African Journal of Agricultural Research Vol. 7(18), pp. 2824-2834, 12 May, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.930
ISSN 1991-637X © 2012 Academic Journals

Full Length Research Paper

Behavioural patterns of cattle in the communal areas of the Eastern Cape Province, South Africa

Bethwell Moyo[1], Sikhalazo Dube[2]*, Mota Lesoli[1] and Patrick Masika[3]

[1]Department of Livestock and Pasture Science, University of Fort Hare, Alice 5700, South Africa.
[2] Animal Production Institute, Agriculture Research Council, Irene 0062, South Africa.
[3]Agricultural and Rural Development Research Institute, University of Fort Hare, Alice 5700, South Africa.

Accepted 30 August, 2011

Incorporating knowledge of cattle activity or social behavior in rangeland management has the potential to improve both range condition and cattle productivity through intervention in and using the ongoing expression of behavior to detect veld condition changes. Currently, there is limited information on free ranging cattle activity patterns despite a concerted effort to introduce rotational grazing in communal rangelands. This grazing method interferes with livestock mobility, a necessity in heterogeneous semi-arid rangelands. It is, therefore, important that before evaluating rotational grazing intervention impacts in communal rangelands, an analysis of cattle activity patterns be done. Activity patterns of cattle in relation to forage quality, veld type, season, time of the day and management type were studied in a free-range grazing system in three villages in the Eastern Cape Province. Behaviour was determined by visually observing two animals during daylight hours for 2 days in each season. Current activity of each animal was recorded at 30 min fixed intervals until noon, and every 60 min thereafter. Percentage of the observation time spent in a particular activity for each observed animal were calculated for the duration of the observation. Seasonal activity patterns varied only at Upper Mnxe, with time spent grazing (77%), resting (35%) and walking (24%) higher in April, November and June respectively. Kraaling and mountain stockpost grazing management types affected the activity patterns of cattle, causing either an increase in morning grazing activity to cater for loss in grazing time or extensive walking in winter to compensate for forage scarcity. Rotational grazing can be introduced in mesic grasslands without adverse effects on animals, in contrast to semi-arid areas where major behavioural changes are needed as a coping strategy.

Key words: Cattle behaviour, grazing management, forage quality, kraaling, sweetveld, stockposts.

INTRODUCTION

Grazing management is affected by both abiotic and biotic factors. Abiotic factors, such as climate, soils and topography, which structure and maintain rangeland ecosystems, determine limits to grazing management (Senft et al., 1987). Effective management of grazing animals depends on a thorough knowledge of an animal's interaction with its environment and incorporating knowledge of cattle activity or social behavior should help to improve veld and cattle management through intervention in the ongoing expression of behavior. Activity patterns of cattle grazing freely on open range and in different veld types have received less attention in Sub-Saharan Africa with most studies concentrated in the Sahel region (Ayatunde et al., 1999; Schlecht et al., 2003). Few studies which looked at grazing behavior in communal rangelands either concentrated on animals subjected to kraaling at night (Baars and Ottens, 2001) or on cattle grazing behavior in relation to rangeland degradation in one veld type (Kassahun et al., 2008). Despite this lack of information on cattle grazing behavior under various management practices, government and outside interests are pressing for greater use of rotational grazing. This grazing method interferes with livestock

*Corresponding author. E-mail: dubes@arc.agric.za. Tel: +27 12 672 9295.

mobility, a necessity in heterogeneous semi-arid rangelands; hence in a country with diverse rangelands, there is a need to assess the necessity for introducing expensive rotational grazing in various veld types.

An assessment of cattle grazing behavior can be used as an indicator for determining whether there is a need to invest in rotational grazing. Quantifying cattle activity patterns in different veld types and seasons helps in understanding the relationship between the animal and its environment. The daily activity pattern of most free-ranging herbivores is centered on foraging activities like grazing, watering, resting, ruminating or travelling. Variation in activity patterns is influenced by both biotic and abiotic factors. Biotic factors, such as forage quality and quantity, including inherent secondary compounds are important factors influencing the feeding patterns of livestock in rangelands (McNaughton, 1990; Bailey, 2005). In addition, daily temperature, which has an effect on thermal balance, affects grazing time (Shinde et al., 1997). Communal rangelands, which supply the bulk of forage for cattle in rural areas, are characterized by high stocking rates and absence of any grazing management system (Moyo et al., 2008a). Management practices that affect grazing time are likely to influence forage consumption and consequently performance of grazing cattle. Vegetation is composed of different plant species occurring in diverse vegetation associations, and the extent of different vegetation associations and their nutritive value vary in relation to relief, aspect, and edaphic conditions. The management practices differ with communities, with some kraaling their animals at night to prevent theft (Moyo et al., 2008a), this practice conflicts with the need for cattle to graze at night especially during the dry season when both forage quantity and quality decreases. Others keep cattle at stock posts where they have continuous access to forage. In order for animals to satisfy their nutrient requirements, they have to adjust their day light feeding patterns (Kristensen et al., 2007).

