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*Full Length Research Paper*

# Heavily stocked 5-paddock rotational grazing effect on cross-bred Afrikaner steer performance and herbaceous vegetation dynamics in a semi-arid veld of Zimbabwe

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**A ten-year high stocking rate trial, mimicking communal areas was initiated at Matopos Research Station, Zimbabwe. Afrikaner steer crosses grazed continuously or rotationally at a high stocking rate (0.4 LU.ha$^{-1}$) in two 45 ha areas, with one fenced into five 9 ha camps each for the rotational grazing sites, with 30 animals per site. It was hypothesized that, heavily stocked rotation will not improve herbage biomass, decreaser species abundance, basal cover or animal performance. Biomass, basal cover and decreaser species abundance were not (P > 0.05) significantly different between the grazing systems, save for *Themeda triandra*, *Setaria incrassata* and *Panicum novemnerve*, but were significant (P < 0.05) in terms of annual variation. Mean maximum steer weight gain was higher (P < 0.05) under continuous grazing. It was concluded that, the creation of rigid rotational grazing schemes in communal areas without proper stocking rates will not improve animal performance, herbage production, basal cover, but might have an effect on species abundance. In higher rainfall years, heavy stocking has no adverse effects on performance. Hence, any plans of grazing interventions on livestock management in communal areas, should consider stocking rate and rainfall, with a rapid stock reduction strategy in projected low rainfall years.**

**Key words:** Basal cover, communal areas, grazing system, herbage biomass, stocking rate, weight gain.

## INTRODUCTION

Zimbabwe's communal areas have long been characterized by high livestock and human population densities (Whitsun Foundation, 1983). This overcrowding was a result of colonial policy; the Land Apportionment Act of 1930, that set aside 30% of the land for African Reserves in drier and less fertile areas (DeGeorges and Reilly, 2007). In addition, multiple production objectives of communal farmers also resulted in them rearing a large number of various livestock species (Agritex, 1993). The increased population pressure and continuous grazing methods induced environmental degradation as evidenced by severe soil loses from erosion (Whitlow, 1988). On the other hand, the customary tenure system also led to an open-access land use practice that aids communal resource over-exploitation by individuals maximizing production at the expense of the community (Hardin, 1968). Soon after independence in 1980, the government formulated policies and programmes aimed at mitigating environmental challenges and improving

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agricultural production in communal areas. They included land redistribution and rotational grazing schemes (Froude, 1974). Rotational grazing method was advocated because of the eighties and past decade commercial farm research evidence pointing to its superior vegetation and cattle responses compared with continuous grazing method (O` Reagain and Turner, 1992; Vaughan-Evans, 1978).

Introduction of the rotational grazing schemes in communal areas failed to halt degradation, improve range utilization and livestock production (Cousins, 1988). This might have been an error of applying results from conservatively stocked and privately owned commercial farms in open-access overstocked communal areas. Few grazing system studies have been carried out in communal areas and hence, responses observed in commercial area studies might not be the same under communal areas, which justifies this investigation. There is little evidence to substantiate claims of improved range condition and superior livestock performance in communal areas after establishment of rotational grazing schemes. To gain knowledge on the effects of rotational grazing at heavy stocking rates of communal areas, a ten year trial was initiated at Matopos Research Station with cross-bred Afrikaner steers grazing a 5-paddock rotational, (hereafter referred to as “rotational grazing”) and a continuous system, stocked at a heavy stocking rate (0.4 $LU.ha^{-1}$) to represent estimated stocking rates in communal areas. The objective of this study, was to investigate the influence of heavy stocking on species abundance, herbaceous biomass, cover, and animal performance in the two grazing systems. It was hypothesized that rotational grazing, at high stocking rates, will not improve herbage biomass, basal cover and animal performance. It was further hypothesized that, it will not enhance the abundance of perennial, palatable and decreaser species, and continuous grazing would negatively impact on perennials but will favour annuals, increasers and invader species.

## PROCEDURES

### Study area

The study was conducted from 1990/1991 to 2000/2001 on a 180 ha site at Mahiye, a section of Matopos Research Station (20°23'S, 28°28'E, 1 320 m a.s.l), located 30 km southwest of Bulawayo, in southwestern Zimbabwe. The study area is characterized by gently undulating topography with quartz meta-gabbro as underlying parent material, resulting in siallitic, medium textured red clay soils (Dye, 1983) of moderately high fertility. Soils are prone to surface crusting, which result in bare patches (Ward et al., 1979). Matopos lies in agro-ecological region V, an area where rainfall is both limited and highly variable (200 to 1400 mm per annum, average 600 mm), mostly falling from October to April (Department of Meteorological Services Zimbabwe, 1981). The annual rainfall recordings for the duration of the study are shown in Figure 1. October is the hottest month (mean maximum 29.4°C). Frost occurs during the dry season (May to September).

