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Full Length Research Paper

Impact of grazing around a watering point on botanical composition of a semi-arid rangeland in the southern Afar region of Ethiopia

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The botanical composition along a stratified grazing gradient around a watering point in a semi-arid rangeland in northeastern Ethiopia was investigated by means of the wheel point method for two growing seasons. Annual grasses and unpalatable forbs, which are indicators of degradation, characterized the severely degraded area in both seasons. In moderately and lightly degraded areas an increases in abundance of perennial species was observed and were more preferred by the pastoral community as animal feed. In both seasons, the most frequently occurring perennial species were *Chrysopogon plumulosus, Paspalidium desertorum* and *Panicum coloratum*. Thus the study confirmed that there were differences in botanical composition at increasing distances from the watering point.

Keywords: Botanical composition; Degradation; Grazing gradient; Species ordination; Watering point

INTRODUCTION

The Allaidege rangeland of Ethiopia is one of the prominent grazing areas of the pastoral community of the Afar Regional State. In the past the rangeland was known to be the best traditional wet season grazing area before the intervention of commercial agriculture in the region. Degradation of the rangeland gradually took place with the development of a watering point causing grazing pressure in the area. This was also accompanied with the failure of exercising the developed grazing utilization scheme in the community (MCE, 2000).

This failure and lack of knowledge in the community compelled the pastoral people to persevere with grazing systems practiced in the past. This mode of grazing effected complete local extinction of palatable perennial species, a fact that is now widely acknowledged by the community (Personal communication with clan leaders and elders, 2004). Up to now, there was no scientific study carried out to quantify the herbaceous compositional change of the range. Beruk (2000) in a survey assessment report of the Afar rangeland emphasized the very limited identification studies on the major indigenous grasses of the area and recommended a comprehensive study on species composition of the range.

Various researchers have reported grazing pressure, rainfall, edaphic condition and grazing history to influence botanical composition of a range (Milchunas and Lauenroth, 1993; O'Connor and Roux, 1995; Turner, 1999). Other researchers (Boudet, 1975; Stoddart et al., 1975; Pratt and Gwynne, 1977) have explicitly indicated that livestock grazing pressure in dry land regions of Africa due to traditional range management caused changes in vegetation composition of the range. Amsalu and Baars (2002) have also reported that the communally grazed agro-pastoral range areas showed poor botanical composition due to grazing pressure. Thus livestock grazing can have a profound impact on vegetation composition.

The general pattern of grazing induced botanical composition change is well documented by Kirkman (1995), Owen-Smith and Danckwerts (1997) and Amsalu and Baars (2002). The heavy utilization by livestock of

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forage plants around watering points compared to areas further away is confirmed by Friedel (1988) and Hart et al. (1993). To this effect it is known that less palatable or undesirable plants increase at the expense of desirable plants. The decrease of palatable plants was confirmed by Tainton (1972) and Noy-Meir, Gutman and Kaplan (1989) to be attributed to the impact of selective livestock grazing inducing a shift in botanical composition (Morris and Tainton, 1993). Hence this study evaluates the long-term effects of grazing impact around watering point on vegetation dynamics of the range.

The objective of the study was to assess the unrestricted grazing effect on the botanical composition of the range around a watering point. The following hypothesis was tested: there is no difference in botanical composition at increasing distances from the watering point.

MATERIALS AND METHODS

Study Area

The experiment was conducted for two seasons in a communal grazing land around a watering point. Individuals from the community group were involved in the field layout to stratify the grazing land into different grazing gradients. In cognizance of the vegetation cover the grazing area was quantitatively stratified into four grazing categories: severely degraded (SD), moderately to severely degraded (MSD), moderately degraded (MD) and lightly degraded (LD) areas. Coordinates were taken by GPS to map and calculate the area. The distance of each stratified grazing field from a watering point was also recorded as 1 500 m, 3 600 m, 5 150 m and 6 250 m for SD, MS, MD and LD, respectively.

Study design

A 1.2 km transect was laid out perpendicular to the direction of the grazing gradient, more or less in the middle of each of the grazed categories. This consideration was to avoid border effects on both sides of the different grazing gradient categories. On each transect, five 30 m x 30 m sample plots were laid out at 300 m intervals, resulting in a total of 20 plots in the experimental field. In each of the sampling plots, proportional species composition is determined using the nearest plant approach at 250 points (Bosch and Janse Van Rensburg, 1987; Bosch and Kellner, 1991; Hardy and Walker, 1991), using the wheel point method of Tidmarsh and Havenga (1955) for two seasons.

The sampling was done when majority of the pasture plants were at flowering stage. The abundance of species in the sample site is expressed as a proportion of the total number of observations made for the sample site.

For some species not identified in the field a representative plant was pressed, labeled and transported to the National Herbarium of Addis Ababa University (AAU) for identification.

Statistical analysis

Descriptive statistics with frequency counts and percentages were calculated for each species and life form was identified. Correspondence analysis was done to graphically show the occurrences of species and life forms with in the grazing gradients (SD, MSD, MD and LD areas). To compare all life forms with all grazing gradient a Chi-square test was performed. Then to determine more specifically where differences occurred, all combinations of degradation by life forms (2 factor x 2 level combinations) were analyzed with Chi-square tests, applying Bonferroni multiple testing. Compositional difference along the years was determined using classification tree analysis.

RESULTS

Species frequency in year 1

The rangeland consisted of a matrix of perennial grasses, annual grasses and herbaceous forbs (Table 1). In the SD grazing area, perennial grasses were not prominent in the composition and represented about 4% of the total herbage composition. Annual grasses and unpalatable herbaceous forbs dominated the grazing area. Both groups (annual grasses and un palatable herbaceous forbs) comprised about 80% of the total composition of the grazing area (Table 1). Perennial grasses that occurred in this grazing area (albeit in low numbers) were *Sporobolus ioclados*, *Paspalidium desertorum*, *Cynodon dactylon* and *Digitaria rivae* (Table 1).

In the MSD area, perennial grasses, annual grasses and others (non grass species) comprised 16%, 63% and 21% of the botanical composition respectively. The annual grass, *Setaria verticillata,* predominantly covers this grazing area, which was also abundant in the SD area (Table 1).

The botanical composition of the MD grazing area consisted of 40% perennial grasses. *P. desertorum, S. ioclados* and *Panicum coloratum* contributed 8%, 5% and 4% respectively to the total species composition. *Chrysopogon plumulosus* was more abundant, contributing 21% of the total species composition in the area. *S. verticillata* and other herbaceous forbs have however contributed almost 60% to the plant composition in the area (Table 1).