Foraging animals have abilities to modify their behaviour to respond to challenges in the foraging environment (Provenza and Balph, 1990). Cattle adjust to the variation in these factors by increasing grazing time when forage quantity is limited (Kristensen et al., 2007). On the other hand, as quality, consequently digestibility, which is directly correlated to crude protein, decreases, herbivores have to ruminate more since retention time of ingesta increases. This reduces time spent grazing (Hendricksen and Minson, 1980; Lachica and Aguilera, 2003). In order to meet its nutritional and energetic requirements, an animal must allocate a certain proportion of its overall activity time budget to feeding. The time allocated to feeding will be influenced by the digestive efficiency of the animal, thermal balance and variations in herbage quantity and quality between seasons (O`Regain and Schwartz, 1995; Harris et al., 2007). Cattle increase daily grazing time in response to declining herbage quality in an effort to compensate for reduced intake rate. If herbage quality is low, cattle take more time ruminating (Ungar, 1996; Gibb et al., 1999). Time of day for feeding activity is another component of the animal's feeding time budget. Feeding activity is reduced during the hottest hours of the day. This is done to maintain heat balance.

To understand the effects of seasonal and spatial variation in resource use patterns and implication for range management, there is a need to understand the activity patterns of cattle. The objective of this study was to investigate activity patterns of cattle in relation to veld type, season, time, kraaling and forage quality. It was hypothesized that, low vegetation biomass at the sweetveld, kraaling and winter forage scarcity lead to animals spending most of their time grazing to satisfy their dry matter and nutrient requirements.

MATERIALS AND METHODS

Study areas

The study was conducted in Magwiji, Mnyameni and Upper Mnxe located in Ukhahlamba (formerly known as Herschel), Amatole and Chris Hani districts in the Eastern Cape Province of South Africa (Figure 1). These three communities cover three veld types, namely Themeda-Festuca Alpine Veld, coastal forest and thorn veld, and highland sour veld (Acocks, 1988). Differences in veld types, presence of cattle projects, evidence of livestock keeping (from extension office records), and presence of stockpost grazing management system were criteria used in selecting the villages. As common in most communal areas of South Africa (Statistics South Africa, 1999), all the study villages are poor and underdeveloped. The majority of villagers are unemployed, and the illiteracy level is high (Moyo et al., 2008a). Magwiji was once under betterment scheme, and it is bisected by rugged mountains of the Wittebergen range with deep and steep streams running north and is covered by sandy loam and sandy clay soils, which are very slowly draining and highly erodable. It is also underlain by sedimentary and volcanic rocks of the Karoo supergroup, laid down in the Triassic and Jurassic periods respectively (Govender, 1998). Lower areas are underlain by sandstones, grey mudstones and shales of molteno formation. Dolerite sills are prevalent and Quaternary alluvium deposits fill several of the valleys.

The climate varies from hot in summer to extreme cold in winter with heavy frost and snowfall along the mountain area. Average annual rainfall is 640 mm, and most rain, fall during the summer months from October to March, with frost and sometimes snow in winter. The total rainfall received in 2006 and 2007 was 976.4 and 551.5 mm, respectively. Mean monthly temperatures range from 9°C in July to 22°C in January. The area is in a sweet grassveld biome of a Themeda-Festuca Alpine Veld (Acocks, 1988). According to Acocks (1988), *Themeda triandra*, *Setaria sphacelata*, *Microchloa caffra*, *Elionurus muticus* and *Heteropogon contortus* are the most common grass species. Mnyameni has a subtropical climate, with rainfall peaking in summer. The average annual rainfall is between 601 to 700 mm and the amounts recorded in 2006 and 2007 were 1056.4 and 876 mm respectively. Mean maximum monthly temperatures range from 14°C in July to 22°C in January. The soils within the study area appear to be closely associated with the typical Eastern Cape coastal geology, consisting of sedimentary formations such as sandstone, mudstone, limestone, conglomerate and tillite (Keyser, 1997). Soil depth ranges from 501 to 700 mm, clay content from 10.1 to 14.9% and silt content is more than 30%. The organic content of the soil ranges between 2 and 4%, while pH is within the range of 5.6 and