The area has been described as an Acacia tree-bush savanna of varying density (Rattray, 1961). It is dominated by *Acacia karroo*, *Acacia nilotica*, *Acacia gerrardi*, *Acacia rehmanniana*, *Acacia nigrescens* and *Maytenus senegalensis*. Common grass species include *Heteropogon contortus*, *Cymbopogon plurinodis*, *Themeda triandra* and *Hyparrhenia* species. *Setaria incrassata* also occurs, especially on wetter areas. The recommended livestock carrying capacity in agro ecological region V is 1 livestock to 10 ha (Vincent and Thomas, 1961).

### Experimental design

A completely randomized design was used with two cattle grazing treatments (continuous and rotational grazing), replicated twice. The experimental unit was the group of animals exposed to the same treatment, in this case, 30 animals under rotational grazing treatment which was replicated. The other treatment had 30 animals under continuous grazing that was also replicated. A heavy stocking rate of 2.5 ha Lu-1 was used in the two treatments. Five, 9 ha paddocks comprised each rotational grazing treatment, while the continuous grazing treatment consisted of one 45 ha paddock.

### Treatment application

Two sites, 45 ha in size, were divided into five nine-hectare paddocks. These sites, together with the subdivisions, were used as the two replications for the rotational grazing treatment. Another undivided 45 ha area with its replicate was used for the two continuous grazing treatments. In each year, two groups of one and two-year-old cross-bred Afrikaner steers were used. The average weight for all the one-year olds used in the 10 year duration of the trial was 170 ± 3.12 kg. The initial weight for the two year-olds was taken as the 13th month weight for animals that were introduced in the trial as one year-olds and the average was 280 ± 4.42 kg. Thirty steers (15 one-year-olds and 15 two-year-olds) were randomly allocated to each treatment. Afrikaner crosses of approximate similar weight and age were used to replace any lost animal during the trial. Steers were weighed individually at the end of every month for the two years in the trial. After two years the steers were culled and replaced by 60 one-year-olds, distributed equally between treatments. The first group of the 60 two-year old steers’ weight was not considered, as they were mainly for setting the stocking rate in preparation for an annual replacement by one year olds. An annual exit of 60 steers from the trial was the best practice, to maintain a constant stocking rate and steady supply of replacement stock than an initial group of 120 steers of the same age. The rotational grazing treatment was based on a five-paddock system. Each paddock was grazed for seven days, allowing approximately 28 days of rest between grazing episodes.

### Grass sampling

At peak herbaceous vegetation growth in early April of each year grazing plots were sampled for standing herbaceous biomass, basal cover and species composition. Each paddock, including the imaginary paddocks in continuously grazed sites was divided into five equal sized sections, each containing permanently marked 50 m vegetation transect. Five permanent transects were established in each paddock parallel to the fence line, and a 30 m non-sampling zone between the fence line and the transect next to the fence was maintained. The biomass of herbaceous vegetation was estimated by clipping 20, 0.5 $m^2$ permanent quadrats placed randomly along each 50 m transect. Quadrats were clipped to ground level and harvested forage was oven dried at 60°C for 48 h and weighed. Basal cover was measured using a basal cover frame with a total of 100 cells. Cover was estimated as a proportion of cells that were covered by stem bases. Frames were used at 20 sampling quadrats located within the permanent transects. Species abundance was

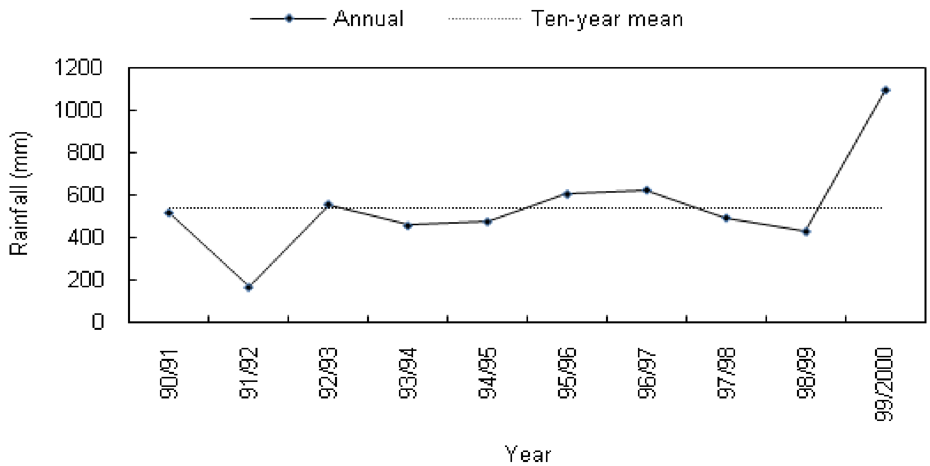


**Figure 1.** Annual rainfall (mm) recorded at Matopos research station, with mean annual rainfall indicated by the horizontal dotted line.