In the LD area perennial grassess contributed 47% to the composition. The perennial grasses *C. plumulosus, S. ioclados* and *P. coloratum* contributed 16%, 17%, and

Table 1: Species composition (%) in each grazing gradient in year 1 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area)

			Percent composition			
Species Name	**Afar vernicular name**	**Life form**	***SD***	***MSD***	***MD***	***LD***
Perennial Grasses			%	%	%	%
Chrysopogon plumulosus Hochst	Durfu	perennial	0	0.24	20.96	16.4
Sporobolus ioclados	Denekto	perennial	1.84	11.52	4.8	16.6
Panicum coloratum	Denekto(p)	perennial	0	3.6	3.6	9.6
Paspalidium desertorum	Bohale	perennial	0.88	0.32	7.92	2.16
Bothriochloa radicans (Lehm)	As ayso	perennial	0	0	2.88	
Cynodon dactylon Pers	Rareta	perennial	1.04	0	0	0
Cenchrus ciliaris	Serdoyta	perennial	0	0	0	0.4
Lintonia nutans Stapf	Afara mole	perennial	0	0	0	0.16
Sporobolus pellucidus Hoehst	Sosokete	perennial	0	0	0.16	1.28
Digitaria rivae (choir) stapf	Forele/ Hamanto	perennial	0.16	0	0.08	0
Total percentage (%)			**3.92**	**15.46**	**40.42**	**46.6**
Annual Grasses						
Setaria verticillata (L.) P.Beauv	Delayta	annual	40	62.64	33.28	23.6
Tetrapogon tenellus(Roxb)chior	Aytodyta	annual	0	0	0.24	0.32
Sporobolus panicoides A. Ruch	Gewita/Bekelayso	annual	0	0.24	0.72	2.16
Total percentage (%)			**40**	**62.88**	**34.24**	**26.1**
Edible annual forbs						
Ipomoea sinensis	Halal	annual	15.4	2.24	7.68	1.76
Other edible forbs						
Blepharis persica	Yamarukta	annual	0	0	4.88	8.16
Legume annual forbs						
Rhynchosia melacophylla (spreng,Boj)	Haro	annual	0.56	2.64	3.44	2.48
Total percentage (%)			**15.9**	**4.88**	**16**	**12.4**
Others						
Phyllanthus maderaspa tensis L.	Akelekelmi	annual	14.7	6.24	0.8	8.64
Leucas nubica Benth	Ergufuma	annual	14.2	0	0	0
Amaranthus spp.	Bunkete	annual	0.8	0	0	0.08
Orthosiphon pallidus Royle	Hebeke	annual	1.76	0.88	0	0.24
Unidentified	Alelus	annual	0.56	0	0	0
Portulaca quadrifiola L.	Halihara	annual	0.08	2.56	0.48	2.24
Unidentified	Ashara	annual	2	0	0	0
Abutilon fruticosum	Hanbukto	annual	4.8	0.8	0.64	0.64
Unidentified	Aburi	annual	1.28	0	0	0
Koheutia caespitosa	Baroberbere	annual	0	6.08	5.92	3.04
Unidentified	Mituki	annual	0	0	1.52	0.08
Total percentage (%)			**40.2**	**16.56**	**9.36**	**15**
Grand total percentage (%)			100%	100%	100%	100%

10% to the composition respectively. Other perennial grasses that contributed less than 2% to the composition were also present. Similar to the more degraded grazing areas, *S. verticillata* and other herbaceous forbs were present contributing 24% and 27% to the composition respectively, but were less prominent compared to the other grazing gradients (Table 1).

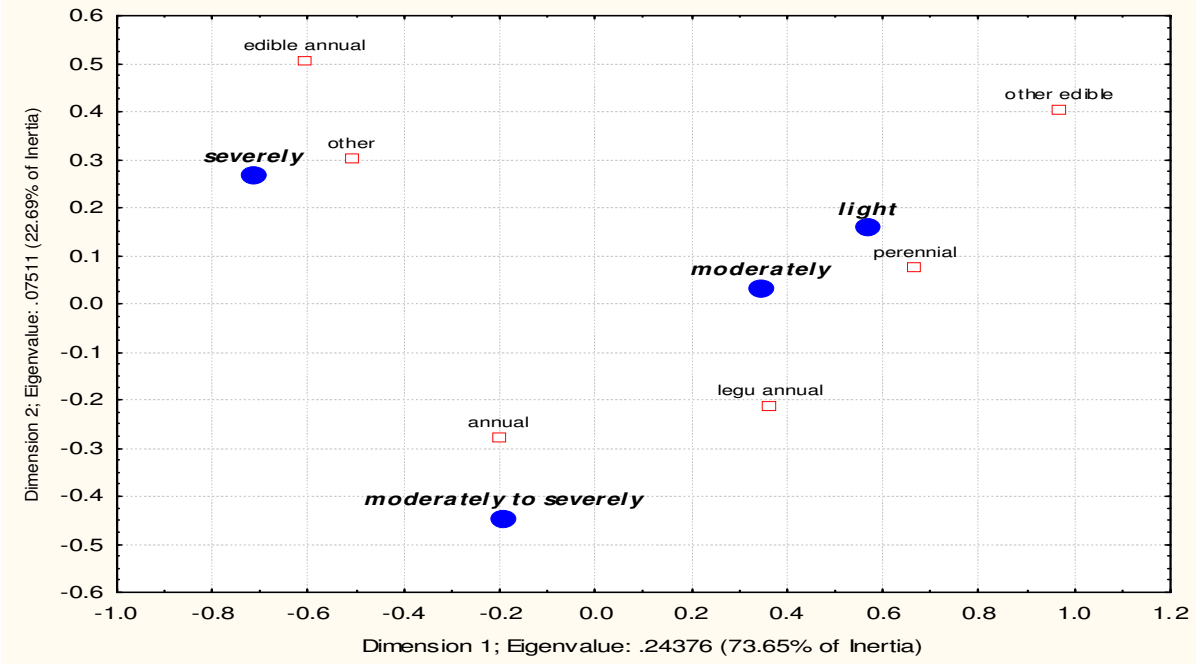

Figure 1: Ordination of the most abundant species in the rangeland according to degradation areas in year 1 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

Ordination of the species in year 1

In this study the species ordination was done by giving emphasis to species with frequency of occurrence above 1 %, which also limits the number of species. It was evident that most unpalatable forb species (others) appear dominantly in the SD area. The annual grass *S. verticillata* was present in all areas but was relatively prominent in abundance in the MSD area. Similarly the analysis implicated that perennial grasses such as *P. desertorum* and *C. plumulosus* were present in MD and LD areas but more abundant in the MD area. *P. coloratum*, which is closely plotted to the LD area, is more abundant in this particular area than in the MD area (Figure 1).

