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Full Length Research Paper

Influence of stocking rate on herbage production, steers livemass gain and carcass price on semi-arid sweet bushveld in Southern Botswana

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The influence of stocking rate on vegetation and animal performance was investigated over a period of 15 years in the Semi-arid Sweet Bushveld of Southern Botswana. The objective of the study was to establish an appropriate stocking rate for the area and evaluate the relationship between animal performance and the available herbage. The trial compared steers grazing at 2, 4, 6, 8, 10 and 12 ha per livestock unit and a non-grazing area. Herbage yield, steer live mass gain and carcass price were the responses measured. Herbage yield was collected from randomly clipped quadrats at the end each growing season. Grass species were grouped according to nutritive value as good, intermediate and poor. The trial was restocked each year with 18-months steers. Steer were weighed at monthly intervals and were slaughtered at the end of the grazing year where carcasses were graded and given a price. Forage yield of good and poor grasses increased and decreased, respectively with decreasing stocking rate. The yield of intermediate grasses increased at heavy grazing and declined at lower stocking rates due to competition from more productive perennial grasses. Live mass gain of individual steers increased with decreasing in stocking rates. Steers at 8 ha lsu^{-1} gained almost similar to those in 10 and 12 ha lsu^{-1} at the expense of the good grasses suggesting that range deterioration may progress for a considerable time before the change is reflected in animal condition. Therefore herbage condition is more sensitive indicator of range deterioration than the condition of the grazing animals. Mean annual livemass gain of approximately 100 kg or more can be achieved on Semi-arid Bushveld with only phosphorus supplementary feeding at 8 ha lsu^{-1} or lower stocking rates. Annual livemass gains for individual steers varied considerably from year to year suggesting flexible stocking rates between 8 - 10 ha lsu^{-1} could be applied depending on rainfall amount. Optimum stocking rate on the basis of good grass species is 10 ha lsu^{-1} for the Semi-arid Sweet bushveld.

Key words: Semi-arid sweet bushveld, grazing, herbage yield, hectares per livestock, stocking rate, livemass gain.

INTRODUCTION

The rate at which rangeland is stocked is probably the single most important management factor affecting animal performance and profitability of a rancher (Holecheck et al., 2001; Stoddart et al., 1975; Tainton, 1999). It is one of the variables that are under the manager's direct control. Forage production studies in North America averaged 23% higher under moderate than heavy grazing and 36% higher under light than heavy grazing (Van Pollen and Lacey, 1979). Excessive stocking increases the probability of forage deficits and negatively influence the financial viability of the enterprise (Hatch and Tainton, 1995).

Rangeland degradation is widespread in the semi-arid savannas of Africa, and to increase animal production

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Table 1. List of grass species according to their nutritive value categories.

Good Grasses	Intermediate grasses	Poor grasses
Panicum maximum	*Eragrostis rigidior*	*Melinis repens*
Schmidtia pappophoroides	*E. lehmanniana*	*Pogonanthra qurossa*
Anthephora pubescence	*E. pillosa*	*Eragrostis pallens*
Bracharia nigropedata	*Chloris virgata*	*Tragus racemosum*
Eragrostis supeba	*Eragrostis supeba*	*Aristida graciliflora*
Digitaria eriantha	*Fingerhuthia africana*	*Stipagrostis uniplumis*
Panicum coloratum	*Cymbopogon excavators*	*Perotis petans*
Eragrostis supeba		
Urochloa trichopus		

would entail the application of appropriate stocking rates, based on knowledge of carrying capacity in the poorer seasons (Barnes, 1979). In semi-arid environments rangeland productivity, and hence carrying capacity, is closely related to rainfall and other climatic factors (Barnes, 1979). Rainfall in these areas fluctuates widely from year to year and thus information on stocking rates needs to be built up over several years. Livestock production in Botswana is being severely affected by recurring droughts (Anon, 2001). Barnes (1979) indicated that a stocking rate at which adequate grazing is available in seasons of low herbage production is essential for ecological and economical stability of a ranch enterprise. Under this practice the range is not overstocked even in fairly severe drought. However, supplemental feeding is necessary at intermediate and heavy stocking rates especially in winter (Hatch and Tainton, 1995; Tacheba and Mphinyane, 1993). As stocking rate affects animal diet selection, it therefore affects the amount of minerals consumed.