estimated by counting all species rooted within the quadrat.

#### Data analysis

Data on steer weight gains were analysed using the mixed models procedure of SAS (1996). Mean, variance and standard deviation on weight gains were computed. Live weight changes were calculated for the period in the trial, and they were computed as the difference between the entry weight and maximum weight. The study was a 2 x 9 factorial design with grazing system as a fixed factor and year as a random factor; since different years had different annual rainfall totals. The mathematical model for body weight gain included grazing system, year and the interactions. The continuous and rotational grazing system weights for all the years were examined in the same model and included year as a random factor. Interactions were determined using the DIFF option in SAS when probability was < 0.05%. The linear mixed model procedure of SPSS (1999) was used to determine the effect of grazing system on standing herbaceous biomass, basal cover and species abundance. The factor 'year' was treated as a repeated measurement, while grazing system was treated as a fixed factor. The emphasis of the analysis was laid on the treatment effect and the treatment x year of measurement interaction. Quadrat measurements were aggregated to get the total of the transect, which was used as the repeated measure over years. Least significant difference (LSD) was used to separate means when ANOVA showed significant ($P < 0.05$) treatment effects. The grasses were classified as either decreasers or increasers as defined by Trollope (1990), to ascertain whether the individual grass species had a response to grazing pressure typical of its functional grouping. There was no data for species abundance in 1991 because of the severe drought, while data for 1994 was lost. Individual grass species were analyzed separately.

## RESULTS AND DISCUSSION

### Rainfall

The distribution in annual rainfall over a ten year period compared to the ten year mean is shown in Figure 1. While it highlights the major drought of 1991/1992, it also identifies slightly below average rainfall in 1993/1994, 1994/1995 and 1998/1999 period. The 1999/2000 stands out to be the wettest year with a total rainfall of 1094 mm. The ten year average annual rainfall at Mahiye was 541 mm. Most part of the annual rainfall falls between November and March (Figure 2), January stands out as the wettest month, while July and August are considerably drier.

### Animal performance

Steer weight gain differed by grazing system ($F_{1, 10610} = 23.42$, $P < 0.001$). Steer performance was significantly higher in continuously grazed (311.8 ± 0.85 kg) paddocks than in rotationally grazed (289.1 ± 0.93) ones (Table 1). There was a significant ($F_{1, 10610} = 23.70$, $P < 0.001$) interaction between grazing system and year (Table 1). Steer weight gains were significantly higher ($P < 0.0001$) in continuously grazed paddocks than rotationally grazed ones in all the years, except for 1990 and 1996, where steer weight gains between the grazing systems were similar (Figure 3). The higher steer weight gains observed in continuously grazed paddocks, corresponds to results obtained by Kreuter et al. (1984) and Barnes and Denny (1991) who found better performance in continuously grazed animals, when they compared beef cattle production at different stocking rates in continuous and rotational grazing systems in South Africa. The superiority of continuous grazing system was also observed in cow-calf and ewe-lamb units at the mountain rangelands of southern Utah in the United States. Cows, calves, ewes and lambs under continuous grazing gained more than those in rotational grazing (Wood et al., 2003). Similarly, recent results of a 16 year steer grazing trial in the northern mixed-grass prairie at Wyoming in the United States, indicate a 6% reduction in steer weight