The MSD, MD and LD areas did share common species such as *S. verticillata, S. ioclados* and *Rhynchosia melacophylla* but a higher abundance was revealed in the MSD area for the first two species alone. *R. melacophylla* maintained an equal frequency distribution in the three degradation areas (Figure. 1). The life form ordination also identified similar species ordination for *S. verticilata* (Annual grass) and *R. melacophylla* (Legume annual forb) (Figure. 2). Blepharis spp. is the only annual strictly limited to the MD and LD areas (Figure. 1).

The species percentage distribution across the grazing gradient was identified using Classification Tree Analysis (CTA). The perennial grass species, other edible and legume annual forbs (*Blepharis* spp.and *R. melacophylla*) had a high frequency of occurrence in the MD and LD areas (37% and 42% respectively) compared to a low frequency of occurrence of 2% and 18% in the SD and MSD areas respectively (Figure.3). In contrast, the unpalatable species (*Phyllanthus maderaspa, Leucas nubica* & *Abutilon fruticosum*) relatively high in frequency and edible annual (*I. sinensis*) which are pioneers were found to have a total frequency of occurrence of 62% in the SD area and a consistent 12-14% frequency of occurrence in the other areas (Figure.3). A frequency of occurrence of 25% and 39% was recorded for annual grass *S. verticillata* in the SD and MSD areas respectively. The percentages for the MD and LD areas were 21% and 15% respectively (Figure.3)

Species frequency in year 2

The botanical composition of the rangeland in general was similar to that of the preceding year with only slight changes in species composition in some of the degradation areas. In the SD area, perennial species comprised 6% of the vegetation compared to 4% in year 1 (Table 2). The most abundant perennial species were *S. ioclados* and *P. desertorum*, which are characteristic inhabitants of degraded or disturbed areas. In contrast, annual grasses, predominantly *S. verticillata* comprise 50% of the total botanical composition and unpalatable

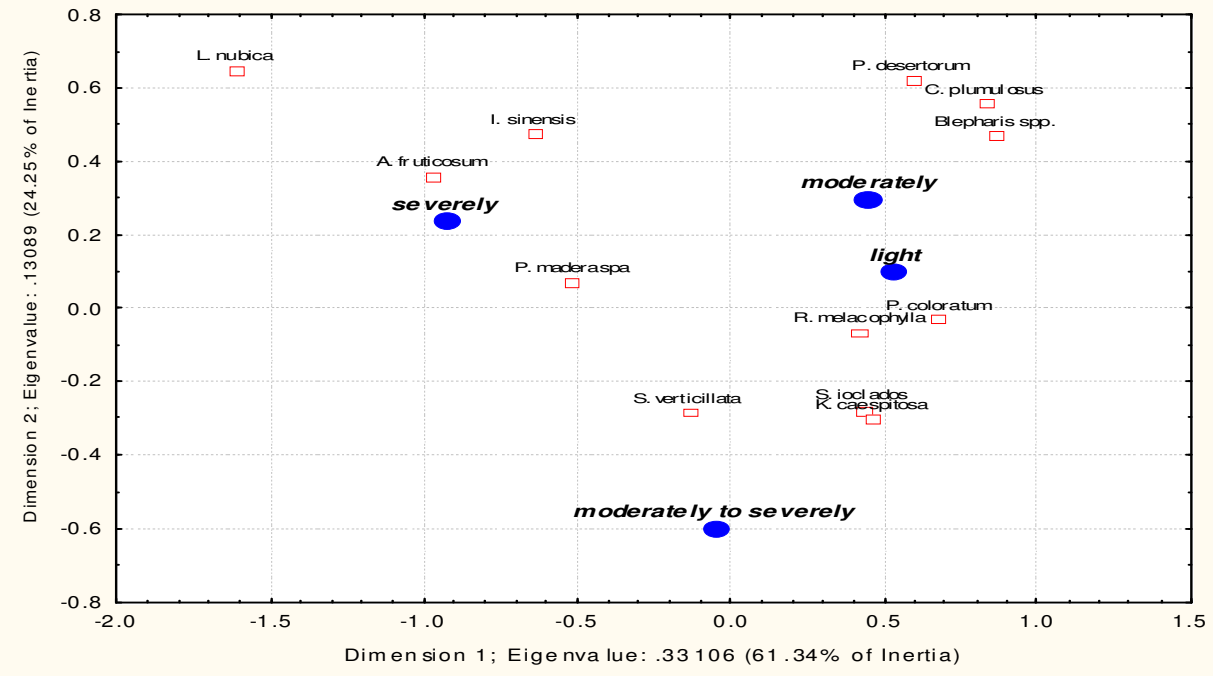

Figure 2. Ordination of life form groups in the rangeland according to degradation areas in year 1 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