Barnes and Denny (1991), Tacheba and Mphinyane (1993) and Timberlake (1994) demonstrated high linear relationships between livemass gain and stocking rate under continuous grazing. However, Barnes and Denny (1991) pointed out that this relationship did not exist under rotational grazing systems. Tacheba and Mphinyane (1993) further showed that herbage yield of *Panicum maximum* and *Eragrostis rigidior* increased with decreased stocking rate as compared to grasses such as *Digitaria eriantha* and other minor species. The importance of stocking rate was also demonstrated by Bransby (1990), where average daily gain and herbage height had a regression relationship of 0.95 and 0.82, respectively, from a kikuyu pasture fertilized with nitrogen.

An appropriate stocking rate minimizes invasion of noxious plants, some of which may be poisonous to livestock. The Molopo area (Donaldson, 1969), Olifants Drift area (van Vegten, 1983), and many others in Botswana are known to have been invaded by woody plant thickets. In simulation experiments, Jeltsch et al. 1997) found that shrub cover increased with increased stocking rate. And this increase was more distinct under mesic than xeric rainfall scenarios. Poisonous plants become a problem as grazing become scarce because animals become less selective and eat plants of poor quality, some of which may be poisonous. The purpose of this study was to establish an appropriate stocking rate for the Semi- arid Sweet Bushveld vegetation type and to evaluate the animal performance as related to available herbage in Southern Botswana.

MATERIALS AND METHODS

The trial was conducted in Masiatilodi ranch located in Southern Botswana, approximately 24.00'°South and 25.00'°East. The soils are classified as arenosol, deep, and somewhat excessively drained (Anon, 1990). The texture is fine sand to loamy fine and run-off is non-existent. The vegetation type consists of Semi-arid Sweet Bushveld of the Sandveld (Weare and Yalala, 1970). The major woody species consists of Terminalia sericea, Acacia erioloba, Acacia fleckii, Grewia flava, and Tarchonanthus camphoratus. The grass component is composed of Schmidtia pappophoroides, Anthephora pubescens, Digitaria eriantha, Eragrostis lehmanniana, Eragrostis pallens, and Stipagrostis uniplumis. Various families of forbs also exist. Annual rainfall averages 475 mm of which 90% falls between October and March (Anon, 1990).

Steers were grazed at six stocking rates of 2, 4, 6, 8, 10 and 12 ha per livestock unit (lsu^{-1}) and a non-grazing area starting from 1988 through 2001. Stocking rate treatments were not replicated. The non-grazing area was lightly grazed at the end of the dry season to reduce accumulation of moribund material. Herbage yield was determined each year through clipping thirty $1m^2$ quadrats which were randomly located in each stocking rate. Herbage samples were collected at the end of the growing season. Grass species were grouped according to nutritive value as good, intermediate and poor. These categories were based on the crude protein content and digestibility of the grass species (Field, 1975). Forbs were lumped separately. Samples were oven dried and weighed, to determine dry matter content. The values were then converted to kg ha^{-1}. A list of grass species included in each category is shown in Table 1.

Steers of 18-months old entered the paddock treatments in October and grazed continuously for one year and replaced with a new batch. Only phosphorus was supplemented to all treatments ad lib except during the rainy periods. Steers were weighed at monthly interval after an over-night fasting. At the end of each grazing year, steers were slaughtered where carcasses were graded and given a price. Livemass gain and carcass price were used to evaluate animal performance. Rainfall amounts were recorded using the standard rain gauge throughout the study period. The

