The effects of continuous and rotational grazing of sourveld on the quality of herbage selected by Simmentaler heifers

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A grazing trial was conducted at the Kokstad Agricultural Station to compare the dry matter digestibility (DMD) and crude protein content (CP) of diets selected by four fistulated cattle which were continuously and rotationally grazing sourveld. Two stocking rates of 1,0 and 2,3 animals/ha (0,5 and 1,2 LSU/ha) were applied under each grazing method. The mean DMD and CP values of diets selected in the continuous and rotational grazing treatments, respectively, were: DMD=64,3%, 62,3%; CP=6,63%, 6,88%. The effect of stocking rate on the quality of the diet selected varied between the two grazing methods. DMD and CP of diets selected under rotational grazing decreased with time during the week-long period of stay in each paddock. On average, DMD and CP values on the first and sixth day respectively, were: DMD=66,6%, 60,5%; CP=8,37%, 6,01%. These differences were more pronounced at the higher than at the lower stocking rate. It was concluded that, although some of the treatment differences were small, grazing method differences in the DMD of diets might at least partially account for observed differences in livemass gains under the two grazing systems.

'n Weidingsproef op suurveld is by die Kokstad Landbounavorsingstasie uitgevoer. Die droëmateriaalverteerbaarheid (DMV) en ruproteïeninhoud (RP) van die dieet wat geselekteer is, is deur vier gefistuleerde beeste tydens aanhoudende en rotasiebeweiding vergelyk. Veeladings van onderskeidelik 1,0 en 2,3 diere/ha (0,5 en 1,2 GVE/ha) is toegepas vir elke weistelsel. Die gemiddelde DMV en RP waardes van die diëte wat geselekteer is in die aanhoudende- en rotasiebeweiding behandeling is onderskeidelik: DMV=64,3%, 62,3%; CP=6,63%, 6,88%. Die invloed wat veelading op die kwaliteit van die geselekteerde dieet gehad het, het verskil tussen die weistelsels. Die DMV en RP van die geselekteerde diëte onder rotasiebeweiding het afgeneem gedurende die periode van 'n week in elke kamp. Die gemiddelde DMV en RP-waardes van die eerste en sesde dag was onderskeidelik DMV=66,6%, 60,5%; CP=8,37, 6,01. By die hoë veelading was die verskille nog duideliker as by die lae veelading. Die gevolgtrekking is, dat alhoewel die verskille in behandeling klein was, die verskille in die DMV van die diëte ten minste gedeeltelik verantwoordelik is vir waargenome verskille in lewendemassatoename tussen die twee weistelsels.

Additional index words: Crude protein, *in vitro* dry matter digestibility, oesophageal fistula, stocking rate

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Introduction

Claims have been made that rotational grazing has potential advantages in improving animal production by increasing herbage growth rates and enhancing the nutritive value of herbage on offer (reviewed by Gammon, 1978). However, it has commonly been concluded that, on tropical and subtropical rangelands, rotational grazing systems lead, at best, to similar and often lower short-term animal production than continuous grazing (Gammon, 1978; Crowder & Chheda, 1982). More specifically, it was reported that substantially greater livemass growth rates were obtained in beef cattle continuously grazing East Griqualand sourveld (approximately 180 days per annum) than when the same veld was rotationally grazed (Kreuter, *et al.*, 1984). Explanations for these differences between grazing systems necessitate investigation of their effects on the diets of the grazing cattle.

Assuming climatic effects to be constant, animal growth rate (performance) is a function of intake (kg DM/day) and forage quality (Ulyatt, 1973). In effect these two parameters are not independent (Spedding, 1966; Ulyatt, 1973; Bransby, 1981). In practice they can be evaluated separately (Pattinson, 1981), but a simple, universal method for quantifying intake is elusive (Cordova, *et al.*, 1978).