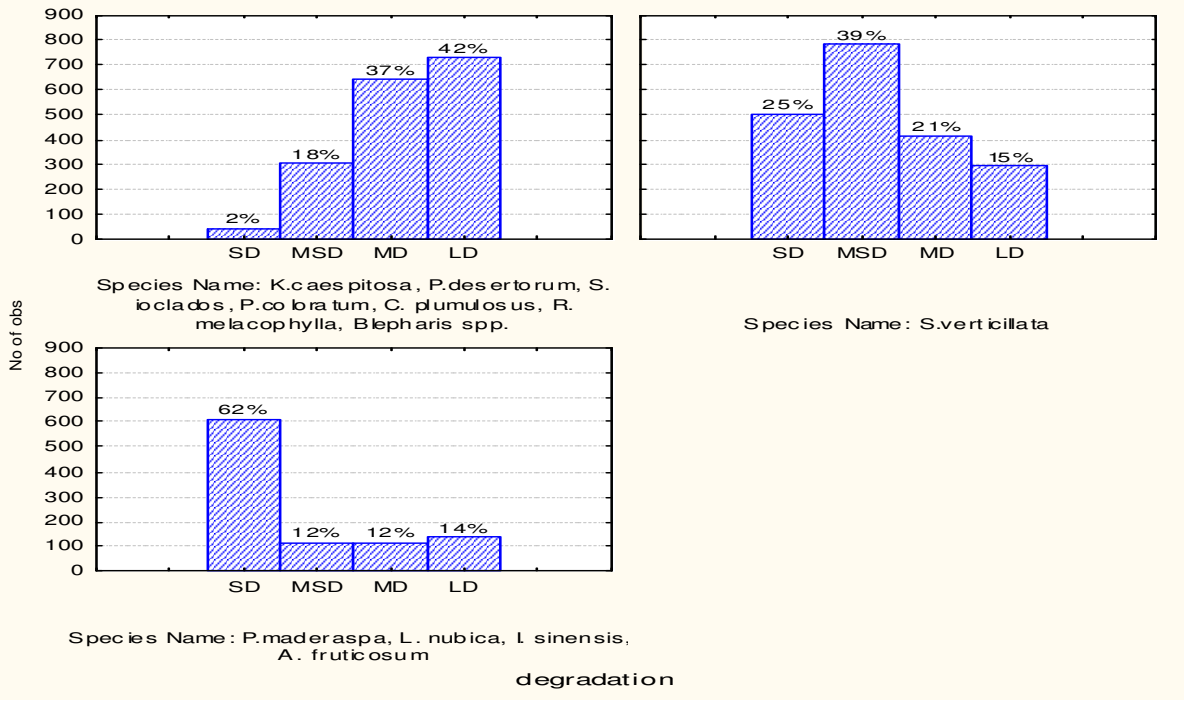

Figure 3: Frequency of occurrence of different species in the degradation areas (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

Table 2: Species composition (%) in the grazing gradients in year 2

			Percent composition of each grazing gradients			
Species Name	**Afar vernicular**	**Life form**	**severely**	**Moderate to severely**	**Moderately**	**lightly**
Perennial Grasses	**name**		%	(%)	%	%
Chrysopogon plumulosus Hochst	Durfu	Perennial	0	4.72	20.16	20.08
Sporobolus ioclados	Denekto	Perennial	2	3.04	3.36	0.4
Panicum coloratum	Denekto(p)	Perennial	0	1.04	4.72	12.4
Paspalidium desertorum	Bohale	Perennial	2.56	11.04	7.92	0.88
Bothriochloa radicans(Lehm)	As ayso	Perennial	0	0	2.8	0.96
Cenchrus ciliaris	Serdoyta	Perennial	0	0	0	0.24
Lintonia nutans Stapf	Afara mole	Perennial	0	0	0	2.56
Sporobolus pellucidus Hoehst	Sosokete	Perennial	0	0.16	0.16	0.64
Digitaria rivae (choir) stapf	Forele/hamanto	Perennial	0.96	0	0.08	0.16
Total percentage (%)			**5.52**	**20**	**39.2**	**38.32**
Annual Grasses						
Setaria verticillata (L.) P.Beauv	Delayta	Annual	50.2	64.8	34.16	25.44
Tetrapogon tenellus(Roxb)chior	Aytodyta	Annual	0	0.24	0.24	0.08
Sporobolus panicoides A. Ruch	Gewita	Annual	0	0	0.72	10.64
Total percentage (%)			**50.2**	**65.04**	**35.12**	**36.16**
Edible forbs						
Edible annual						
Ipomoea sinensis	Halal	Annual	31.7	4.4	7.36	1.2
Other edible						
Blepharis spp.	Yamarukta	Annual	0	6.64	5.52	20.8
Legume annual						
Rhynchosia melacophylla (spreng,Boj)	Haro	Annual	0.24	0.72	3.44	0.16
Total percentage (%)			**31.9**	**11.76**	**16.32**	**22.16**
others						
Phyllanthus maderaspa tensis L.	Akelekelmi	Annual	4.48	0.48	0.8	0.56
Leucas nubica Benth	Ergufuma	Annual	0	0	0	0
Amaranthus spp.	Bunkete	Annual	0.16	0	0	0
Orthosiphon pallidus Royle	Hebeke	Annual	0.32	0	0	0
	Alelus	Annual	0.96	0	0	0
Portulaca quadrifiola L.	Halihara	Annual	0.88	0.08	0.48	0.32
	Ashara	Annual	0.08	0	0	0
Abutilon fruticosum	Hanbukto	Annual	0.88	0.16	0.64	0.16
	Baroberbere	Annual	4.64	1.6	5.92	0.16
	Mituki	Annual	0	0.88	1.52	1.92
Total percentage (%)			**12.4**	**3.2**	**9.36**	**3.12**
Grand total percentage (%)			100%	100%	100%	100%

herbaceous forbs (others) 12% (Table 2). The MSD area consisted of 20%, 65% and 15% perennial grasses, annual grasses and others respectively. Similar to the previous year, *S. verticillata* was the most abundant species comprising 65% composition of the total herbage of this grazing area (Table 2).

In the MD area, similar to the previous year, perennials were more prominent (39% of the composition). The most