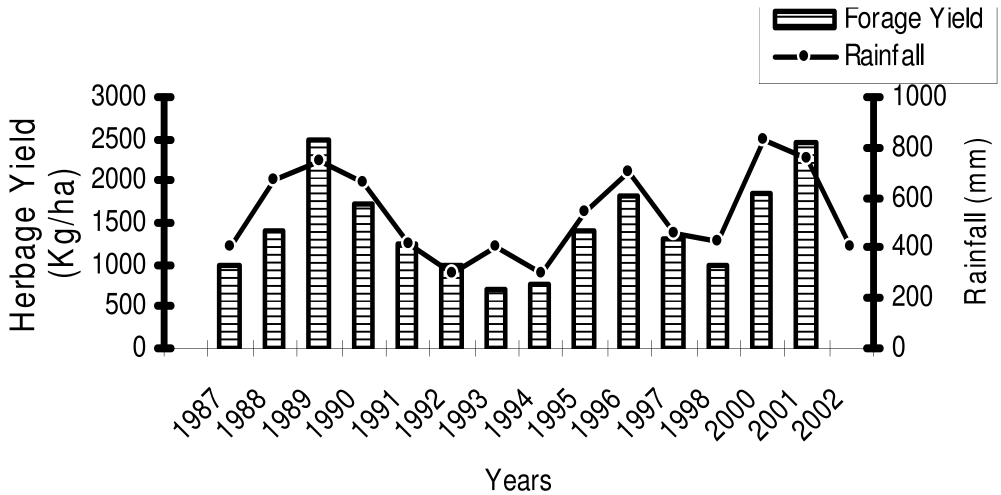

Figure 1. Annual rainfall and herbage production at Masiatilodi Research Station from 1987 to 2002.

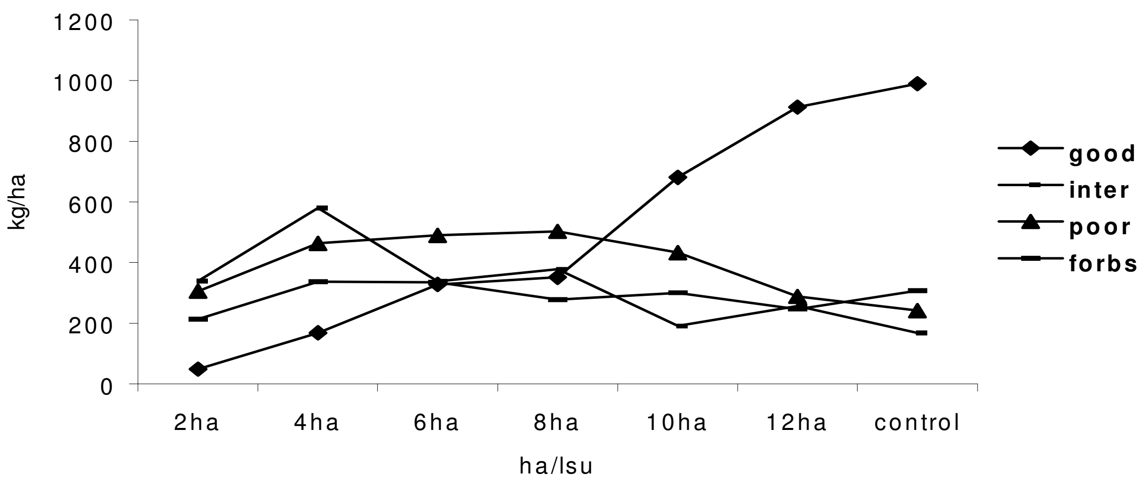

Figure 2. Herbage production (kg ha^{-1}) of herbaceous plants at each stocking rate at Masiatilodi Research Station.

main effects of stocking rate on forage dry matter yield, livemass gain, and carcass price were determined using General Linear Model of the SAS program (SAS, 1996). Where differences were significant at the 5% level, Scheffe's test was used to separate the means.

RESULTS

Annual rainfall and herbage production

Annual rainfall and herbage production from 1987 to 2002 at Masiatilodi Research Station are presented in figure 1. Rainfall amount was 46 and 85% above average for 1988 and 2001, respectively. Total rainfall in 1993 and 1994 was critical poor, averaging 42 and 41% below average and inevitable plant growth was retarded. Herbage production recorded around 760 kg ha^{-1} for both 1993 and 1994, while production in 1989 and 2001 was around 2450 kg ha^{-1}.