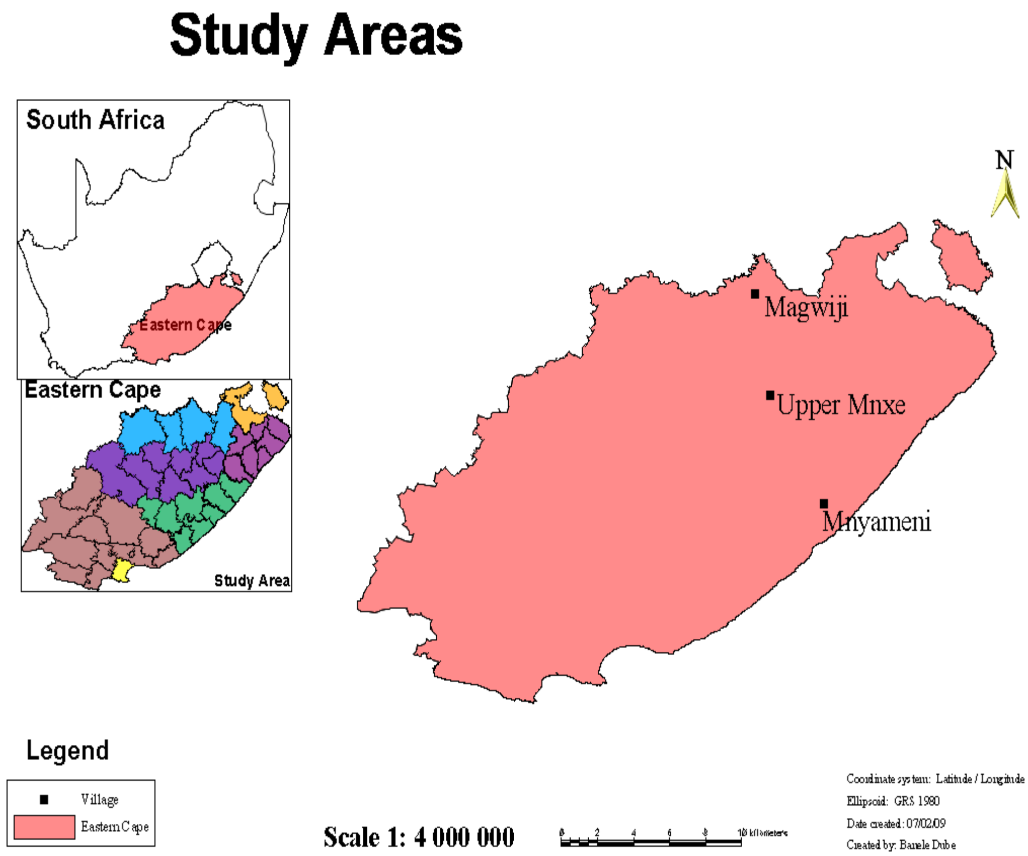

Figure 1. Location of study areas in South Africa.

6.5.

The area is in a coastal forest and thornveld veld type (Acocks, 1988). *Eragrostis plana, Paspalum dilatatum* and *Sporobolus africanus* are the most common grass species, with *Coddia rudis*, *Acacia karroo* and *Diospyros lyciodes* dominating the woody species. Upper Mnxe has rainfall which is relatively high from November to April (501 to 600 mm) and lowest from May to October (151 to 200 mm). Total annual rainfall recorded in 2006 and 2007 was 849.6 and 520.6 mm respectively. Mean maximum monthly temperatures range from 11°C in July to 20°C in January. The top soil has 15 to 35% clay content and is underlain by mudstone, sandstone and strips of dolerite, conglomerate and quartzite (Keyser, 1997). The area is in a highland sour veld type (Acocks, 1988). *T. triandra, H. contortus* and *Tristachya leucothrix* are the most common grass species.