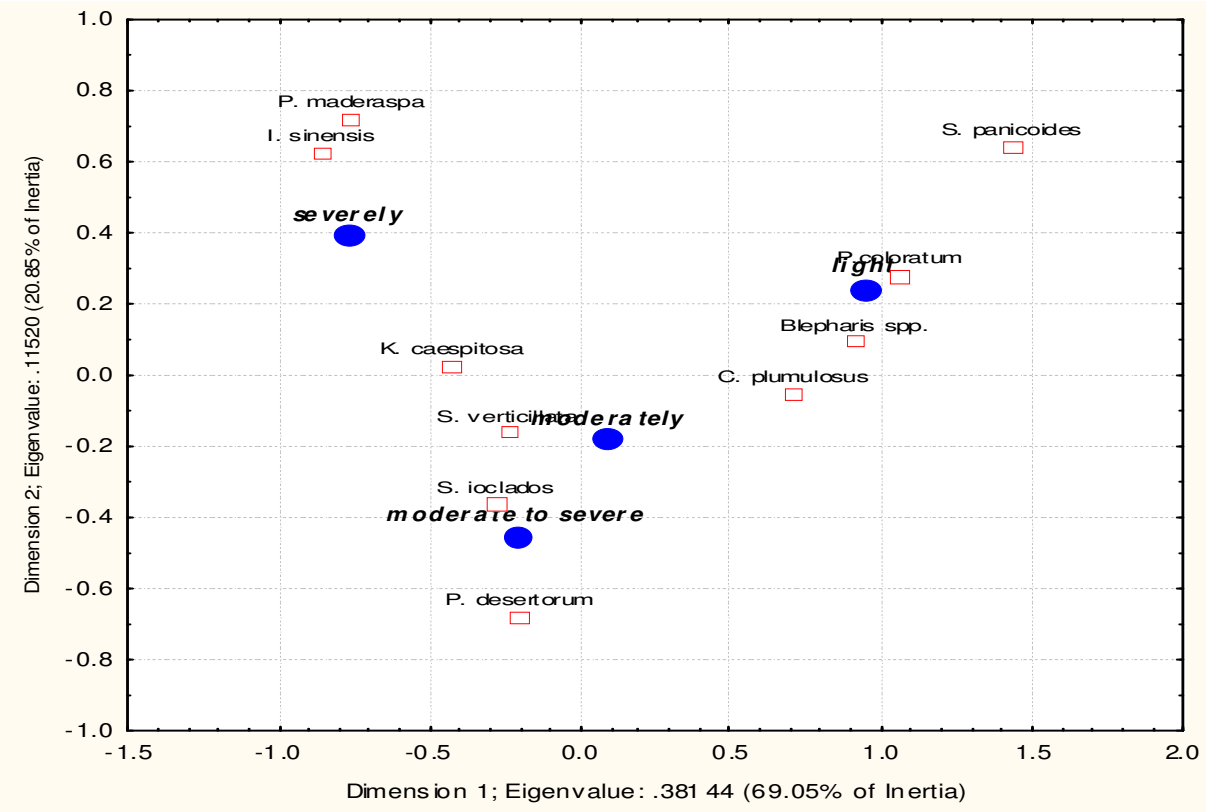

Figure 4. Ordination of the most abundant species in the rangeland according to degradation areas in year 2 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

frequently occurring species were *C. plumulosus*, *P. desertorum* and *P. coloratum* contributing 20%, 8% and 4% to the composition respectively. *Bothriochloa radicans, Sporobolus pellucidus* and Digitaria rivae were present in small numbers. The annual grass *S. verticillata* and other herbaceous forbs comprised 35% and 26% of the composition respectively (Table 2).

In the LD area, perennial grasses, annual grasses and others comprised 38%, 36% & 25% of the total composition respectively, which was similar to the MD area. In contrast with the composition of the LD area in year 1, a low frequency of occurrence of perennials (38% compared to 46% in 2003) was recorded while abundance of the annual grass species increased (Table 2).

Ordination of species in year 2

Ordination of the species and the life forms using correspondence analysis was done for each degradation area (Figure. 4 and 5). From the Figureures certain trends could be observed in the botanical composition of the herbaceous species over the study period. Certain species were more abundant in the plots of degradation areas close to the watering point relative to the plots of degradation areas further away from the watering point. On the other hand, the decrease in abundance of other species was a common phenomena observed. The species that increased in abundance relative to plots further from the watering point were the unpalatable species and *Ipomoea sinensis*, which is palatable. Although lower in abundance, the unpalatable species were also detected in the degradation areas further away from the watering point. The annual grass, *S. verticillata* existed in all grazing gradients but was more frequent in MSD and SD areas, similar to the trend observed for the same species in year 1 (Figure 4).

The perennial species were ordinated in accordance to their preference/palatability for animals and it was sometimes impossible to detect patterns of change of botanical composition for some of the species. For example, *P. desertorum*, which is less palatable, was more abundant in the MSD area relative to the MD and SD areas (Figure. 4). The lower abundance of this species in the SD area indicates that availability of preferred species is scarce and animals are persuaded to graze the less palatable species available.

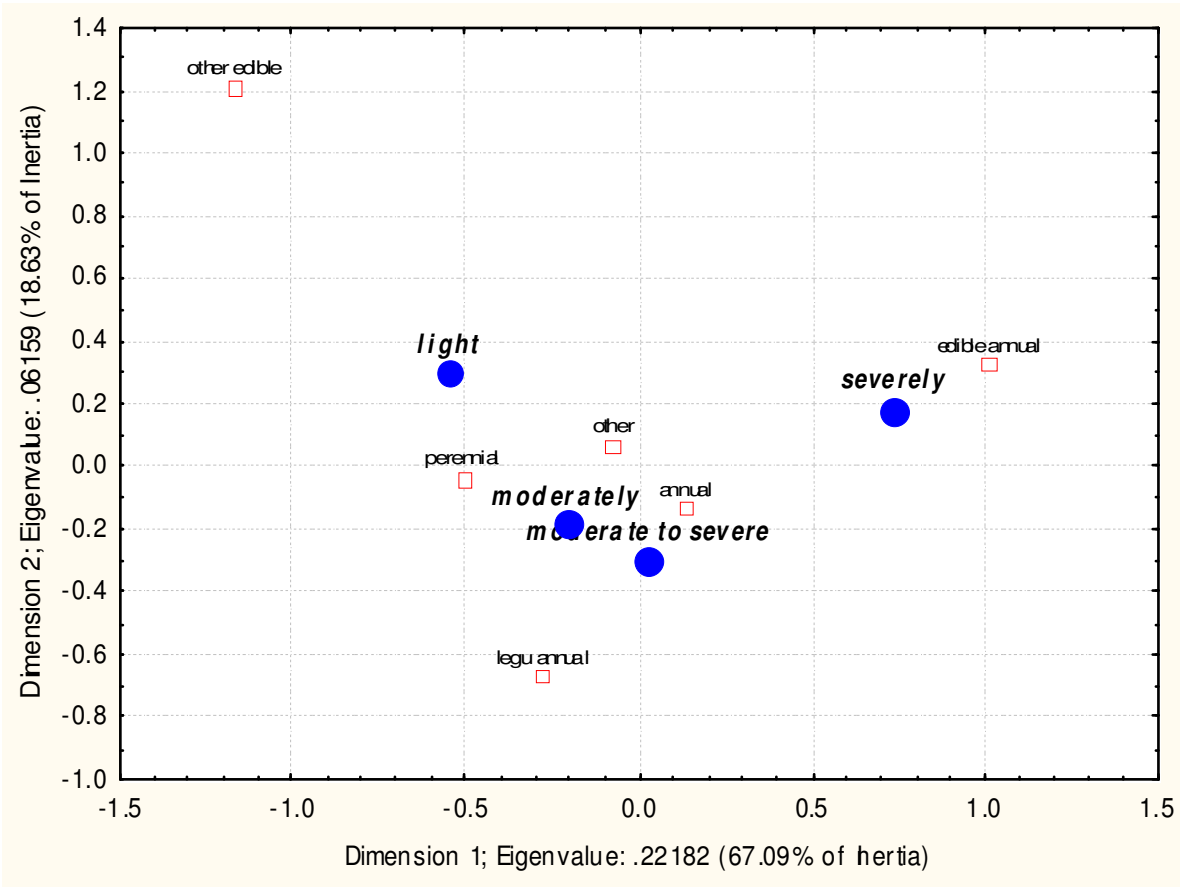

Figure 5: Ordination of life form groups in the rangeland according to degradation areas in year 2 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