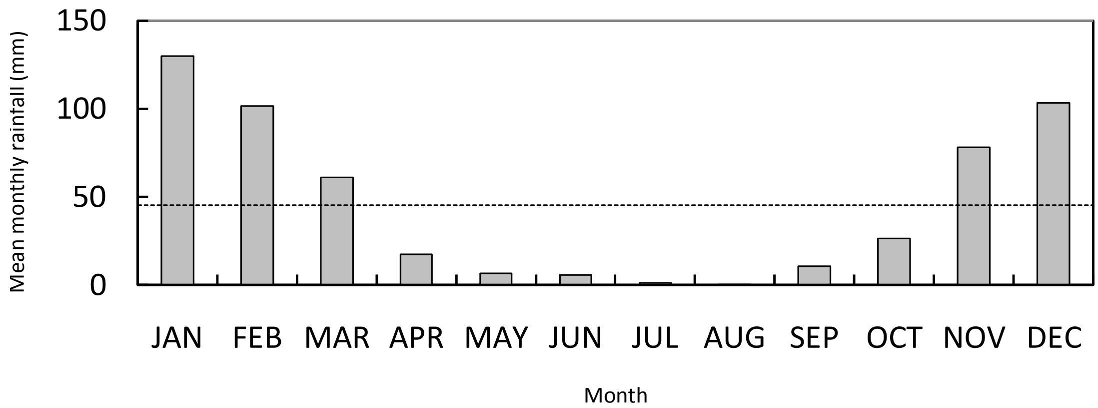


**Figure 2.** Ten-year monthly average rainfall at Matopos Research Station, with annual monthly average indicated by the horizontal dotted line.

**Table 1.** Means ± SE and P-values of standing crop herbaceous biomass (kg ha$^{-1}$), body weight gain (kg) and basal cover (%) for the two grazing treatments (1991 to 2000).

| Treatment | Standing herbage biomass (kg ha$^{-1}$) | | Body weight gain (kg) | | Basal cover (%) | |
|---|---|---|---|---|---|---|
| | *N | Mean ± SE | N | Mean ± SE | *N | Mean ± SE |
| Grazing | | | | | | |
| Continuous | 10 | 0.55 ± 0.04 | 5650 | 311.1 ± 0.85 | 9 | 31 ± 1.72 |
| Rotational | 10 | 0.6 ± 0.04 | 4971 | 289.1 ± 0.93 | 8 | 31 ± 1.82 |
| F-test probabilities | | | | | | |
| Grazing system | P > 0.05 | | P < 0.0001 | | P > 0.05 | |
| Year | P < 0.01 | | | | P < 0.01 | |
| Grazing x Year | P > 0.05 | | P < 0.0001 | | P < 0.05 | |

NB: *N: Number of paddocks.

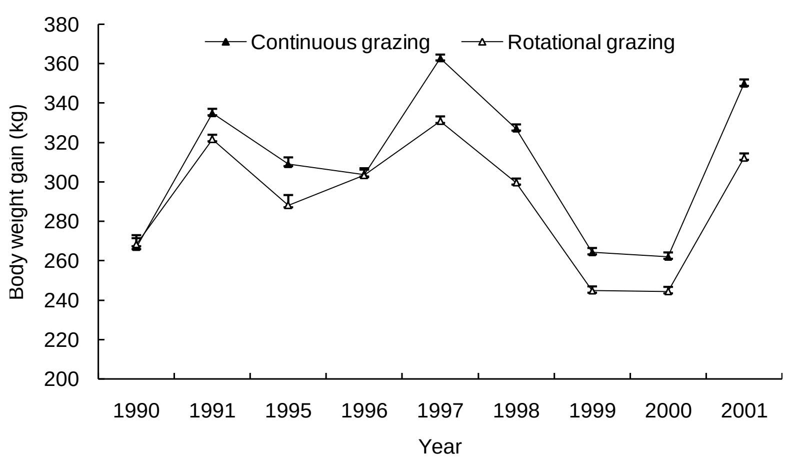


**Figure 3.** Effect of grazing systems on steer weight gains across years.

gain under rotational grazing compared to continuous grazing (Derner et al., 2008). Furthermore, a review of the empirical basis for grazing management recommenddations by O`Reagain and Turner (1992), reports many studies affirming higher performance of animals under continuous grazing.