Cattle activity sampling

Cattle behavior was classified into three categories namely: resting, which included sleeping, minor movements and standing; feeding, which included grazing and drinking; and walking which was directed movement of more than five steps while the head is up (Hassoun, 2002). The daily activity patterns were recorded in four seasons: winter (June to August); spring (September to November), summer (December to February), autumn (March to May). Grazing behavior was determined two days per season by visually observing two animals during daylight hours (08:00 to 16:00 h) local time. Animals were released at 7.00 a.m. and locked up in a kraal at 6.00 p.m. at Mnyameni and Upper Mnxe. At Magwiji animals grazed in stockposts on the mountains, and were not kraaled during the study period. The observers recorded the current activity of each animal at 30 min intervals. This method is the fixed interval time point sampling (Martin and Bateson, 1985). It was noted that Hull et al. (1960) did not find any significant difference in the major behavior patterns after observing cattle continuously at 30 and 60 min intervals. Animals were observed from a distance of approximately 200 m; a distance at which disruption of "normal" activity patterns is significantly reduced.

Vegetation sampling

Grazing sites mostly used by cattle were marked by identification pegs to avoid data being collected on measured sites. The site where animals spent a relatively longer time grazing each day was positioned with a GPS receiver. To estimate forage quality, herbaceous vegetation was clipped to ground level in five 1 m^2 quadrats placed randomly along each 100 m transect laid out in each site. Herbaceous species were clipped in groups: dominant species (defined as the species having the greatest aerial cover over the entire quadrat), subdominant species one, two and three in descending magnitude of aerial cover. The remaining grass species were pooled into other species group. Legumes and monocotyledons were clipped separately. The harvested forage were oven dried at 60°C for 48 h.

Chemical analysis of forage samples

Oven dried forage samples were ground in a Wiley mill to pass through a 1 mm screen. The milled samples were packed and

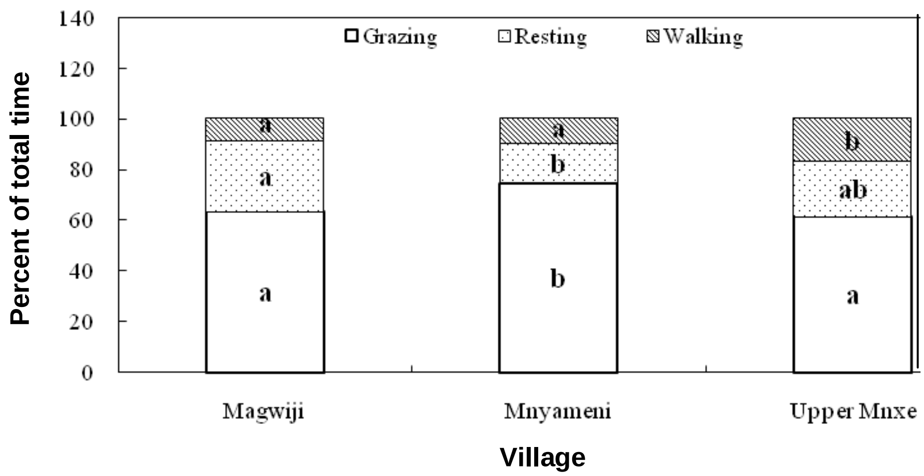

Figure 2. Percent of each behavioural activity across villages. Bars sharing the same letter for each activity do not differ significantly (P < 0.05).

labeled. The samples of each species harvested were analysed on a per season basis for crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and lignin. NDF and ADF were determined following the detergent fibre procedures described by Goering and van Soest (1970). Lignin and cellulose were also estimated using the gravimetric method of Goering and van Soest (1970). Nitrogen content was determined using the Micro-Kjeldahl technique and then converted to percent CP by multiplying percent nitrogen by 6.25.

Data analysis

Activity budgets describe the time an animal spends engaged in an activity as a percentage of the total time spent foraging. Each data record was allocated to one of three behavioral categories. Activity patterns were studied by calculating the percentage of the observation time spent in a particular activity for each observed animal for the duration of the observation. Activity budget data were effectively proportions of each day observation period, and were subjected to arcsine or square root transformation to normalize distributions (Zar, 1996). The analysis of grazing behavior is based on the proportion of time spent grazing, resting and walking. An ANOVA with post-hoc means tests (Tukey Honestly significant difference) was used to determine which activity occupied significantly more of the time than others. To test whether activity patterns varied in different times of the day, each day was divided into three periods: period 1 (08:00 to 10:00 h); period 2 (10:30 to 12:30 h); period 3 (13:00 to 16:00 h). From the data, time budgets were constructed.

