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EVALUATION OF VELD POTENTIAL IN EAST GRIQUALAND USING BEEF CATTLE UNDER TWO GRAZING MANAGEMENT SYSTEMS

EVALUASIE VAN VELD POTENSIAAL IN GRIKWALAND-OOS DEUR VLEISBEESTE ONDER TWEE BEWEIDINGSBESTUURSSTELSELS TE GEBRUIK

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ABSTRACT

Beef production from veld, in the short term, was found to be greater under a continuous grazing system than under a rotational grazing system. Average daily gains decreased from a maximum in late-spring and the highest three-year mean value was 0,5 kg/animal/day. Livemass gains/ha were highest at a stocking rate of 2,2 animals/ha and were 131,4 kg/ha under continuous grazing and 88,6 kg/ha under rotational grazing. Estimated mean maximum gains/ha were 0,78 kg/ha/day at a stocking rate of 2,5 animals/ha under continuous grazing and 0,55 kg/ha/day at a stocking rate of 1,7 animals/ha under rotational grazing. However, optimum economic stocking rates were estimated to occur below those where beef production/ha was maximum.

UITTREKSEL

Daar is gevind dat vleisproduksie vanaf veld, oor 'n kort-termyn, hoër was met aanhoudende- as met 'n wisselwidingsstelsel. Gemiddelde daaglikse toenames het afgeneem vanaf 'n maksimum in laat-lente en die hoogste drie jaar gemiddelde waarde was 0,5 kg/dier/dag. Vleisbees toenames/ha was die hoogste by 'n veebelading van 2,2 diere/ha en was 131,4 kg/ha onder aanhoudende- en 88,6 kg/ha onder wisselbeweiding. Geskatte gemiddelde maksimum toenames/ha was 0,78 kg/ha/dag by 'n veebelading van 2,5 diere/ha onder aanhoudende beweiding en 0,55 kg/ha/dag by 'n veebelading van 1,7 diere/ha onder wisselbeweiding. Optimum ekonomiese veebeladings is egter geskat laer as dié te wees waarby vleisproduksie/ha 'n maksimum was.

Additional index words: Continuous grazing, optimum stocking rate, rotational grazing, stocking rate.

INTRODUCTION

It has been estimated that approximately 90% of the mean gross farm income in the Mt. Currie area of East Griqualand is derived from cattle and sheep enterprises which depend predominantly on veld for three main reasons. These are the widespread occurrence of low potential soils, only 20% of the area being arable, the relative low rainfall (750mm/anum at the Kokstad Research Station), and the lack of abundant water resources for irrigation. In attempting to maximise profitability it is imperative that the productivity of the veld be characterised, particularly with respect to stocking rate (SR).

The objectives of the trial were, therefore, firstly to determine how production per animal and production/ha varied with SR under continuous and rotational grazing management systems. Secondly, an attempt has been made to determine optimum SR's for each management system both in terms of maximum production/ha and maximum profitability.

Stocking rate is considered to be the most important single factor in grazing management affecting the productivity of grazing animals (Edwards, 1980). The simplest and most useful model defining the relationship between SR and performance of grazing animals is that proposed by Jones & Sandland (1974), which postulates a linear relationship between average daily gain (ADG) and SR over a wide range of SR's.

Grazing method is a second factor which influences the conversion of herbage to animal products (McMeekan & Walshe, 1963). The continuous grazing system is free of management variables and thus enables an uncompounded evaluation of the inherent production pattern of veld at any given time. However, rotational grazing systems have many advantages in controlling grazing patterns and thus facilitate maintenance of long term veld condition. Rennie (1975) has shown in East Griqualand that well-managed multi-camp systems can contribute materially to sustained high levels of red meat production. Booysen, Tainton & Foran (1975) have indicated that each of these grazing systems would be expected to have its own optimum SR.

PROCEDURE

The experiment was sited at the Kokstad Research Station in Bio-climatic subregion 4f, the drier phase of the highland sourveld (Phillips, 1973). The veld is classified as Veld Type 56 — Highland Sourveld to *Cymbopogon-Themeda* veld transition (Acocks, 1975). The veld condition was assessed during the 1977/78 rest year and again in 1981/82. No significant differences existed between treatments at each assessment or between assessments. The veld was in fairly good condition, having a mean score of 64 based on the quantitative climax method (Foran, 1976). The soil was of the Newport and Southwold series (MacVicar, De Villiers, Loxton, Verster, Lambrechts, Merryweather, le Roux, Van Rooyen & Harmse, 1977). These series are common throughout the subregion.