The lower weight gains in rotationally grazed paddocks might be due to the high livestock density in the camps which might have reduced the opportunity for steers to select palatable and nutritious species. In contrast, fewer disturbances in the grazing pattern and social behavior of animals under continuous grazing allows selection of key grazing resource areas and nutritious species in different seasons (Weir, 1990). An opportunity to select nutritious species in continuous grazing leads to higher digestibility (Vallentine, 2001) of such diets, and hence improved performance. In addition, intake of forages might have been higher in continuous grazing since the opportunity to select quality forage limits the effect of decreased intake associated with poor roughage (Simon et al., 1995). Scoones (1995a) suggested that, the feeding patterns of cattle respond to the spatial heterogeneous availability of herbage at the landscape level in different seasons. In semi-arid areas, cattle feed in certain parts of a landscape in a particular season due to variations in quantity and quality of forage, notably low lying areas with high levels of available herbaceous biomass (Scoones, 1995b). This flexibility to select key resource areas is absent in rotational grazing, and this might have a negative effect on animal performance. Rigid rotational grazing schemes cannot be expected to have consistent impact on animal performance as both animal demands and forage growth rates are not constant throughout the year in a heterogeneous landscape. Results from previous studies on grazing system impact on animal performance show some inconsistency. Some reveal rotational grazing showing superior animal performance (Du Toit, 2001), poor performance (Bryant et al., 1989) and no differences (Hepworth et al., 1991) in others. Variation in rainfall might have indirectly contributed to the variation in body weight gains in the two grazing systems. The significant interaction between grazing system and year, might be related to rainfall. The year 1990/1991 was characterized by below average rainfall (Figure 1), and this below average rainfall might explain the insignificant ($P > 0.05$) differences in steer weight gains in 1990. An interaction between grazing system and rainfall was also observed by Derner et al. (2003) in which grazing system differences were found during years with above average rainfall and not in dry years. The absence of significant grazing system difference in low rainfall years was also observed by Wang et al. (2008) in sheep grazing the inner Mongolian steppe in China. Quantity of rainfall affects forage production, and it has been reported that, forage production was similar between grazing systems in dry years (Derner and Hart, 2007). Weight gains may have been associated with the quality of herbage selected in continuous grazing than the quantity; since results show lower herbaceous biomass in continuous grazing. Continuous grazing encourages re-growth of high quality forage (Kothmann, 1980) compared to low quality moribund tissue in rested rotationally grazed paddocks. High rainfall most likely caused a quick growth and increased biomass of palatable annuals, hence better animal performance. In addition, in drier years the relative difference between the two systems is considerably less, and that affirms the indirect effect of rainfall on the re-growth of the different grass species. The indirect effect of rainfall on animal performance was reported in studies by Hatch and Tainton (1995, 1997) and Fynn and O`Connor (2000).

### Standing herbaceous biomass and basal cover

Herbage biomass did not ($F_{1,\,18} = 0.84$, $P = 0.37$) differ significantly between grazing systems. Similarly, basal cover did not ($F_{1,\,15} = 0.006$, $P = 0.94$) differ significantly between grazing systems (Table 1). There was a significant ($F_{8,\,144} = 108.32$, $P < 0.01$) variation in herbage biomass and basal cover ($F_{7,\,105} = 35.69$, $P < 0.01$) between years. A significant ($F_{7,\,105} = 4.10$, $P < 0.01$) interaction between grazing system and basal cover for different years was observed. Basal cover in continuously grazed paddocks which was previously higher ($P < 0.01$) in 1991 dropped to lower levels ($P < 0.01$) than those of rotationally grazed paddocks in 1992. In addition, in the year 2000, rotationally grazed paddocks increased in basal cover, while an unexpected decrease was observed in continuously grazed paddocks. Absence of a grazing system effect on herbage biomass and basal cover corroborates conclusions made by Venter et al. (1989), of no difference in the productivity of heavily stocked communally grazed grasslands of KwaZulu when compared with the neighbouring Umfolozi Game Reserve in South Africa. A similar observation was also reported in Texas (Ralphs et al., 1990) and Matopos (Barnes and Denny, 1991). Milchunas and Lauenroth (1993) extensively reviewed grazing and production data of many semi-arid sites and concluded that, grazing system does not affect herbaceous vegetation production and cover. In addition, O`Connor`s (1994) study in Gazankulu, a South African savanna concluded that, the differences in basal cover in heavily and lightly grazed areas were due to rainfall than grazing. The hypothesis that, rotational grazing at high stocking rate will improve herbage biomass and basal cover was therefore rejected.

In contrast to the findings made in this study, Fourie et al. (1984) studying the influence of stocking rate and grazing system on plant basal cover and botanical composition in the Northern Cape, South Africa, found that rotational grazing was superior to continuous grazing. Sharrow (1983) compared effects of a 5-paddock rotational grazing system with continuous grazing and found more forage under the rotational grazing system. In this study, there was no difference in counts of the most abundant species in the two grazing systems, and this might explain the observed similarity in herbage biomass in the two grazing systems, because species composition is related to herbage quantity (Penning de Vries and Djiteye, 1982). Resilience of a

**Table 2.** Estimated marginal means (±SE) of increaser (I) and decreaser (D) grass species abundance (in counts) in two grazing treatments (1990/1991 – 1999/2000) at Matopos research station. N (number of permanent transects sampled) = 50 for both grazing systems. Significant p-values (p<0.05) are shown in bold.

