stage interaction effects was found for biomass productivity. Biomass yield was higher at flowering and seeding in closed system and least in open system (Table 1). These differences in biomass production could mainly be the erratic and inadequate rainfall in the rangeland leads to forage biomass that is poor in quantity and quality. The herbaceous layer is often more affected than the woody component of the vegetation. This encourages the growth of undesirable and unpalatable plant species. The human factor also plays a major role in rangeland degradation. It is important to note that rangeland degradation not only decreases biological productivity, but also negatively affects the general environment according to (Coppock 1994).

3.1.2. Plant density

The plant density was significantly ($P < 0.0001$) higher in closed system at the flowering that in open system (Table 1). Highly significant ($P < 0.0001$) range system x growth stage interaction effects was found for plant density. The lower densities were at seeding in open system. Because many grassland sites on the protected area are being encroached by forest, livestock distribution is being impacted. Control of forest encroachment will improve livestock distribution and overall forage production (MFW1994). This is in line with Skerman (1966) who reported that grazing pressure can increase to appoint where demand can no longer be met with decrease in palatable plants density.

3.1.3. Plant cover

The closed system and flowering was significantly ($P < 0.0001$) higher plant cover compared to open system and seeding. Range system x growth stage interaction for plant cover was highly significant. Plant cover at flowering in closed system was higher; while at seeding in open system was lower (Table 1). During the collected samples at seeding, rangeland affected by grazed large numbers of animals and removal animal to export leaded that to lower vegetation cover (El hag 2009).This situation is related to the main problems associated with rangeland management and over-stocking leads to progressive reduction in biomass production and plant cover. El Wakeel and Abu Sabah (1997) found that rangelands lower vegetation during the dry stage and overstocking lead to overgrazing in North Kordofan. In Africa the semi-arid ecological zone, covers 20% of the area of the region (Dawit 2000).

3.1.4. Bare soil and litter

Bare soil and litter had significantly ($P < 0.0001$) higher in open system at seed seeding that than the closed system and flowering (Table 1). A significant range system x growth stage interaction was increased bare soil and litter on the open system at seeding was higher ($P < 0.05$) and decreased bare soil and litter at flowering at closed system. This situation is related to during collected samples at the seed setting stage rangeland affected by grazed large numbers of animals and removal animal to export related to the main problems to higher litter and bare soil (El hag 2009). In the arid and semi-arid areas it leads to soil degradation (Strang 1980). Skerman (1966) stated that replacement of perennials by annuals in arid and semi-arid region was attributed to the removal of litter and ground cover by continuous overgrazing and over cultivation.

3.1.5. Available browse of shrubs and forage productivity

Table 2 shows forage of plants and shrubs browse, carrying capacity and stocking rates.

Forage productivity (plants and available shrubs browse) kg/ha on rangeland was significantly ($P < 0.05$) higher in closed system at flowering than in the open system and lower at seeding. Lowers forage productivity at seeding in open system. This situation leaded to decrease forage productivity of rangeland as affected by degradation and desertification, Harrison and Jackson (1958) reported that decrease in the productivity of shrubs browse and forage of plant as affected by degradation and desertification, for the Semi Desert in the North

Kordofan and Darfur and low rainfall savannah on sand soil area. In most of the grasslands under seasonal rainfall areas, shrubs make considerable contribution to stock feed especially in the dry season.

Table 1

Effects of growth stages and systems on range vegetation characteristics in El Rosa, north Kordofan State, Sudan.

Parameter	Biomass (kg/h)	Density (p/ m^2)	Cover (%)	Bare soil (%)	Litter (%)
Systems:					
Closed	1299	24.75	67.94	22.62	9.57
Open	559.8	20.91	50.59	34.02	15.45
Mean	92.94	21.49	59.26	28.32	12.51
SE±	74.5***	0.38***	0.98***	0.93***	0.50***
Growth stages:					
Flowering	1032.9	25.40	64.74	26.26	9.06
Seeding	825.9	17.59	53.79	30.38	15.96
Mean	929.4	21.49	59.26	28.32	12.51
SE ±	74.5***	0.38***	0.98***	0.93*	0.50***
Season x system:					
Flower x closed	1440.6a	29.88a	71.69a	19.09d	9.22c
Flowering x open	655.1b	20.91b	57.78b	33.44b	8.90b
Seeding x closed	1157.5c	19.61c	64.19c	26.15c	9.91d
Seeding x open	494.4d	15.57d	43.39d	34.60a	22.00a
Mean	929.4	21.49	59.26	28.32	12.51
SE ±	74.5***	0.38***	0.98***	0.93***	0.50***

Means in the same column under the same factor with different letters are significantly different.

*= significant at ($P < 0.05$), **= highly significant ($P < 0.001$) and ***= very highly significant ($P < 0.0001$).