Forage quality is most accurately represented by metabolizable energy, ME (MJ/kg DM), because the supply of energy of feed is generally the single most limiting factor in animal production (Bransby, 1981). Techniques to estimate ME are too sophisticated for routine analyses but ME is usually well correlated with dry matter digestibility (DMD) (Minson & Milford, 1967). DMD has been considered to be the most useful measure of nutritive value because it has a direct effect on nutrient absorption in the alimentary canal, and it influences the amount of feed consumed (Ulyatt, 1973; Bransby, 1981). For example, the observation that low levels of intake are the major cause of low animal productivity in tropical environments has often been ascribed to DMD's of tropical and subtropical grasses being below 70% (i.e. ME<9,2 MJ/kg DM) (Crowder & Chheda, 1982). At such low nutritive values, voluntary DM intake is directly dependent on the ME content of the feed (Ulyatt, 1973).

However, DMD is not always well correlated with animal performance owing to nutrient limitations in the feed other than energy (Clark & Barth, 1970). Sufficient protein is particularly important in maintaining the rumen flora of cattle grazing relatively indigestible tropical and subtropical forages.

This article presents the results of an experiment undertaken to determine whether there were any differences in the DMD and protein content of the diets selected by cattle continuously and rotationally grazing sourveld in East Griqualand. It is hypothesized that such differences can at least partially account for observed differences in animal performance under these two forms of grazing management in sourveld.

Procedure

Data collection

A grazing trial was conducted during the 1983/84 grazing season at the Kokstad Agricultural Research Station. The predominant vegetation was Highland sourveld to *Cymbopogon-Themeda* transition veld (Acocks, 1975) in the drier phase of Bioclimatic Region 4 (Phillips, 1973) and the most common species were *Tristachya leucothrix* and *Themeda triandra*. Mean veld condition scores (Tainton, 1981), from 1981 and 1985 assessments, were 62% (*SE* 5,01, CV% 8,1) and 66% (*SE* 4,61, CV% 6,9). This indicates that the veld was in moderately good condition with a high degree of uniformity and little change during the trial.

Four unreplicated grazing treatments were applied; two grazing methods each at two stocking rates. Under continuous grazing cattle were placed in a single paddock for 196 days from 26 October, while, under rotational grazing, they were moved on a weekly basis through six paddocks of equal size. All treatments commenced and terminated on the same days. Stocking rates were selected to correspond with the previous grazing trial (Kreuter, *et al.*, 1984). Between six and eight heifers were allocated to each treatment, according to the area fenced for it, to achieve two fixed levels of stocking: 1,0 and 2,3 heifers/ha i.e. 0,5 and 1,2 LSU/ha at the end of the trial. Simmentaler-cross yearling heifers, the mean weights of which were 165 kg and 225 kg at the start and end of the experiment, were used in all treatments.

Clipped samples of standing herbage and ingesta samples from heifers fitted with oesophageal fistulas were collected during four consecutive weeks in spring (mid-November to mid-December), summer (mid-January to mid-February) and autumn (mid-March to mid-April). Sampling occurred on the first, third and sixth days of the week-long stay in the rotationally-grazed paddocks.

In each treatment, herbage clippings were obtained from ten randomly-placed one metre square plots cut to 25 mm above ground level. These samples were combined and thoroughly mixed after which a sub-sample was selected. Fistula samples were obtained from four fistulated heifers after they had been starved of feed for 12 h to ensure adequately large ingesta samples during 30-min foraging periods. Using a latin square design, each fistulated heifer was allocated to each treatment for a week during each of the four-week sampling periods. Carry-over effects of grazing treatment on the grazing behaviour of the heifers were thus randomized. After collection, the fistula samples were drained of excess saliva. All clipped and fistula samples were force-draft dried at 50°C for 48 h and milled to 1-mm particle size. Prior to quality analyses, equal quantities were selected from corresponding samples collected within each four-week sampling period. These sub-samples were bulked to obtain one representative sample for each of the three seasons.