Rainfall and mean temperatures recorded during the periods of grazing in 1975/76, 1976/77 and 1978/79 are presented in Table 1.

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TABLE 1. *Rainfall (mm) and mean temperature (°C) recorded at Kokstad Research Station from September to April over three seasons.*

Year	Period								Total	
	Sept./Oct.		Nov./Dec.		Jan./Feb.		Mar./Apr.		Sept. to Apr.	
	rain	temp	rain	temp	rain	temp	rain	temp	rain	temp
1975/76	112	14,6	392	16,3	396	18,2	290	16,0	1 190	16,24
1976/77	139	14,5	193	17,6	282	19,7	118	16,2	732	17,00
1978/79	132	13,4	203	17,6	236	19,4	143	17,0	714	16,86
30 year mean	111	14,6	198	17,5	244	19,1	151	16,5	704	16,90

In the 1975/76 September to April period the rainfall was 69% higher than the mean rainfall of 704 mm for this period of the year, but during the 1976/77 and 1978/79 seasons rainfall very closely approximated the mean. The three-year rainfall was 25% higher than the long-term mean. Temperatures did not differ substantially from the mean in any season.

Experimental treatments

The experiment consisted of five unreplicated treatments (four in the 1975/76 season). Continuous and rotational grazing systems were compared at light and heavy SR's using the variable (put-and-take) stocking method, in an attempt to maintain predetermined levels of herbage availability. This was achieved by stocking to maintain disc heights of 9 cm and 6 cm in the light and heavy stocking rate treatments under continuous grazing, and an average (over all camps) of a disc height of 9 cm and 6 cm in the light and heavy rotationally grazed treatments. The treatments were thus continuous grazing low SR (CL), continuous grazing high SR (CH), rotational grazing low SR (RL) and rotational grazing high stocking rate (RH). From 1976/77 onwards an intermediate SR treatment was added under continuous grazing (CM).

Animals used were Hereford or Hereford x Simmentaler yearling heifers and steers which at the beginning of the grazing season had a mean mass of 246 kg in 1975/76, 226 kg in 1976/77 and 179 kg in 1978/79. In the 1975/76 season six tester animals were used in each treatment. In the subsequent seasons eight testers were used. Animals similar to the testers were used as fillers. All animals were weighed at fortnightly intervals.

The rotational grazing treatments were based on a six-paddock system with a cycle of one week grazing and five weeks rest in each paddock. Grazing commenced simultaneously on all treatments when there was sufficient spring growth for grazing in each camp and was also terminated simultaneously, when consecutive mass losses were recorded over two weighing in any of the treatments, except when this occurred prior to mid-March. All camps were given a full year's rest during the 1977/78 season, during which time veld assessments were carried out. The veld was burned in mid-August of 1978.

Attention must be drawn to the fact that the two areas used for continuous and rotational grazing treatments were previously subject to different treatments. Any comparison of the two systems must, therefore, be tentative, despite similarities in veld condition scores, as there might have been confounding residual effects from the previous treatments.

The results to be presented in this paper are based on animal performance in the grazing trial and economic analyses based on current economic conditions. Furthermore, less attention is given to the CM treatment than the extreme treatments under both grazing systems, except where results obtained from the CH and CM treatments are considerably different.

RESULTS AND DISCUSSIONS

Animal production

1. Average daily gain

Individual animal performance, expressed as ADG, fluctuated under all treatments throughout any given season. To show generalised patterns of ADG more clearly smoothed curves were derived from five-point running mean ADG's, from these values three-year means were obtained for each grazing system at the low and high SR's. Figure 1 illustrates changes in three year mean ADG's as well as the range of ADG's recorded during this period. Table 2 includes maximum, minimum and mean values of the mean curves presented in Figure 1.