The relationship between the animal's activity (grazing, resting, walking) and the chemical composition (CP, phosphorus, Total nitrogen, NDF, ADF, cellulose, lignin) of the herbaceous species in frequently grazed sites was obtained by canonical correlation analysis using PROC CANCORR of SAS (SAS Institute, 1990). Canonical correlation analysis is the multivariate extension of correlation analysis, and can be used to simultaneously analyze mixtures of variables defining different processes (Bidwell and Engle, 1992). Three pairs of canonical variables were established using a 5% level of significance. Only the results of the first canonical correlations were presented, since additional canonical correlations added little to interpretations. Correlations between canonical and original variables were included to aid in interpretation. Canonical coefficients were considered significant when higher than 0.30 following the Wilks' Lambda statistic (Harris, 1975).

RESULTS

Behaviour activities across villages

A total of 594 cattle observations were made, 298 for males and 296 for females. Grazing was the dominant activity (70%), followed by resting (22%) and walking (8%). The activity pattern was generally the same in all villages, with grazing being the dominant activity (Figure 2). The proportion of time spent grazing was ($F_{2, 36}$ = 11.19, P < 0.01) higher at Mnyameni compared to Magwiji and Upper Mnxe, while time spent resting was higher ($F_{2, 36}$ = 5.53, P < 0.01) at Magwiji compared to Mnyameni (Figure 2). Animals spent ($F_{2, 36}$ = 16.67, P < 0.01) more time walking at Upper Mnxe compared to the other two villages. The time spent grazing was consistently higher at Mnyameni in all the seasons (Table 1). Cattle spent more time grazing at Mnyameni in winter ($F_{2, 9}$ = 12.83, P < 0.01) and spring ($F_{2, 9}$ = 10.63, P < 0.01). On the other hand a similar consistent trend of more time spent walking was observed at Upper Mnxe; more time was spent walking in winter ($F_{2, 9}$ = 11.47, P < 0.01) and spring ($F_{2, 9}$ = 5.74, P < 0.05) (Table 1). Time spent resting by cattle in the three villages was only different in winter, with more time ($F_{2, 9}$ = 12.61, P < 0.01) spent resting at Magwiji than other villages (Table 1).

Behaviour activities across seasons

The activity pattern was generally the same in all seasons, with grazing being the dominant activity, followed by resting and walking (Figure 3). The percentage of time spent grazing for the combined data

Table 1. Mean percentage (± SEM) occurrence of cattle grazing, resting and walking behavior in different villages across seasons.

Behaviour	Village	February	Proportion of behaviour (%)		
			April	June	November
Grazing	Magwiji	$58.7^a \pm 0.43$	$76.6^a \pm 0.63$	$68.2^a \pm 0.53$	$60.2^a \pm 0.46$
	Mnyameni	$78.6^a \pm 0.69$	$78.8^a \pm 0.66$	$90.5^b \pm 0.67$	$74.7^a \pm 0.57$
	Upper Mnxe	$67.3^a \pm 0.52$	$76.9^a \pm 0.52$	$65.0^a \pm 0.50$	$40.8^b \pm 0.43$
Resting	Magwiji	$36.8^a \pm 0.34$	$18.2^a \pm 0.22$	$27.3^a \pm 0.27$	$34.2^a \pm 0.32$
	Mnyameni	$19.3^a \pm 0.31$	$21.2^a \pm 0.34$	$5.4^b \pm 0.19$	$17.8^a \pm 0.24$
	Upper Mnxe	$25.0^a \pm 0.33$	$15.4^a \pm 0.24$	$13.2^b \pm 0.30$	$35.5^a \pm 0.28$
Walking	Magwiji	$4.6^a \pm 0.23$	$5.3^a \pm 0.14$	$4.6^a \pm 0.19$	$5.7^a \pm 0.23$
	Mnyameni	$2.1^a \pm 0.20$	$1.0^a \pm 0.17$	$4.2^a \pm 0.14$	$7.5^a \pm 0.19$
	Upper Mnxe	$7.7^a \pm 0.15$	$7.7^a \pm 0.24$	$22.0^b \pm 0.21$	$23.8^b \pm 0.29$

Means in the same column within a behavior with different superscripts are significantly different at P < 0.05.