C. plumulosus which is known to be a palatable species has a very low abundance in the MSD area closer to the watering point relative to the higher abundance observed in MD and LD areas further away from the watering point. *C. plumulosus* did not occur in the SD area. Similarly *P. coloratum* was more abundant in the LD area relative to the abundance in the MD area. The abundance of the species varied from nil to very low in SD and MSD areas respectively. *S. ioclados,* despite its low abundance in the SD area, existed at a consistent frequency in both MSD and MD areas (Figure. 4).

In terms of life forms the same trends as in year 1 were evident. The only deviation was the case of the “others” group that were more evenly distributed over the four degradation areas (Figure. 5) than in year 1, when it occurred mainly in the SD area (Figure. 2).

Frequency of life forms in grazing gradients in year 1 and year 2

Species compositional difference in each degradation area was examined based on the frequency of occurrence of different life forms (perennial grass, annual grass and others) observed in the field including all those species found to be very few in frequency of occurrence. This is because the life forms concisely categorized the species distribution in each degradation area. The perennial species distribution in the grazing gradient was emphasized for the important role they play in both animal production and soil erosion control. Before running a test comparison of each grazing gradient for the different life forms that occurred, a chi square test of the degradation levels (SD, MSD, MD & LD areas) and life forms of the species was carried out to evaluate if life forms are dependent on degradation or not. Accordingly, a highly significant difference ($p<0.05$) was recorded in both years for the different degradation areas and the three life forms considered (Figures 6 and 7).

In year 1, annual grasses and others were most abundant in the SD area with 48% and 49% frequency of occurrence respectively compared to the 3% occurrence of perennials. In the MSD area, annual grass species were dominant with a frequency of occurrence of 66%, whereas perennials and others were at equal proportions of 17%. In MD and LD areas a three-fold increase of

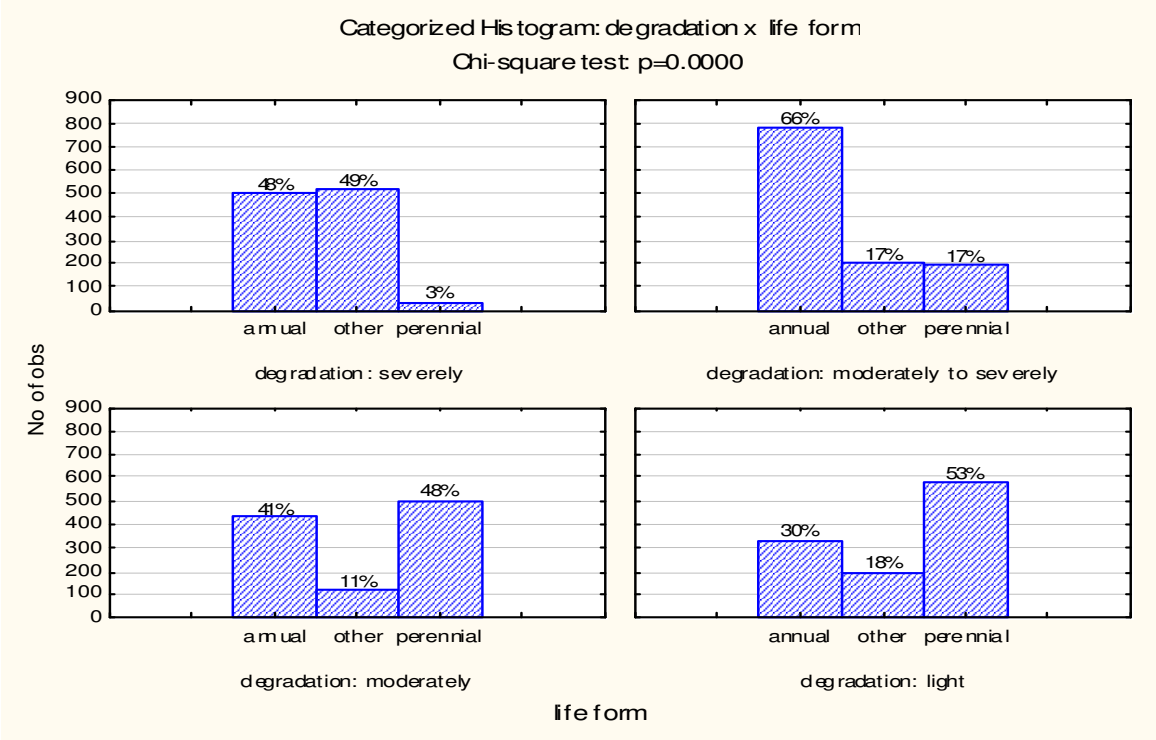

Figure 6: Frequency of occurrence of life forms in the grazing gradient in year 1 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