Generally, ADG was maximal in late-spring (mid-November), decreasing gradually to a minimum during

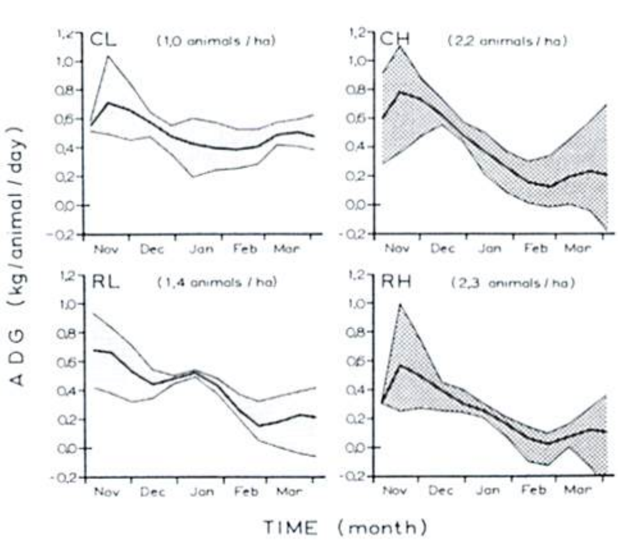

FIG. 1 *Intra-seasonal mean Average daily gain (ADG) variations and inter-seasonal range in ADG's over the three year trial period.*

late-summer/early-autumn (February) and subsequently increasing to a secondary peak in mid-autumn (March). In the RL treatment there was, however, an intermediate peak in summer (early January), which is difficult to explain. This pattern is similar to that described by Brockett, Gray & Lyle (1982) for steers grazing an *Eragrostis curvula* pasture in the same area.

Interseasonal variation in ADG was greatest at the beginning and end of the season and least during the mid-

TABLE 2. *Maximum, minimum and three-year mean ADG's based on smoothed data for continuous and rotational grazing management systems at low and high SR's.*

	ADG — kg/animal/day			
	Continuous		Rotational	
Season	CL 1,0 animals/ha	CH 2,2 animals/ha	RL 1,4 animals/ha	RH 2,3 animals/ha
maximum (mid-November)	0,71	0,78	0,68	0,57
minimum (February)	0,38	0,12	0,15	0,02
mean (Nov-March)	0,50	0,39	0,40	0,24

summer period. From this it would appear that forage quality, and not forage availability, largely determine animal performance. The CL treatment shows least interseasonal variation in ADG, probably because this treatment provided the maximum opportunity for selection so that poor forage quality was less of a limitation on performance in this treatment than in those in which there was limited opportunity for selection. This lack of variation tends to support the conclusion reached above.

From Table 2 it is evident that the CL treatment resulted in the greatest ADG's, giving a mean of 0,5 kg/animal/day. Furthermore, SR had a marginally greater effect on ADG than did management system. The mean ADG's for the RL and CH were 0,40 and 0,39 kg/animal/day respectively. This suggests that animal performance was not determined by SR to the degree that might have been expected.

2. Production per hectare

Animal production/ha is presented for each grazing season in Figure 2, which also illustrates three-year mean linear regressions for each treatment. The corresponding regression equations and regression coefficients are presented in Table 3, which also shows calculated three-year mean maximum gains per/ha and the mean number of days to these maxima.

The regression coefficients are highly significant, indicating good fits of the linear regressions to the corresponding data, although the 1975/76 data indicate that a quadratic fit might be more realistic. It is evident from the three-year mean regressions (Figure 2) and the mean maximum gains/ha (Table 3) that under both grazing systems the higher SR treatments out-performed the lower SR's, although such superiority was not obvious under rotational grazing. Furthermore, continuous grazing was superior to rotational grazing at the higher SR's but the same difference was not evident at the low SR's.

Higher animal production on veld under continuous, as compared with rotational grazing, has commonly been recorded (Foran, 1974), although the reasons for this are not clearly understood. The opportunity given to animals to select a diet of higher quality than the average, and the reduced social disturbance of animals under continuous compared with rotational grazing, may be largely responsible for this (Foran 1974). The lack of any difference between the two low SR treatments in the two grazing systems, however, suggests that social disturbance was not a factor, and differences in animal performance were, therefore, due to differences in opportunity for selection. Greater difference might have been expected between the two systems at the lower SR's, where opportunity for selection in the continuous system is maximised, while at the higher SR's the lower selection capabilities (due to greater grazing pressure) should have resulted in less difference between the two systems.