Effect of stocking rate on herbage production

Herbage production of good grass species increased with decreasing stocking rate and was always highest in the 12 ha lsu^{-1} and the control area (Figure 2). Traces of good grasses were produced in the 2 ha lsu^{-1}. There was, however, lack of significant (P>0.05) difference bet-ween 6 and 8 ha lsu $^{-1}$ but the difference occurred bet-ween 8 and 10 ha lsu^{-1}. The increase in good grass spe-cies from 12 ha lsu^{-1} to the control area was insignificant (P>0.05). The intermediate grass species increased up to 4 ha lsu^{-1}, and then declined. This category of grass spe-cies is known to increase with reduction of grazing pres-sure up to middle stocking rates and then decrease due to competition of good grass species. The trend for poor

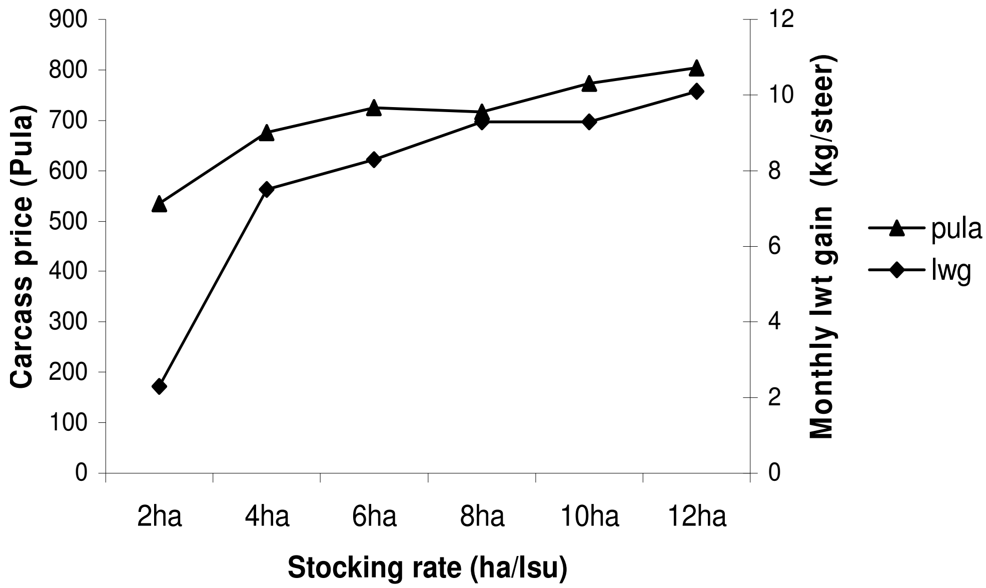

Figure 3. Average livemass gain (kg/steer/month) and carcass price (Pula/steer) in Masiatilodi ranch.

grass species also increased up to 4 ha lsu^{-1} and remained stable (P>0.05) until 8 halsu^{-1}, and then made a significant (P<0.05) fall thereafter. The trend of the forbs category was similar to that of intermediate grass species, but trailed below the grass categories except for the good grasses which were very low at 2 and 4 ha lsu^{-1}.

Effect of stocking rate on steer livemass gain

Mean monthly livemass gain and price per individual steer is presented in Figure 3. Livemass gain of individual steers increased with decreasing in stocking rates. The monthly mean livemass gain of stocking rate at 2 ha lsu^{-1} was around 2 kg per steer. There was significant (P < 0.001) difference in livemass gain between stocking rate of 2 and 4 ha lsu^{-1} compared to other differences between adjacent lighter stocking rates. High monthly livemass gain of 10 – 12 kg per steer were attained starting at 8 ha lsu^{-1} and lower stocking rates. Steers in the 8 ha lsu^{-1}, however, gained almost similar (P>0.05) livemass to those at 10 and 12 ha lsu^{-1}. At stocking rate of 2 ha lsu^{-1} steers had to be removed or fed to avoid mortality during the drought years. While at stocking rate of 4 ha lsu^{-1} no removal of steers or feeding was necessary except in consecutive drought years.