Herbage quality was analysed for *in vitro* DMD, using the rumen liquor technique (Tilley & Terry, 1963; Minson & MacLeod, 1972), and crude protein (CP), using the Kjeldahl technique (Horwitz, 1980).

Analysis of data

Limitations on land and cattle prevented the inclusion of treatment replications. In addition, a single fistulated heifer was available for each treatment at any given time. Consequently only one fistula sample and one clipped sample were obtained from each treatment on each sampling occasion.

As a result of the lack of replication it was not possible to obtain an estimate of the true experimental error. Therefore, variances of the main effects and first order interactions could only be tested against the summed variance of higher order interactions, as recommended by Rayner (1967).

Results

Season

There was a significant ($P<0,01$) decrease in both DMD and CP of standing herbage from spring to autumn. This is in keeping with the characteristics of maturing sourveld. There was also a close correlation between the seasonal differences in the quality of standing and consumed herbage ($P<0,01$) (Figure 1). However, the decline in the quality of the diets was less than that of the forage on offer. This implies that, on average, the degree of selection for higher than average quality forage, especially CP, increased as the veld matured. Grazing treatment differences in these trends were found to be small.

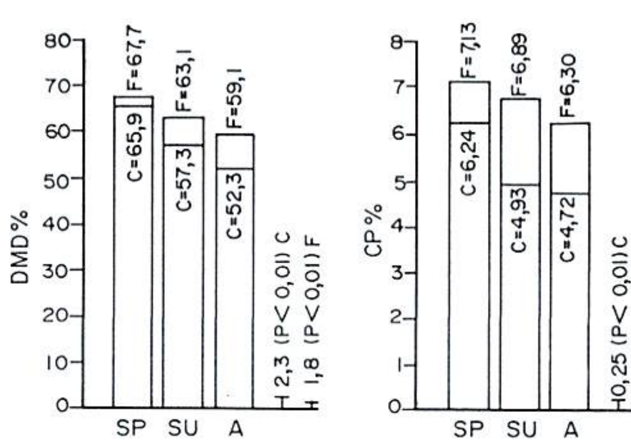

Figure 1 Seasonal differences in the mean dry matter digestibility (DMD) and crude protein (CP) of clipped (C) and fistula (F) samples (SP=spring; SU=summer; A=autumn).

Table 1 The level of significance of the main effects and interaction of grazing method and stocking rate on the herbage quality and diet

Variance source	Dry matter digestibility Herbage	: Diet	Crude protein Herbage	: Diet
Grazing method (GM)	NS	**	NS	*
Stocking rate (SR)	NS	NS	**	*
GM * SR	NS	**	NS	NS

**=$P<0,01$; *=$0,01<P<0,05$; NS=$P>0,05$

Grazing treatment

Averaged for all three seasons, grazing treatment effects on the DMD and CP of standing herbage and selected diets varied (Table 1, Figure 2).

From Table 1 and Figure 2 it is evident that the only significant ($P<0,01$) treatment effect on the quality of standing herbage was the effect of stocking rate on CP. No corresponding effect on DMD was observed which was surprising since DMD and CP were found to be highly correlated. A possible explanation for the stocking rate effect on CP is that herbage was grazed more intensively under the heavier than under the light stocking treatments. Intensively grazed herbage tends to contain a higher proportion of regrowth which generally has a higher protein content than mature herbage (Crowder & Chheda, 1982). A similar differential effect on herbage quality might have been expected under the two grazing methods since instantaneous grazing pressure was more intense under rotational than under continuous grazing. No such difference was found.