Data for each grazing season indicate that maximum gain/ha was generally attained at the end of the grazing period, except during the 1975/76 season, when there

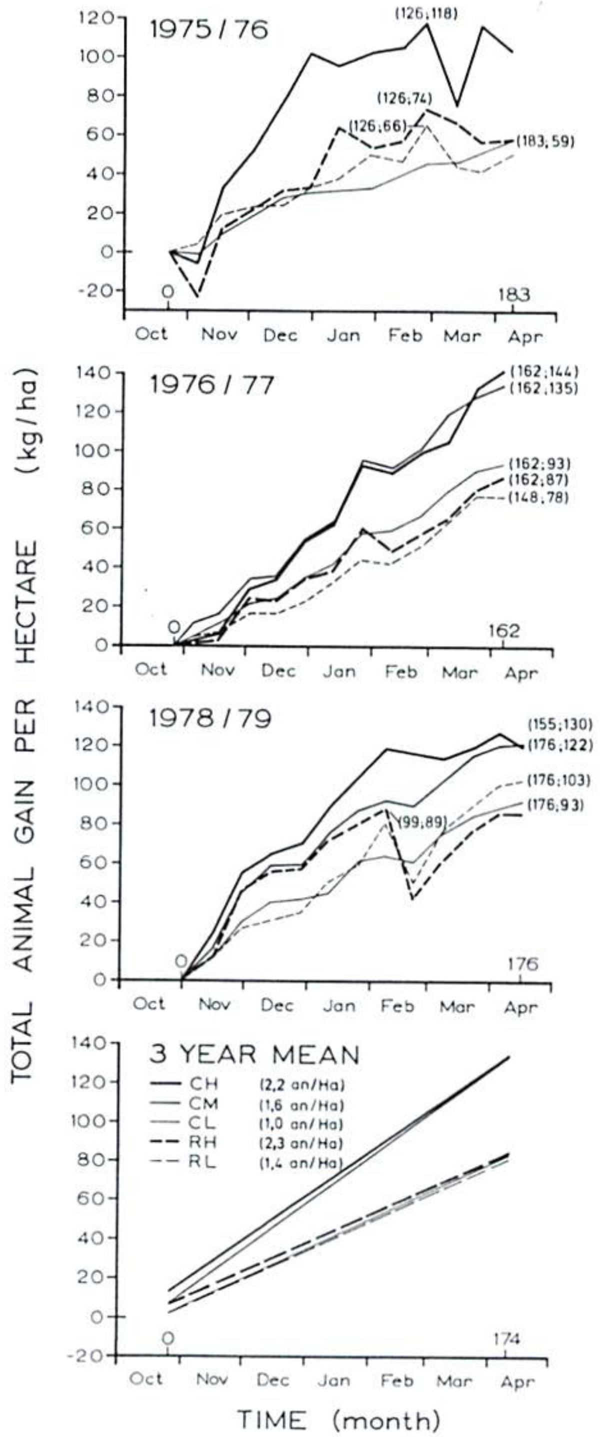

FIG. 2. *Seasonal accumulative animal gain/ha and three-year mean linear regressions for continuous grazing at low, intermediate and high stocking rates (CL, CM and CH respectively and for rotational grazing at low and high stocking rates (RL and RH respectively). Parenthesised figures indicate days to maximum gain per hectare followed by actual maximum gain per hectare for each treatment.*

Table 3. *Linear regressions fitted to animal gain per hectare per day, mean maximum gain per hectare (kg/ha) and mean number of days to mean maximum gain per hectare.*

Treatment	Linear regression (T = number of days)	regression coefficient (r)	Mean max. gain/ha	Mean days to mean max. gain/ha
CL	Gain = - 9,79 + 0,489 T	0,921	82,65	174
CM	Gain = -12,30 + 0,766 T	0,974	128,95	169
CH	Gain = - 5,73 + 0,745 T	0,910	131,40	148
RL	Gain = -10,50 + 0,477 T	0,902	81,75	150
RH	Gain = - 5,83 + 0,475 T	0,857	88,60	129

CM = continuous grazing intermediate stocking rate; for CL, CH, and RH see table 2.

was a production decline after the end of February in all except the CL treatment (Figure 2). From Table 3 it is, however, apparent that on average, animals continued to gain longer into the autumn at low SR's than at high SR's.

Optimum stocking rates

1. Optimum stocking rate for production (OPSR)

On the assumption that ADG and SR have a linear relationship (Jones & Sandland, 1974), ADG and animal gain per hectare can be estimated over a range of stocking rates from a limited number of observed ADG and SR values. Figure 3 presents such estimates for continuous and rotational grazing systems based on observed values for each grazing season.