| Species | Class | Grazing system | | | | d.f | F | F -test probabilities | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Continuous | | Rotational | | | | Grazing | Year | Grazing x year |
| *Aristida barbicollis* | I | 113.9 | ±8.92 | 117.8 | ±8.92 | 1, 98 | 0.09 | 0.76 | 0.00 | 0.02 |
| *Brachiaria nigropedata* | D | 49.2 | ±6.83 | 44.0 | ±6.83 | 1, 98 | 0.29 | 0.59 | 0.00 | 0.27 |
| *Bothriochloa insculpta* | I | 15.2 | ±1.74 | 15.7 | ±1.74 | 1, 98 | 0.03 | 0.85 | 0.00 | 0.22 |
| *Cymbopogon plurinodis* | I | 23.2 | ±4.53 | 52.2 | ±4.53 | 1, 98 | 20.38 | 0.00 | 0.00 | 0.00 |
| *Chloris virgata* | I | 155.3 | ±18.46 | 158.6 | ±18.46 | 1, 98 | 0.02 | 0.90 | 0.00 | 0.62 |
| *Digitaria milanjiana* | D | 32.9 | ±6.12 | 33.7 | ±6.12 | 1, 98 | 0.01 | 0.92 | 0.00 | 0.78 |
| *Eragrostis superba* | I | 4.1 | ±0.93 | 6.2 | ±0.93 | 1, 98 | 2.55 | 0.11 | 0.00 | 0.03 |
| *Eragrostis* species | I | 27.4 | ±3.17 | 28.2 | ±3.17 | 1, 98 | 0.04 | 0.85 | 0.00 | 0.60 |
| Forbs | I | 38.7 | ±1.81 | 31.7 | ±1.81 | 1, 98 | 7.48 | 0.01 | 0.00 | 0.07 |
| *Heteropogon contortus* | I | 123.6 | ±9.62 | 100.9 | ±9.62 | 1, 98 | 2.78 | 0.10 | 0.00 | 0.16 |
| *Panicum novemnerve* | D | 23.0 | ±3.76 | 34.6 | ±3.76 | 1, 98 | 4.75 | 0.03 | 0.00 | 0.11 |
| *Rhynchelytrum nerviglume* | I | 10.2 | ±2.70 | 9.7 | ±2.70 | 1, 98 | 0.02 | 0.89 | 0.00 | 0.38 |
| *Setaria incrassata* | D | 3.8 | ±2.61 | 11.9 | ±2.61 | 1, 98 | 4.93 | 0.03 | 0.00 | 0.01 |
| *Tragus beteronianus* | I | 38.7 | ±3.73 | 43.4 | ±3.73 | 1, 98 | 0.82 | 0.37 | 0.00 | 0.17 |
| *Themeda triandra* | D | 11.4 | ±2.86 | 20.9 | ±2.86 | 1, 98 | 5.48 | 0.02 | 0.00 | 0.10 |
| *Urochloa mosambicencis* | I | 9.8 | ±1.61 | 4.7 | ±1.61 | 1, 98 | 4.99 | 0.03 | 0.00 | 0.08 |

veld to grazing confounds the effect of the grazing procedure on herbage biomass and cover, and this might be the condition at Matopos veld, since it has been under grazing for a long time. Similar long-term plant productivity in the two systems is the evidence of the high likelihood of resilience to grazing pressure by this ecologically stable rangeland. The 1992 drought might have led to the similarity in grazing system effects, since there was no herbage produced in both sites therefore introduction of livestock thereafter was on veld almost homogenous in grass quantity and pretreatment, hence the livestock grazing effect might be realised after a certain threshold of time (Oba et al., 2000).

Climatic factors, especially rainfall, which varied between years, play a significant role in determining herbaceous vegetation production and cover, as observed in the significant differences in biomass and cover between years. Rainfall is the limiting environmental factor that determines grassland production in arid and semi-arid areas (Snyman, 1998). Trends in annual vegetation dynamics closely followed the trend in annual rainfall. Overall, herbaceous vegetation production and basal cover in this study were episodic and closely linked to rainfall. Similar results were obtained in Kenyan arid rangelands by Ekaya et al. (2001), as well as by Fynn and O`Connor (2000) in South Africa.