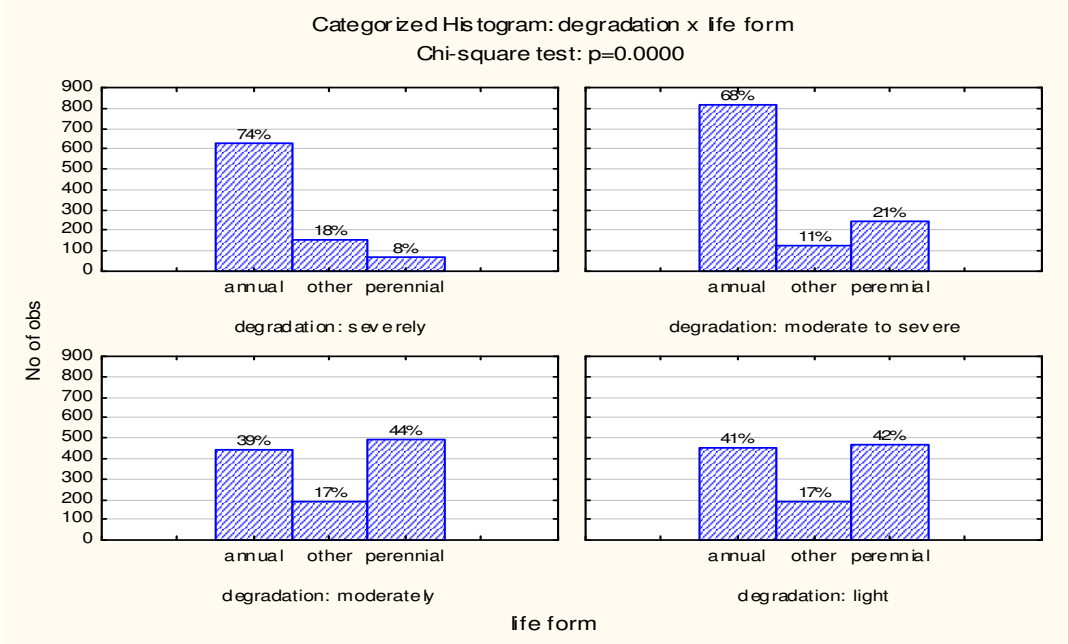

Figure 7: Frequency of occurrence of life forms in the grazing gradient in year 2(SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area).

Table 3: Bonferroni comparison test for life form compositional difference in each grazing gradient in year 1 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area)

	Combination	Bonferroni adapted p-value
1	(severely, moderately to severely) vs (annual, other)	< 0.01
2	(severely, moderately to severely) vs (annual, perennial)	< 0.01
3	(severely, moderately to severely) vs (other, perennial)	< 0.01
4	(severely, moderately) vs (annual, other)	< 0.01
5	(severely, moderately) vs (annual, perennial)	< 0.01
6	(severely, moderately) vs (other, perennial)	< 0.01
7	(severely, light) vs (annual, other)	< 0.01
8	(severely, light) vs (annual, perennial)	< 0.01
9	(severely, light) vs (other, perennial)	< 0.01
10	(moderately to severely, moderately) vs (annual, other)	1
11	(moderately to severely, moderately) vs (annual, perennial)	< 0.01
12	(moderately to severely, moderately) vs (other, perennial)	< 0.01
13	(moderately to severely, light) vs (annual, other)	< 0.01
14	(moderately to severely, light) vs (annual, perennial)	< 0.01
15	(moderately to severely, light) vs (other, perennial)	< 0.01
16	(moderately, light) vs (annual, other)	< 0.01
17	(moderately, light) vs (annual, perennial)	< 0.01
18	(moderately, light) vs (other, perennial)	0.09

frequency was recorded for perennials compared to the MSD area. On the other hand, annual grasses decreased to 41% and 30% and the others to 11% and 30% in MD and LD areas respectively (Figure. 6). This in general was evidence that the grazing gradient had an impact on the herbaceous composition.

In year 2, the occurrence of annuals was high in SD and MSD areas with frequency of occurrence of 74% and 66% respectively. The others and perennials were 18% and 8%, 11% and 21% for SD and MSD areas respectively. In MD and LD areas the annual grasses were more or less similar in frequency in both areas in both years. The others and perennials were almost similar in both MD and LD areas (Figure. 7).

Statistical compositional difference of life forms for year 1

A Bonferroni multiple comparison tests were made to observe the compositional difference in each degradation area for the different life forms (Table 3). The comparison made for almost all the combined tests implicated that the different life forms were significantly different ($p< 0.05$) for each comparison test of the life form vs (versus) degradation showing the impact of degradation on life form. One exception is combination test entry No. 10 made for MSD and MD areas vs the life forms of annuals and others, in which the case was not significant ($p> 0.05$). This means that the frequency of occurrence of the annuals and others was similar in both areas. (Figure.6). The same applies for entry No. 18, made for MD and LD areas vs others and perennials. Regarding perennial species, the relative proportion was compared to annuals and others in relation to each degradation area. The Figureure shows that the frequency of abundance of perennials increased along the grazing gradient away from the watering point for each comparison made (Figure 6).

Statistical compositional difference of life forms for year 2

The Chi-square test in general denoted that the life forms differ significantly ($p<0.05$) along the grazing gradient (Figure. 7). Perennial grasses, which are the major fodder source for animals are low in abundance in both SD and MSD areas where the relative abundance of annuals was high.

On the other hand, quite satisfactory frequency of abundance for perennials was observed in MD and LD areas with a decline in abundance of the annual species. The MD and LD areas had more or less similar frequency of occurrence of annuals, others and perennials. The frequency of occurrence of the perennials in both gradients was two- fold that of perennials in the MSD area (Figure. 7).

The Bonferroni test was carried out to compare the compositional difference of each degradation area versus life form was significant for most combinations (Table 4). The MSD combination test for both MD and LD areas implicated that the proportion of abundance of others and perennial species was more or less the same making the test insignificant ($p >0.05$). Similarly, the MD and LD areas were also insignificant ($p> 0.05$) for the life form comparison of other vs annual, other vs perennial and annual vs perennial. It could be assumed from Figures 5

Table 4: Bonferroni comparison test of life form compositional difference of each grazing gradient in year 2 (SD = severely degraded area, MSD = moderately to severely degraded area, MD = moderately degraded area and LD = lightly degraded area)

	Combination	Bonferroni adapted p-value
1	(severely, moderate to severe) vs (other, annual)	< 0.01
2	(severely, moderate to severe) vs (other, perennial)	< 0.01
3	(severely, moderate to severe) vs (annual, perennial)	< 0.01
4	(severely, moderately) vs (other, annual)	< 0.01
5	(severely, moderately) vs (other, perennial)	< 0.01
6	(severely, moderately) vs (annual, perennial)	< 0.01
7	(severely, light) vs (other, annual)	< 0.01
8	(severely, light) vs (other, perennial)	< 0.01
9	(severely, light) vs (annual, perennial)	< 0.01
10	(moderate to severe, moderately) vs (other, annual)	< 0.01
11	(moderate to severe, moderately) vs (other, perennial)	0.5
12	(moderate to severe, moderately) vs (annual, perennial)	< 0.01
13	(moderate to severe, light) vs (other, annual)	< 0.01
14	(moderate to severe, light) vs (other, perennial)	1
15	(moderate to severe, light) vs (annual, perennial)	< 0.01
16	(moderately, light) vs (other, annual)	1
17	(moderately, light) vs (other, perennial)	1
18	(moderately, light) vs (annual, perennial)	1

and 6 that there was a decrease of perennials and an increase of others in the MD area and an increase of annuals and a decrease of perennials in the LD area in year 2 compared to the preceding year.