In considering these estimates the following points should be borne in mind. Firstly, the assumption of linearity over all SR's may be invalid, particularly at the low and high SR extremes. Secondly, any extrapolation of mathematical relationships beyond the range of observed values must be treated with considerable caution. The observed SR's do not in all cases straddle the SR at which animal gain/ha is calculated to be at its maximum (OPSR). In particular, the OPSR for continuous grazing during the 1976/77 season, (Figure 3b) appears to be an unrealistic extrapolation. This high OPSR and the corresponding high maximum gain per hectare value it gives rise to, affect the three-year mean values for continuous grazing considerably. These must, therefore, be viewed with reservation.

In terms of individual animal performance (ADG), (Figure 3a) in the 1975/76 season, rotational grazing was superior to continuous grazing at SR's below 1,25 animals/ha, while at higher SR's the relationship between the systems was reversed. In 1976/77 (Figure 3b) continuous grazing was superior at all SR's while in 1978/79 there was little difference between the two systems. The three-year mean (Figure 3d) shows that, except at the lowest SR's, continuous grazing resulted in the better ADG's than did rotational grazing at all SR's and increasingly so with increasing SR.

In Figure 3, numbers parenthesised along the vertical axes indicate the maximum possible ADG's assuming a linear relationship between ADG and SR, while figures parenthesised in the body of the diagrams represent the estimated maximum animal gains/ha/day preceeded by the OPSR.

From the three-year mean values (Figure 3d) continuous grazing appears to lead to greater animal gain/ha than does rotational grazing, while the corresponding OPSR is higher than under rotational grazing. The comparative figures are: OPSR of 2,5 and 1,7 animals/ha, respectively, for continuous and rotational grazing and correspondingly maximum gains of 0,78 and 0,55 kg/ha/day.

Intra-seasonal changes of mean OPSR's and the corresponding maximum gains/ha over the 1975/76, 1976/77 and 1978/79 grazing periods are presented in Figure 4. Seasonal changes in ADG have been discussed previously.

Mean OPSR's decrease during the season to reach their lowest values in autumn under both systems of grazing. The estimated peak animal production/ha therefore occurs at decreasing SR's from the early to the late season periods. This implies that maintenance of a single SR at the mid-season (January/February) optimum would result in sub-maximal gains/ha in the early and late season periods because of under-and over-stocking respectively.

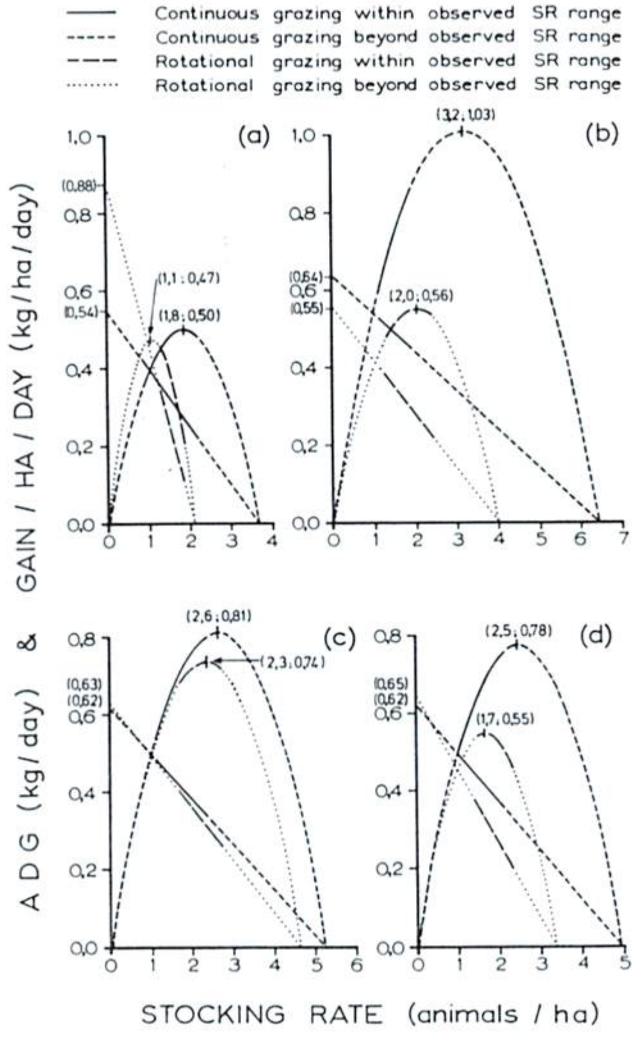

FIG. 3. *Average daily gain (ADG) and animal gain/ha/day at various stocking rates based on the Jones & Sandland (1974) model. The diagrams represent (a) 1975/76, (b) 1976/77, (c) 1978/79 and (d) 3-year means.*