Effect of stocking rate on carcass price

Carcass price followed the same trend as that of livemass gain (Figure 3). The low price at 2 ha lsu^{-1} was accounted for by low gains which were attained. There was, however, no significant (P>0.05) fall in price of individual steers at 8 ha lsu^{-1}. The difference in carcass price between 10 and 12 ha lsu^{-1} was not significant (P>0.05) either.

Steer growth patterns

Figure 4 presents three selected stocking rates (2, 6 and 10 ha lsu^{-1}) from the trial to demonstrate the growth pattern of steers as influenced by the amount of annual rainfall or available herbage. Annual livemass gain for individual steers varied considerably from year to year for all treatments. Annual rainfall in 1988, 1989 and 2001 grazing periods was above average and recorded 746 mm, 669 mm and 891 mm, respectively. Individual steers attained high livemass gain with little difference between the 6 and 10 ha lsu^{-1} more especially during the growing seasons as a result of more rainfall (Figure 4). However, in 1993 and 1994 livemass gains attained were lower and the differences between each stocking rate gain widened as the season advanced due to declined available herbage.

Rainfall recorded during 1993 and 1994 was 214 mm and 309 mm, respectively, and as a result, individual steers attained 370 kg or below for each treatment. Livemass gain during the dry seasons of the drought years decreased with increasing stocking rate. The mean mass attained for individual steers was 277 kg at the 2 ha lsu^{-1} during 1993. The magnitude of gain between the 2 ha lsu^{-1} and the 6 or 10 ha lsu^{-1} was wide. Steers in the heavy treatment would loss weight faster especially during the last two months of the dry season of below average rainall resulting in destocking the trial. At the beginning of the

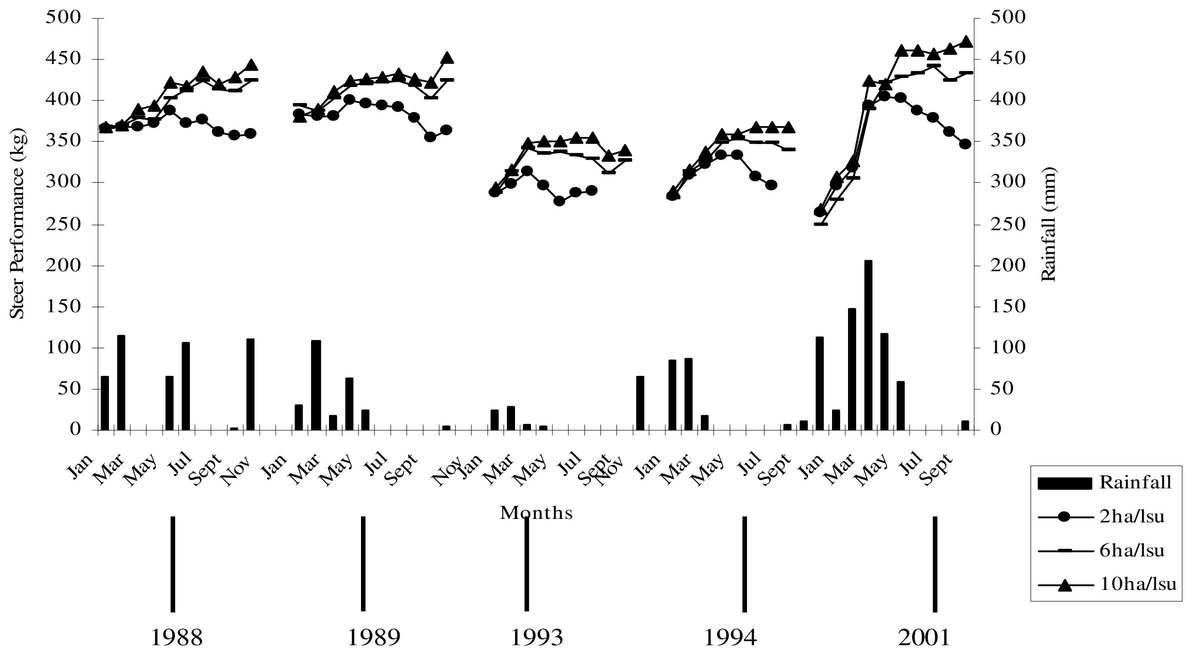

Figure 4. Pattern of steer performance (kg) at selected stocking rates over years of different rainfall.

grazing season livemass of all treatments uniformly clustered together and increase as the season advanced. However, at the end of the growing season, steers in the moderate or lower stocking rates continued to maintain or slightly gained, while those in heavily grazed paddocks lost weight (Figure 4). Individual steers would loss up to 10 kg per month from their peak mass gain during the drought periods.