Species compositional differences in year 1 and year 2

To compare changes in botanical composition of each degradation area over the two years, Classification Tree Analysis was carried out where it revealed that there were species differences in the 2 seasons. The differences were restricted only to the severely degraded area where frequency of occurrence of annual grasses was 73% in year 2 compared to 48% in year 1. On the other hand, 50% frequency of occurrence was recorded for others in year 1 and 20% in year 2. The species composition of other areas was more or less similar over the two years.

Discussion and summary

The classification of the species in each degradation area in general was a reflection of the pasture species response to grazing intensity of the rangeland. Dyksterhuis (1949) and Foran et al. (1978) stated that the most realistic and ecologically sound method of classification is to classify the species according to their reaction to injudicious range management practices and other disturbances such as drought and fire. Similarly, Bosch and Janse Van Rensburg (1987) grouped the species of the western grassland biome into five categories on the basis of their abundance curves on the grazing gradient.

The plant species that characterize the severely degraded area close to the watering point were annual grasses and unpalatable herbaceous forbs in both seasons. These are in general defined as pioneer species or short-lived plants, which increase under high levels of continuous selective grazing. This definition and characterization agrees with reports made by Andrew and Lange (1986), Friedel and Blackmore (1988) and Beukes and Ellis (2003). The pioneer annual grass species was *S. verticillata* with abundance percentages of 40% and 50% in year 1 and year 2 respectively in the severely overgrazed vegetation close to the watering point (Table 1 and 2). The dominance of this species in overgrazed area was also reported by Van Oudtshoorn (1999).

In this study, most of the forbs found are unpalatable except the annual herb *Ipomoea sinensis* that comprised 15% of the composition of the total herbage of the severely degraded area grazed by cattle (Table 1). This study has recognized high percentage abundance of forbs in the SD area close to the watering point. However, some forbs were recorded in the degradation areas far from the watering point. This agrees with the finding of Friedel and Blackmore (1988) that some forb species were closely associated with the watering point where others occurred throughout the gradient. The 4% occurrence of perennial grass species in the SD area in year 1 (Table 1) consisted mainly of *S. ioclados* and *C. dactylon* while the 6% perennial grass species in year 2 consisted of *P. desertorum* and *S. ioclados* (Table 2). These are known to be less palatable species and usually dominant in heavily grazed areas (Van

Oudtshoorn, 1999; Amsalu and Baars, 2002). Studies carried out around artificial water sources have indicated a decrease in palatable perennial plants (Pinchak et al., 1991; Hart et al., 1991, 1993). This study also highlighted the absence of palatable perennial species in the SD area that confirms results of previous studies.

The observed development of this less palatable species poor and sparse community in the inner 1500m zone around the watering point (SD area) is in agreement with other workers who found that grazing impacts are greatly diminished beyond 1-2 km from a watering point (Foran, 1980; Pinchak et al., 1991; Perkins and Thomas, 1993; Fusco et al., 1995).

In the MSD area a small increase in palatable perennial species was depicted in both seasons relative to the nil occurrences in the severely degraded area. The frequency of occurrence was less than 1% in year 1 and almost 5% in year 2 for *C. plumulosus*. *P. coloratum* exhibited 4% occurrence in year 1 and 1% occurrence in year 2. *C. plumulosus* and *P. coloratum* are the most preferred and palatable species but *C. plumulosus* is known as a more preferred species compared to *P. coloratum* (Personal communication: Afar elders and herdsmen). The finding was in agreement with Ayana and Baars (2000) who assessed the condition of the Borana rangelands in six communal grazing areas and on a Government owned ranch. In that study, *C. plumulosus* and *P. coloratum* were classified as desirable/preferred species, likely to decrease with heavy grazing pressure. The scientifically determined preferableness of the species substantiated the preferableness of the species as perceived by the community. Bogdan (1977) also concluded that these species are readily grazed by all kinds of stock and are much valued by pastoralists. Moreover, in the MSD area, an increase of the less palatable perennial species *S. ioclados* and *P. desertorum* was observed in both growing seasons. (In year 1*S. ioclados* was found to be dominant in the area with 12% frequency of occurrence. On the contrary in year 2, *P. desertorum* was more abundant than in year 1 growing season).

The annual grass *S. verticillata* has shown abundances as high as 63% and 65% in year 1 and year 2 respectively in the MSD areas (Table 1 and 2). The grass was evaluated as the sole crop in some of the plots and in the space between the tussocks of the perennial grasses. In year 2, the frequency abundance of annuals was high in the SD and MSD areas at 74% and 66% respectively (Figure. 7). This could be due to inter-annual variation of rainfall in year 1 and year 2 and agrees with many researchers who found that inter-annual variation in rainfall influence species composition of range vegetation (Ellis and Swift, 1988; Westoby et al., 1989). Others have critically stated that, short-term rainfall events (Van Rooyen et al., 1990), and certain rainfall conditions of semi-arid areas (Figureueroa & Davy, 1991), influence the dominance of annual species. The frequency of occurrence of the unpalatable forbs has declined to 3% in this area.

In the MD and LD areas, which are far from the watering point, a drastic increase in abundance of the palatable perennial species was observed. In both areas, less than 10% frequency of abundance was recorded for the less palatable perennial species.

In conclusion, this study confirmed what other researchers found in other semi-arid parts of the world. Unpalatable forbs and annual grass dominate the vegetation in heavily overgrazed areas (such as near a watering point). As the grazing pressure decrease further away from the watering point, some of the forbs are replaced by unpalatable perennial grass species and in areas that have low grazing pressure; palatable perennial grass species dominate the vegetation. Thus, the hypothesis that was tested is there fore rejected.

In general the study concluded that there was difference in botanical composition at increasing distances from the watering point. This was confirmed from the major distribution of annual grasses and unpalatable forbs in severely degraded area. The same species cover was observed in moderate to severely degraded area, more prominently covered by annual grasses, indicating the loss in ground cover of the palatable perennial species attributing to loss in forage biomass yield of the range. This change in ecosystem is corrected by proper holistic range management practices where the need to exercise the four fundamental process of ecosystems is justified to manage the rangeland and reverse the degraded areas. At the same time, in degraded and soil seed bank exhausted areas; keeping large stock of animals to physically act on the land to improve soil physical and chemical characteristics where then re-seeding of the potential local grasses is to be advocated to restore the severely degraded grazing areas of the range. Concomitantly, the establishment of additional watering points in accordance of the rangeland size is advisable, to create uniform grazing distribution of the livestock within the rangeland.

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