3.1.6. Carrying capacity

Carrying capacity was significantly higher in closed system at seeding than in flowering and lower in open system at flowering (Table 2). Coppock (1994) indicated that rangeland degradation is generally caused by poor management of rangeland resources, such management practices relate to the expansion of sedentary agriculture, the expansion of agricultural projects, the expansion of natural parks and game reserves and the conflict among the interethnic and interethnic groups. This leads to higher livestock pressure on the rangelands and ultimately causes overgrazing and resource degradation that may have irreversible consequences for the environment.

3.1.7. Stoking rates

Stoking rates in closed system at flowering were significantly ($P < 0.0001$) higher and least in open system at seeding. Mworia *et al* (1998) conducted study revealed that the higher stocked grazing treatments had a significantly lower herbaceous basal cover than the more lightly stocked grazing treatments. The open grasslands are the predominant feed source of the grazing animals; the area sustains over 90% of its inhabitants as pastoralists, with considerable numbers and distribution of livestock (CSA 1994). Both these factors put a great deal of pressure on the feed resources of the region, causing overgrazing and degradation of the range (Beruk 2000). Wood and Blackburn (1984) observed high yields in deferred rotational grazing and enclosures and low yield in the high-intensity, low-frequency, moderately stocked, continuously grazed pastures. Very low yield was recorded for continuously grazed pastures. Pluttar *et al* (1987) found a reduction of yield in heavily stocked rotational grazing and moderately stocked deferred rotational grazing systems. Abdel-Magid, Schuman and Hart (1987) observed that grazing systems (continuous, rotational deferred and short-duration rotation grazing systems) did not affect the water infiltration in a consistent manner. However, increased stocking rates resulted in reduced infiltration during the grazing season.

3.1.8. Species frequencies

Plant frequencies was higher in closed system at two growth stages than the open system (Table 3), like Huskneet, Bano, Gaw, Difra, Aboelrakhus, Fisiya, Tmrfar, leflef and Himeira, however Simeima, Buied, Abodaib, Shuleny and Rabaa was record only in closed system at flowering. Nuida frequencies were higher in open system at two growth stages than closed system. To this effect, species composition was intensively used to predict animal production on South African rangelands (Tainton 1986). Heady (1966) who also, detected significant changes in species composition along several grazing gradients in a continuous grazing system in East Africa. The species composition of rangeland varies depending on topography, climate and soil types (Skerman 1977). Different grasslands contain diverse types of grasses, legumes, and other herbaceous species. The botanical composition of plant community can also change due to factors like altitude, grazing practices, burning, drought, and temperature effects, pest, and erosion. Therefore, due to, the productivity of an area in terms of its capacity to support livestock may change. Change in plant composition results as a result of the adaptability of the plant species to these influences over a period of time (Skerman 1977).

Table 2
Productivity of range plant and browses, carrying capacity and stocking rates in closed and open system at flowering and seeding in El Rosa, north Kordofan State, Sudan.

Parameters	Plant (kg/ha)	Browses (kg/ha)	Forage. P (kg/ha)	Carrying. C (AU/ha/year)	Stocking. R (AUM/year)
Systems					
Closed	1299	2.1	1301.1	0.48	48
Open	559.8	1.25	561.05	0.21	21
Growth stages					
Flowering	1032.9	2.05	1034.95	0.38	38
Seeding	825.9	1.3	827.2	0.31	31
Mean	74.5	1.67	931.07	0.34	34

* = significant (P < 0.05), ** = highly significant (P < 0.001) and *** = very highly significant (P < 0.0001).

Table 3
Plant species frequencies in the closed and open system at flowering and seeding, El Rosa, north Kordofan State, Sudan.

Plant species		Flowering		Seeding	
Latin names	**Local names**	**Closed**	**Open**	**Closed**	**Open**
Cenchrus biflorus	Huskneet	21.80	19.85	18.95	17.05
Eragrostis tremula	Bano	16.21	15.96	15.98	15.80
Aristida sp	Gaw	14.01	13.87	13.91	13.82
Echinocloa colonum	Difra	08.10	07.96	07.95	0 7.86
Andropogon gayanus	Aborakhus	07.10	07.08	07.08	06.92
Fimbristyls hispidula	Fisiya	06.19	05.93	05.99	05.72
Oldenlandia senegalensis	Tmrfar	05.09	04.71	04.93	04.85
Luffa aegyptiaca	leflef	04.00	03.98	03.92	03.81
Hymenocardia acida	Himeira	04.03	01.95	03.37	03.23
Sesamum alatum	Simeima	02.02	-	-	-
Commelinia subulata	Buid	01.18	-	-	-
Ceraotheca sesamoid	Abodaib	01.17	-	-	-
Zornia glochidiata	Shuleny	01.10	-	-	-
Zalea sp	Rabaa	01.00	-	-	-
Sida cordofolia	Nuida	07.00	18.71	17.92	20.94

4. Conclusion

All vegetation characteristic and biomass were higher in closed system. Bare soil and litter were higher in open system. Carrying capacity was higher in closed system at seeding. Stoking rates was higher in closed system at flowering. Plant frequencies were higher in closed system at the two stages. Nuida was higher in open system at the two stages.

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