## Species abundance

Rotational grazing significantly (P<0.05) improved the abundance of the following decreaser species; *T. triandra*, *S. incrassata* and *Panicum novemnerve* (Table 2). Conversely, increasers, *Urochloa mosambicensis*, Forbs and *C. plurinodis* significantly (P<0.05) increased in continuous grazed treatments (Table 2). Species abundance significantly varied between years (P < 0.01) for all species (Table 2) and the trend was similar for all grasses in both systems (Figure 4), save for *Eragrostis superba*, *C. plurinodis*, *S. incrassata* and *Aristida barbicollis* (as shown by the significant interaction (P < 0.05) between year and grazing system: Table 2).

The abundance of decreaser species was consistently lower compared to most of the increaser species (Figure 4). Some varying effect of grazing system on the abundance of decreaser and increaser species was also observed; however, the typical trend of continuous and rotational grazing promoting the proliferation of increaser and decreaser species respectively was conspicuous. The difference in mean species abundance between years concurs with literature, suggesting that climatic factors (rainfall) override grazing, in determining grass species composition and abundance (O` Regain and Turner, 1992). The impact of drought and the grazing treatment thereafter, explains the higher abundance of *T. triandra* in rotationally grazed paddocks. Survival and growth of *T. triandra* is determined by the grazing procedure after a disturbance like drought, with heavy grazing without rest impacting negatively on its abundance as found by Danckwerts and Stuart-Hill (1988) in the Eastern Cape.

Rotational grazing provided a rest period for *T. triandra*, *S. incrassata* and *P. novemnerve* to grow, set seeds and hence their higher recruitment. It also reduced the