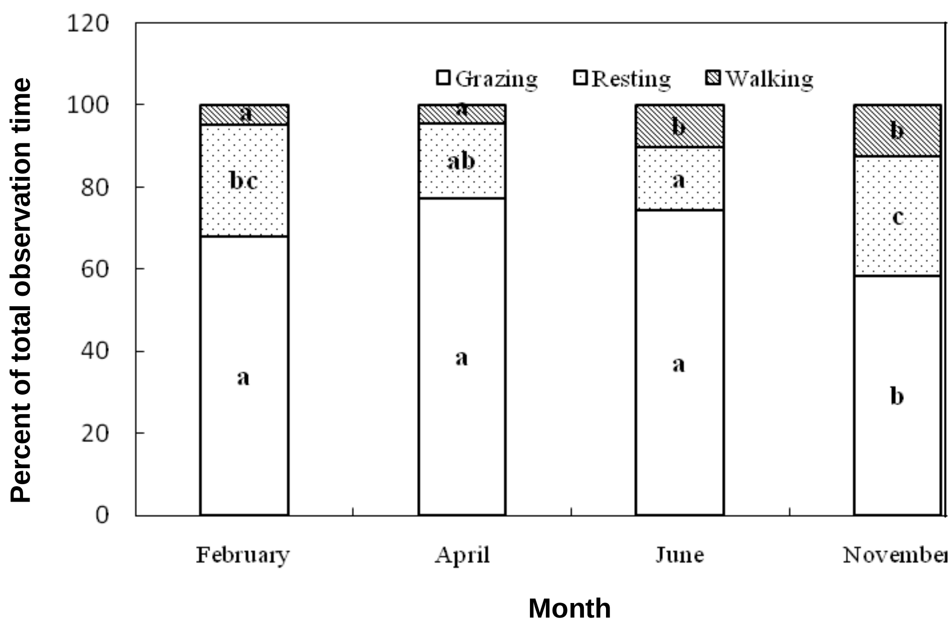

Figure 3. Percent of each behavioural activity across season. Bars sharing the same letter for each activity do not differ significantly (P < 0.05).

of all villages was not different in summer, autumn and winter; however, it was lower ($F_{3, 36} = 6.27$, $P < 0.01$) in spring. On the other hand differences were observed in percentage resting time, with cattle spending ($F_{3, 36} = 4.28$, $P < 0.05$) more time resting in summer and spring. There was ($F_{3, 36} = 4.76$, $P < 0.01$) less time spent walking in autumn and summer than in spring and winter (Figure 3). There was no significant difference in time spent grazing across seasons at Magwiji and Mnyameni. The same applied to time spent resting and walking. On the other hand time spent grazing at Upper Mnxe was higher ($F_{3, 12} = 11.46$, $P < 0.01$) in autumn. More time ($F_{3, 12} = 9.74$, $P < 0.01$) was spent resting in spring while time spent walking was ($F_{3, 12} = 5.17$, $P < 0.05$) higher in winter (Figure 4).

Cattle behavior in different times of the day

Different times of the day were characterized by differences in grazing and resting activity patterns. Cattle spent ($F_{2, 105} = 3.99$, $P < 0.05$) more time grazing in the

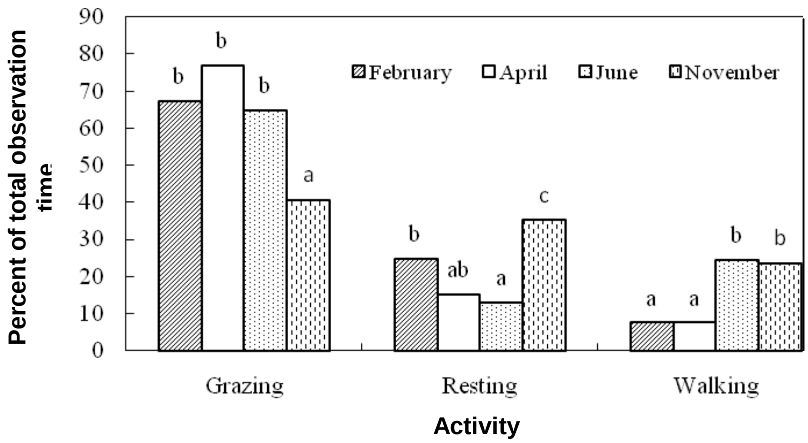

Figure 4. Percent of each behavioural activity across season at Upper Mnxe. Bars sharing the same letter within a behavioural activity do not differ significantly (P < 0.05).

Table 2. Cattle behavioural patterns during different day periods.