Mean diet quality under continuous (CG) and rotational grazing (RG) were: DMD CG=64,3%; DMD RG =62,3% (CG−RG=2% $P<0,01$); CP CG=6,63%; CP RG=6,88% (CG−RG=0,25% $0,01<P<0,05$). Relational functions between *in vitro* and *in vivo* DMD

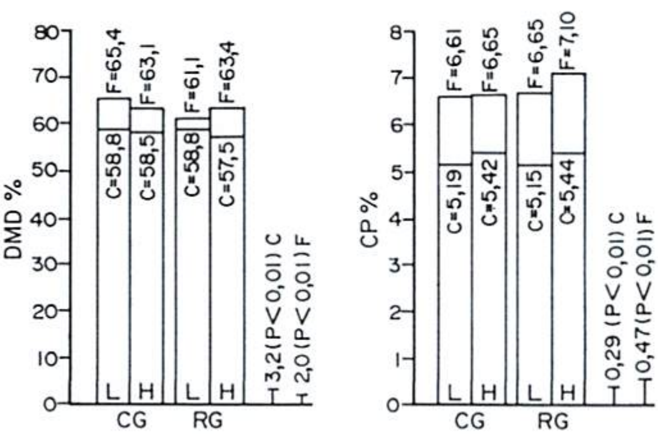

Figure 2 The combined effect of grazing method and stocking rate on dry matter digestibility (DMD) and crude protein (CP) of clipped (C) and fistula (F) samples (CG=continuous grazing; RG=rotational grazing; L=low stocking rate; H=high stocking rate).

(Zacharias, 1986), between *in vivo* DMD and ME (Corbett, 1978), and between ME and net energy, NE (Garrett, 1980), were used to convert the mean *in vitro* DMD estimates to NE. Expected livemass gains were then calculated from feed requirement tables (N.R.C. 1984) using a mean intake of 3,5 kg DM/day for both grazing methods. This value was obtained from the rotationally-grazed paddocks with a disc meter (Bransby & Tainton, 1977) and it was assumed that DM intake in the two grazing systems was equivalent because intake under continuous grazing could not be assessed. At 62,3% DMD ingesta, net energy for growth (NEg) for a 250-kg heifer was thus calculated to be 7,61 MJ/day under rotational grazing and 8,57 MJ/day from 64,3% DMD ingesta under continuous grazing. The mean 180-day livemass gains per 250-kg heifer, corresponding to these NEg values, were 52,2 kg and 62,1 kg respectively. These gains and the 10-kg difference approximated the observed mean livemass gains under the two grazing systems in the preceding trial (Kreuter, *et al.*, 1984). Thus, theoretically at least the observed mass gain differences could be accounted for almost exclusively by a 2% DMD difference in the selected diets. This might be considered particularly relevant owing to the small difference (0,25%) in the CP of selected diets. However, this conclusion should be treated cautiously as the assumption of equivalent intakes in the two grazing systems may be erroneous, given the differences in the instantaneous grazing pressure.

Interaction effects between grazing method and stocking rate were mixed. Under continuous grazing, DMD but not CP of the selected diet was lower ($P<0,01$) at the higher stocking rate but under rotational grazing both DMD and CP were greater ($P<0,01$ and $0,01<P<0,05$ respectively) at the higher stocking rate. These differences are difficult to explain especially in the case of DMD where differences in diets did not correlate with differences in standing herbage. In the case of CP it appears that the quality of herbage on offer may have had some effect on the quality of the diets that were selected.

Day in period of stay

A fourth experimental factor, the day of the week-long period of stay in the rotationally-grazed paddocks, was also found to significantly affect diet quality in some of the grazing treatments (Table 2, Figure 3).

Table 2 The level of significance of the main effect of the day in the period of stay in rotationally-grazed paddocks (day) and its interaction with grazing method (method) on the herbage quality and diet

Variance source	Dry matter digestibility Herbage	: Diet	Crude protein Herbage	: Diet
Day	NS	**	*	**
Day * Method	NS	**	*	**