Maximum animal gains/ha, corresponding to the mean OPSR's, likewise decrease under both grazing systems from late spring/early summer to autumn (Figure 4b. Under continuous grazing the decrease is from 1,5 to 0,5 kg/ha/day, while under rotational grazing it is from 1,0 kg/ha/day in the early season to 0,4 kg/ha/day in the late season. Generally, an increase in herbage production is expected during the mid-summer period. On this basis alone, gain/ha would correspondingly also be expected to increase to a maximum during mid-summer, but as previously indicated, ADG at this time is generally depressed.

2. Optimum economic stocking rate

Thus far SR optimisation has been considered in respect of maximum beef production/ha. In an attempt to determine the effect of economic factors on selection of the appropriate SR, a weaner to long-yearling beef production system is considered briefly. The assumptions are that weaners (200 kgs) are bought in autumn, over-wintered on *Eragrostis curvula* hay and supplementary lick, grown out on veld in summer and sold in autumn as long-yearlings (approximately 300 kgs). Equations used

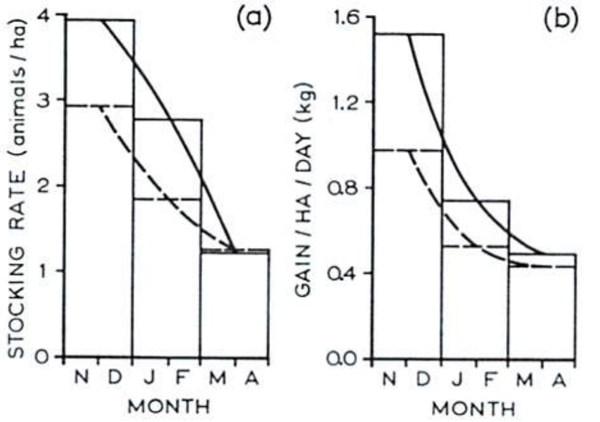

FIG. 4. *Intra-seasonal variation of (a) mean optimum production stocking rate and (b) animal gain/ha at the mean optimum stocking rates. — continuous grazing. ------ rotational grazing.*

to determine optimum economic SR (OESR) and the potential profit obtainable at the OESR are presented in Tainton (1981). The following economic assumptions are also made: land value/ha = R135,00, improvements/ha = R25,00. Annual variable costs are based on a per animal winter feed cost of R48,00 (*E. curvula* hay plus "Dundee" lick, as fed at the Kokstad Research Station (Lyle, 1983) plus R4,00 for veterinary and marketing costs; interest rate = 12% p.a. The estimates of OESR's and potential profits at these SR's and at OPSR as well as a SR of 1,25 animals/ha are presented in Table 4.

As OESR's are estimated using OPSR and ADG at the OPSR, the precautions previously mentioned must be taken in accepting the absolute validities of these estimates, particularly for continuous grazing. Furthermore, SR's are presented as animal numbers/ha, not as MLU's (which can be derived here by multiplying SR's by a factor of 0,8). In the moister phase of the Highland Sourveld (Bioclimatic subregion 4e) a SR of approximately 1,0 MLU/ha is considered economically and ecologically suitable. It has been estimated that in drier highland sourveld phase of East Griqualand, the potential grazing capacity is 0,71 MLU/ha (0,89 animals/ha) while the current grazing capacity is only 0,53 MLU/ha (0,66 animals/ha), (Anon., 1981). Estimated OESR's exceeding 1,25 animals/ha (1,0 MLU/ha) therefore appear excessive and profits associated with such high SR's are probably overestimates.

From Table 4 it is evident that continuous grazing is more profitable than rotational grazing at both the OESR and at a SR of 1,25 animals/ha. Assuming a maximum allowable SR of 1,25 animals/ha a current purchase price of 90c and a future sale price of R1,50/kg livemass, the maximum potential profits are R39,40/ha at a SR of 1,25 animals/ha for continuous grazing and R25,60/ha at a SR of 0,96 animals/ha for rotational grazing.