Time	Grazing (%)	Resting (%)	Walking (%)
Morning	$36.7^{b} \pm 3.20$	$33.0^{ab} \pm 4.37$	36.3 ± 2.74
Mid-morning	$30.8^{a} \pm 3.46$	$26.5\ ^{a} \pm 3.01$	27.7 ± 2.37
Afternoon	$32.5^{a} \pm 3.33$	$40.5^{b} \pm 3.63$	36.0 ± 2.37

NB [a,b]Column means within behavioural activity with different superscripts are significantly different.

morning and resting ($F_{2,\ 48}$ = 7.01, P < 0.01) in the afternoon (Table 2). There was no significant (P > 0.05) difference in the amount of time spent walking by cattle in the different times of the day in all the villages. The percentage of time spent resting by cattle was not (P > 0.05) different between different time periods of the day at Magwiji. On the other hand, cattle spent 45 and 44% of their afternoon time resting at Mnyameni ($F_{2,\ 17}$ = 4.11, P < 0.05) and Upper Mnxe ($F_{2,\ 25}$ = 6.09, P < 0.01), respectively (Figure 5).

There was no significant (P > 0.05) difference in the time spent grazing during different time periods of the day at Magwiji in summer and spring, however, cattle spent more time grazing in the morning, which was 39 and 41% in autumn ($F_{2,\ 9}$ = 3.69, P < 0.05) and winter ($F_{2,\ 10}$ = 4.36, P < 0.05), respectively (Table 3). Time spent grazing was ($F_{2,\ 9}$ = 6.27, P < 0.05) higher (42%) only in autumn during mid-morning grazing period at Mnyameni (Table 3). Cattle spent 53% of their grazing time in the morning ($F_{2,\ 9}$ = 138.90, P < 0.01) and 43% in the afternoon ($F_{2,\ 11}$ = 4.34, P < 0.05) in summer and winter respectively at Upper Mnxe (Table 3).

Forage quality and activity patterns

Season had an influence on phosphorus, total nitrogen, crude protein, NDF, and cellulose of forage in frequently grazed sites. Total nitrogen, phosphorus and crude protein were lower in June, while cellulose and NDF were higher in November (Table 4). The relationship between forage quality and cattle activities was poor as shown by the low canonical correlation (0.38) and Wilk's lambda (Table 5). None of the three canonical pairs were significant (P > 0.05) between forage quality and cattle activity. Correlations between the first pair of canonical variates and the original set of variables indicated that definable relationships between groups of related characteristics could be developed. The first canonical variate for cattle activity was correlated with walking (r = 0.65) and grazing (r = -0.46) activity, while the one for forage quality was correlated with NDF (r = 0.92) and ADF (r = 0.25) (Table 5).

Comparing the original cattle activity variables with the canonical variates of forage quality, revealed that time spent walking was strongly correlated with the forage quality canonical variate, which is mainly represented by NDF as previously indicated by the 0.92 correlation coefficient. This simply means the higher the NDF in the forage, the more the time was spent walking by cattle in search of forage. Comparing the original forage quality variables with the cattle activity canonical variate showed that NDF was highly correlated with the cattle activity canonical variate, dominated by walking and grazing activities (Table 5). The negative coefficient of grazing shows that an increase in NDF was associated with a decrease in time spent grazing. The canonical correlation of 0.38 is mainly due to relationships between time spent walking and grazing versus the NDF quantity in the forage. Resting and other nutritional parameters had less impact on the relationship.

DISCUSSION

Most of the ruminants spend most of their time grazing,

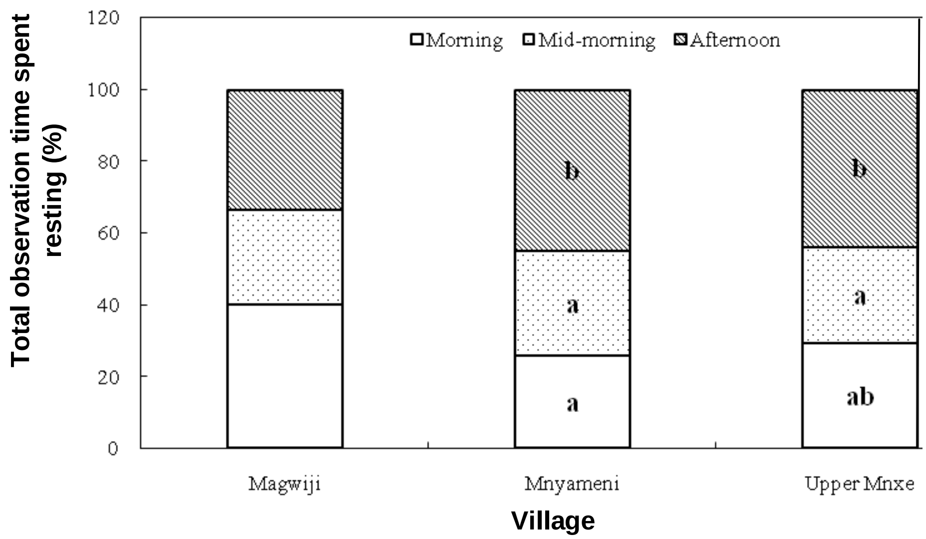

Figure 5. Percentage of total observation time spent resting in different time periods of the day at the three villages. Sections within a bar sharing the same letter do not differ significantly (P < 0.05).