Figure 5 illustrates the individual animal livemass gain as they related to the poor and good herbage categories at each stocking rate. Poor grasses dominated heavily grazed treatments while lightly grazed treatments were dominated by good grasses.

The stocking rate at 8 ha lsu^{-1} was at the minimum point were deterioration of good grasses occur and stocking rates higher than this point, started to be dominated by poor grasses. Mean monthly livemass gain of approximately 10 – 12 kg were achieved at 8 ha lsu^{-1} or lower stocking rates without supplementary feeding except phosphorus on Semi-arid Sweet Bushveld (Figure 5).

DISCUSSION

The reduction of individual steer performance may be ascribed to reduced herbage availability which was not maintained as stocking rates increased and/or a stocking rate induced change to less palatable (good grasses) and productive plant species. The high level of dry matter yield in 1989, 1989 and 2001 was accounted for by the preceding years of above average rainfall. Steers under heavy stocking were more susceptible to the effects of drought and generally had a significantly shorter grazing season.

Though steer performance was reasonably good at 8 ha lsu^{-1}, this occurred at the expense of the good grass species and this suggested, however, that range deterioration may progress for considerable period before the change is reflected in livestock condition. The condition of good grasses is, therefore, more sensitive indicator of range deterioration than the performance of livestock. Steer livemass gains at different stocking rates uniformly clustered together during the early growing season due to ample forage usually available during the early growing season.

Stocking the rangeland at 2 or 4 ha lsu^{-1} reduced herbage yield due to the greater forage demand while higher yields at 10 and 12 ha lsu^{-1} occurred due to less forage demand. The slight increase of good grasses from 12 ha lsu^{-1} to the control suggest that stocking this rangeland at 12 ha lsu^{-1} or less would under-utilize the good grass species. Grazing the Semi-arid Sweet bushveld vegetation at 10 ha lsu^{-1} maintains satisfactory proportion of good grass category. Since animals at 8 ha lsu^{-1} gained almost similar to those in 10 and 12 ha lsu^{-1} on the expense of the good grass species; suggests that stocking this rangeland at 8 ha lsu^{-1} may be appropriate during periods of above average rainfall because more herbage production would be expected. There appears to be a threshold stocking rate above which range deterioration occurs. For example steer performance remained almost constant at stocking rates less than 8 ha lsu^{-1} but declined above this level. This suggested that a range of stocking rates may be applied without causing range degradation provided the critical stocking rate for that particular vegetation is not exceeded. Range condition ap pears to be more dependent upon level of stoking. Based