It must, however, be emphasised that despite the apparent short-term economic advantages of continuous grazing under the experimental conditions, selective grazing associated with this system will, it is believed, result in long-term veld deterioration and, inevitably, a decrease in beef production and profit margins. The value of these economic estimates therefore, lies not in their absolute values, nor for comparing grazing systems, but in showing the effect of increasing SR on potential financial returns. Clearly, from Table 4, increasing the SR does not imply an increase in the net income per hectare. Optimum economic stocking rates occur where the value of the marginal product (VMP) is equal to the value of the marginal cost (VMC), at a SR lower than that at which maximum gain/ha occurs.

CONCLUSIONS

Conclusion derived from the data are tenuous, due to the limitations inherent in the experimental design. These limitations include the non-uniformity of the pre-experimental treatments of the areas used for the continuous and rotational systems. Seocndly, the number of SR treatments used were insufficient, particularly under

Table 4. *Optimum economic SR (OESR) and comparative profitability of beef production at three different SR's.*

Purchase Price (R/kg)	Economic parameter	Sale Price (R/kg) Continuous 0,90	Continuous 1,50	Rotational 0,90	Rotational 1,50
	OESR (animals/ha)	0,63	1,37[1]	0,48	0,96
0,90	Profit at OESR (R/ha)	- 11,40	39,70	-11,40	25,60
	Profit at 1,25 animals/ha (R/ha)	19,40	39,40	-30,50	21,60
	Profit at OPSR (R/ha)	- 78,50	0,70	-55,70	0,10
1,50	Profit at OESR (R/ha)	- 14,60	22,30	-16,60	15,30
	Profit at 1,25 animals/ha (R/ha)	- 36,00	22,00	-46,70	5,40
	Profit at OPSR (R/ha)	-110,00	-31,60	-77,50	21,70

[1] OESR's exceeding 1,25 animals ha are considered excessive for Bioclimatic Region 4 (see text).

rotational grazing and there were no treatment replications, so that goodness of fit of regressions within seasons could not be tested. Thirdly, the use of variable SR's resulted in differences in mean seasonal SR's, both between grazing systems and between seasons, making direct comparisons impossible.

However, the data obtained continuous grazing was found to generally out-perform rotational grazing both in terms of ADG and livemass production/ha. The highest mean aDG was 0,5 kg/animal/day attained in the CL treatment. In general, maximum ADG occurred in late spring and decreased gradually to autumn when ADG increased to a secondary peak. Stocking rate appeared to have only a marginally greater effect on ADG than did the grazing system, RL (1,4 animals/ha) resulting in only 0,1 kg/animal/day greater ADG than CH (2,2 animals/ha).

Beef production/ha was 48% greater at the highest SR of approximately 2,2 animals/ha under continuous grazing than under rotational grazing, but this marked difference was not evident at the lower SR's. Consequently, the maximum animal gain/ha as estimated with the Jones & Sandland (1974) model was higher and occurred at a higher SR under continuous grazing than under rotational grazing. Using the same model it was found that the maximum production levels/ha and the optimum SR at which these maxima occurred decreased from late-spring/-early-summer to autumn, but at all times these parameters were greater under continuous than under rotational grazing.

Possible reasons for the superiority of the continuous grazing system in this trial are, firstly, the animals ability, in this system, to select the more palatable species and young regrowth, which are of higher nutritional value than the ungrazed, unpalatable species. Under rotational grazing the opportunity for selection is restricted, particularly at high SR's and thus ADG is expected to be lower. Secondly, under continuous grazing there is less interference with animal social behaviour, possible resulting in a less disturbed pattern of grazing and thus better animal growth. Thirdly, the above average mean rainfall during the three-year trial probably resulted in an abundance of herbage. The advantage of rotational grazing in conserving fodder was thus not realised. In drier years the relative differences between the two systems might be considerably less.

The apparent short term superiority of continuous grazing should not be viewed as a long-term advantage, as inevitable veld deterioration resulting from the depletion of selectively-grazed palatable veld species will, in time, result in diminishing ADG's and thus decreased production per unit area. The trial was not run over a sufficiently long period to monitor significant changes in veld condition. However, even small short-term changes can result in serious long-term deterioration.

Maximum profitability at various purchase and sale price structures of beef animals was found to occur at SR's below those which provided for maximum beef production/ha on veld. Increasing SR, and thus animal production/ha, does not, therefore, imply an increase in net income/ha, as animal production/ha is quadratically related to SR, while variable costs increase linearly as SR increases.

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