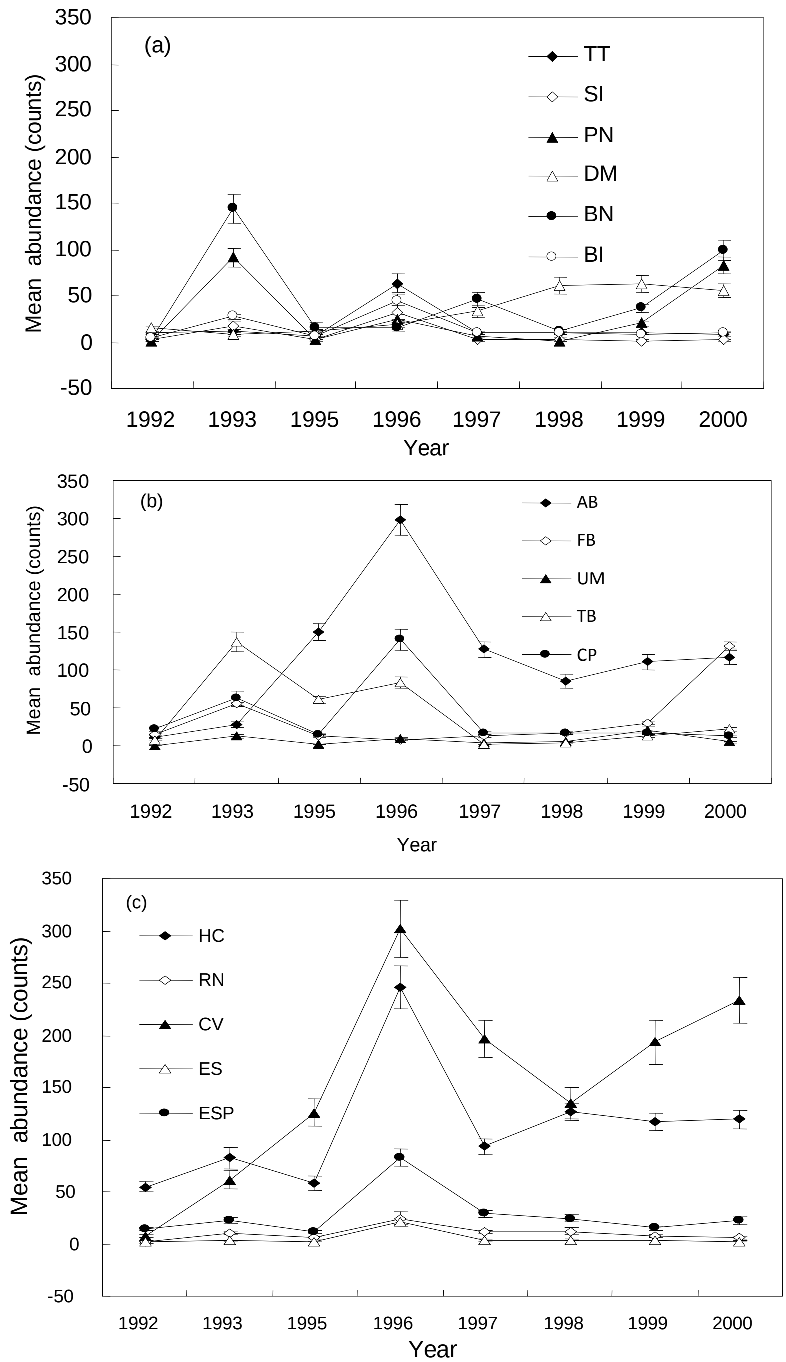


**Figure 4.** (a – c) Changes in mean abundance of (a) Decreaser species and ((b) and (c)) Increaser species over the ten year trial period. TT = *Themeda triandra*, SI = *Setaria incrassata*, PN = *Panicum novemnerve*, DM = *Digitaria milanjiana*, BN = *Brachiaria nigropedata*, BI = *Bothriochloa insculpta*, AB = *Aristida barbicollis*, FB = Forbs, UM = *Urochloa mosambicensis*, TB = *Tragus beteronianus*, CP = *Cymbopogon plurinodis*, HC = *Heteropogon contortus*, RN = *Rhynchelytrum nerviglume*, CV = *Chloris virgata*, ES = *Eragrostis superba*, ESP = *Eragrostis* sp.

selection pressure on these species, therefore, promoting their survival and growth. In addition, *S. incrassata's* characteristic rhizomatous growth form and drought tolerance might have contributed to its tolerance to the heavy periods of grazing. The abundance of the rest of the grasses in both increaser and decreaser groups was not affected by grazing system as observed by Teague (2004). Manley et al. (1997) concluded that, rotational grazing does not improve range condition or increase grass or forbs standing crop, at the same or higher stocking rates, compared with continuous grazing. Similarly, Taylor et al. (1997) concluded that rotational grazing was not able to sustain initial species composition and abundance at any stocking rate tested.

*U. mosambicensis* increased in continuously grazed sites, probably a result of higher stocking rates and overgrazing. An increase of forbs in continuous grazing treatments suggest that, the constant high grazing pressure and selection resulted in decreased abundance of most decreasers and perennial grass species, therefore rendering a competitive advantage to forbs. This is similar to results obtained by Hayes and Holl (2003), who found that constant heavy grazing, increased the abundance of forbs in mesic grasslands of California. However, a study by Gillen and Sims (2005) in Oklahoma sand sagebrush-grassland indicated that, climate had a bigger impact on veld condition than grazing treatments.

Non-selection of the less palatable *C. plurinodis* in continuously grazed sites might have resulted in its high abundance. The above average annual rainfall received in 1996 might have indirectly caused the observed increase in the abundance of *A. barbicollis*, *C. plurinodis*, *E. superba* and *S. incrassata* in rotationally grazed paddocks. In addition, the 1992 drought may have had an ‘equalizing effect’ on species which had no difference in abundance in the two grazing systems. It is suggested that in a year of below-average rainfall, the differently grazed paddocks would all experience little or no herbage production. With above-average rain, minor changes in species abundance would be due to the inherent variability between sites differing in persistent seed banks (Oba et al., 2000).

The fact that little change in abundance was evident in most of the species suggests that, in certain areas, semi-arid savanna grasslands are resistant to grazing-induced change (Fynn and O`Connor, 2000). It has been suggested that semi-arid grasslands, with a long evolutionary history of grazing, have greater resistance to composition or abundance change than grasslands with a short evolutionary history of grazing (Milchunas et al., 1988). The results might not precisely predict responses in communal areas, since selective grazers (goats, sheep and donkeys) were not included in the trial. In addition, the impact of human influences was also not captured.

## Conclusion

Introduction of a rotational grazing system in communal areas to improve range condition and animal performance is difficult because of its rigid implementation in heterogeneous grazing areas. It is well known that stocking rate has a significant effect on both range condition and animal performance. However where rotational grazing schemes have been implemented in communal areas, it has been difficult to control stocking rates.

Livestock grazing rangelands in a resilient, stable or climax state, do not seem to benefit from rotational grazing. Even after a drought or during below-average rainfall years, highly stocked rotational grazing systems do not seem to support better livestock gains or the assumed benefits of rotation on forage production and availability. In the contrary, higher cattle performance under continuous grazing appears to confirm its relevancy in communal areas. Studies on continuous grazing can be utilized together with other grazing strategies in heterogeneous areas and could therefore be of big value in the management of communal grazing areas. It is concluded that rotational grazing schemes can only be successfully introduced in communal areas, after appropriate stocking rate levels have been determined. Therefore, use of continuous grazing currently remains the most practical method of range use in communal areas.

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