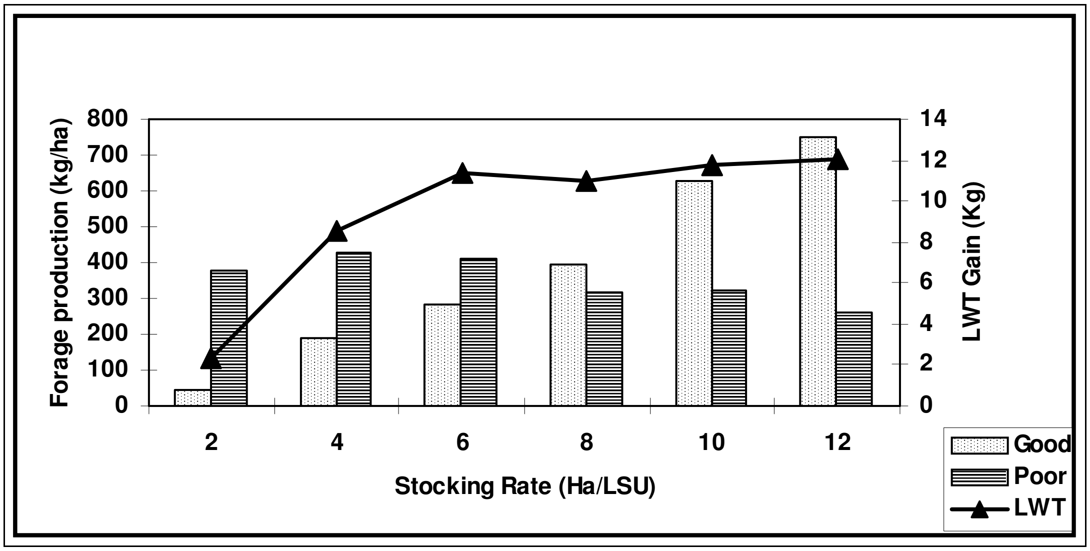

Figure 5. Relationship between monthly live-mass gain of individual steers and herbage yield from two grass categories as influenced by stocking rate.

on the effects of stocking rate on vegetation production, these data revealed the animal responses as they related to the kg ha^{-1} of herbage that was available at the time of the study.

These results concur with those of Turner and Tainton (1989) who reported herbage yield increase of about 142 kg ha^{-1} for each 0.1 lsu ha^{-1} decrease in stocking rate depending on a particular range condition. The report further noted that information on seasonal animal performance at different stocking rates will permit objective planning of a beef production enterprise. For example, if animal mass gains and the patterns of those gains through the season are known, estimation of finishing periods would be facilitated, or period for which mineral supplements or conserved feed should be provided to obtain maximum benefit from the rangeland could be optimized. Thus, knowledge of the role of supplemental feeding can sustain weight and lives of livestock. Little difference was observed in steer gains between stocking rates during the early growing season and not necessary to feed animals because ample forage of sufficient quality was usually available (Mphinyane and Rethman, 2003). However, during the dry seasons, more especially during drought years, steers at 2 ha lsu^{-1} had to be removed from the treatments before the end of the grazing cycle due to insufficient herbage.

Du Pisani et al. (1987) reported that herbage yield from dryland *Cenchrus cilliaris* pasture increased with decrease with stocking rate. They further pointed that animals in high and medium stocking rate were not able to complete the grazing cycle in years of below average rainfall, a scenario observed in this study, where animals in 2 ha lsu^{-1} became emaciated and However, supplemental feeding is necessary at intermediate and heavy stocking rates especially in winter (Hatch and Tainton, 1995; Tacheba and Mphinyane, 1993). As stocking rate affects animal diet selection, it therefore affects the amount of minerals consumed had to be removed or fed before end of the grazing cycle. Mpiti-Shakhane et al. (2002a) recorded 643 kg ha^{-1} and 630 kg ha^{-1} for light and medium stocking rates, respectively, above heavy stocking rate in a one-year study.

Conclusions

Optimum stocking rate on the basis of grasses of economic importance (good grass category) is 10 ha lsu^{-1} for the Semi-arid Sweet bushveld of Southern Botswana. However, during years of above average rainfall, stocking rates can be increased to 8 ha lsu^{-1}. Mean annual livemass gain of approximately 100 kg or more can be achieved on Semi-arid Bushveld with only phosphorus supplementary feeding at 8 ha lsu^{-1} or lower stocking rates. Steers at 8 ha lsu^{-1} gained similar livemass compared to those at 10 or 12 ha lsu^{-1} but on the expense of the good grass category. Animals can display a good performance condition while the range condition is undergoing deterioration, implying that herbage condition is more sensitive indicator of range deterioration than the grazing animal. Stocking rate is a major determinant of both range condition and animal performance and it is an important management variable under the control of the manager. Flexible stocking rates should be considered in grazing management because rainfall in semi-arid areas fluctuates widely from year to year resulting in significant variation in herbage yield. This study typically demonstrated the abundance of good perennial grasses decline while the proportion of poor grasses increases with the increase in stocking rate.

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