**=$P<0,01$; *=$0,01<P<0,05$; NS=$P>0,05$

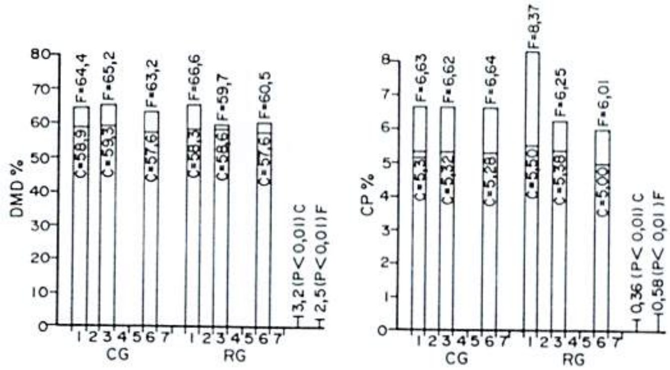

Figure 3 The combined effect of the period of stay and grazing method on the dry matter digestibility (DMD) and crude protein (CP) of clipped (C) and fistula (F) samples (CG= continuous grazing; RG=rotational grazing; 1–7=day in the period of stay in the rotationally grazed paddocks).

Under rotational grazing there was, on average, a significant ($P<0,01$) decline in the DMD and CP of selected diets from the first to the third day in the week-long period of stay in each paddock. Changes in the CP content of diets corresponded to changes in the herbage quality but DMD did not. Weekly fluctuations in diet quality did not occur under continuous grazing because animals were not moved between paddocks. Thus, under rotational grazing cattle selected diets which, on average, were higher ($P<0,01$) in CP at the beginning of the week-long period of stay but lower ($P<0,01$) in both DMD and CP by the end of the week than the uniform diet under continuous grazing.

Discussion and Conclusion

As treatment differences in the seasonal decline in diet quality were small, the observed differences in diet quality must be attributed to factors other than the seasonal effect.

The mean quality of standing herbage was almost identical under the two methods of grazing throughout the trial. However, in rotationally-grazed paddocks, diets decreased in quality from a maximum at the beginning of the week-long period of stay while, under continuous grazing, diet quality remained constant in any given week. In contrast to claims that rotational grazing systems can enhance diet quality (reviewed by Gammon, 1978), the net effect of these fluctuations was a 2% lower DMD in the diet under rotational grazing compared with continuous grazing and a small (0,25%) difference in CP. It was estimated that, in a 250-kg heifer, this DMD difference could reduce livemass gain by 10 kg over 180 days. Thus the restricted opportunity to select a diet of high digestibility, under rotational relative to continuous grazing, could account for almost all the reported (Kreuter, *et al.*, 1984) livemass gain difference between these two grazing systems on East Griqualand sourveld.

However, the opportunities to select a high quality diet and to ingest a large amount of forage are physically and physiologically correlated (Spedding, 1966; Ulyatt, 1973; Bransby, 1981). DM intake cannot, therefore, be disregarded in accounting for differences in animal performance among grazing systems. For example, Karnezos, *et al.* (1988) concluded that, on two cultivated pastures in Natal, herbage intake played a more significant role in accounting for livemass gains in cattle than herbage quality.

In the rotationally-grazed paddocks, instantaneous herbage availability constituted 16,67% of that in the corresponding continuous grazing treatment. This may have had a two-fold effect on DM intake. Firstly, there may have been insufficient herbage by the end of the period of stay in rotationally-grazed paddocks to maintain the same level of forage intake as in the continuously-grazed paddocks. Therefore, the relatively poorer performance of animals under rotational grazing may have been brought about by the fluctuation in DM intake. Secondly, there may have been less total herbage on offer, and thus restricted intake, under rotational grazing. This is because the greater instantaneous grazing pressure under rotational relative to continuous grazing may have led to less residual leaf area and thus lower herbage regrowth rates.

Although the effects of grazing systems on diet quality may account for a large component of the differences in animal performance, total quantity and fluctuations of herbage availability, and thus DM intake, must also be carefully examined in determining grazing system effects on animal performance. Knowledge of the relative role of these factors on animal performance, and the effect of grazing systems on them, is important in devising grazing management systems which permit the use of rotational grazing concepts and simultaneously provide satisfactory levels of animal performance.

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