Table 3. Percentage (± SEM) of total observation time spent grazing in different periods of the day for different seasons at Magwiji, Mnyameni and Upper Mnxe.

Village	Season	Proportion of total time spent grazing		
		Morning	Mid-morning	Afternoon
Magwiji	February	$43.5^{a} \pm 0.46$	$34.8^{a} \pm 0.61$	$21.7^{a} \pm 0.43$
	April	$38.9^{a} \pm 0.80$	$24.9^{b} \pm 0.55$	$36.3^{b} \pm 0.67$
	June	$40.5^{a} \pm 0.50$	$25.1^{b} \pm 0.51$	$34.4^{b} \pm 0.48$
	November	$31.8^{a} \pm 0.47$	$31.8^{a} \pm 0.60$	$36.4^{a} \pm 0.55$
Mnyameni	February	$31.5^{a} \pm 0.72$	$33.6^{a} \pm 0.69$	$35.0^{a} \pm 0.59$
	April	$35.6^{a} \pm 0.69$	$42.2^{a} \pm 0.83$	$22.2^{b} \pm 0.50$
	June	$33.7^{a} \pm 0.85$	$29.4^{a} \pm 0.59$	$36.8^{a} \pm 0.67$
	November	$36.6^{a} \pm 0.75$	$27.9^{a} \pm 0.71$	$35.5^{a} \pm 0.51$
Upper Mnxe	February	$53.1^{a} \pm 0.52$	$29.2^{b} \pm 0.55$	$17.7^{c} \pm 0.33$
	April	$34.8^{a} \pm 0.69$	$32.6^{a} \pm 0.71$	$32.6^{a} \pm 0.63$
	June	$33.3^{ab} \pm 0.66$	$23.9^{a} \pm 0.44$	$42.7^{b} \pm 0.73$
	November	$29.1^{a} \pm 0.41$	$36.8^{a} \pm 0.47$	$34.1^{a} \pm 0.43$

Means in the same row within a village with different superscripts are significantly different at P < 0.05.

Table 4. Seasonal variation of nutrient composition of forages from frequently grazed sites .

Season	Nutrient composition (%)						
	TN	CP	NDF	ADF	Cellulose	Lignin	P
February	$0.8^{a} \pm 0.05$	$5.2^{b} \pm 0.37$	$22.7^{a} \pm 0.82$	42.8 ± 0.63	$2.3^{a} \pm 0.48$	10.6 ± 0.67	$0.06^{a} \pm 0.006$
April	$0.7^{a} \pm 0.04$	$4.7^{b} \pm 0.30$	$21.7^{a} \pm 0.89$	41.0 ± 0.78	$2.1^{a} \pm 0.48$	10.7 ± 0.87	$0.09^{b} \pm 0.009$
June	$0.4^{b} \pm 0.04$	$2.7^{a} \pm 0.26$	$22.6^{a} \pm 0.72$	41.6 ± 0.65	$2.1^{a} \pm 0.31$	10.0 ± 0.41	$0.06^{a} \pm 0.007$
November	$0.7^{a} \pm 0.03$	$4.7^{b} \pm 0.21$	$63.2^{b} \pm 1.10$	41.3 ± 0.56	$5.1^{b} \pm 0.47$	12.2 ± 0.99	$0.08^{b} \pm 0.006$

TN, Total Nitrogen; CP, Crude Protein; NDF, Neutral Detergent Fibre; ADF, Acid Detergent Fibre; P, Phosphorus.

Table 5. First canonical correlation coefficient between forage quality and cattle activity; original variables and their canonical variates, in frequently selected sites.

Variable	Canonical coefficient	Original variables versus their canonical variates	[3]Original variables versus opposite canonical variates
Cattle activity			
Grazing	324.09	-0.46	-0.17
Resting	318.37	0.19	0.07
Walking	131.95	0.65	0.25
Forage quality			
Phosphorus	0.09	-0.02	-0.01
Total Nitrogen	-2.23	-0.09	-0.03
CP	2.14	-0.05	-0.02
NDF	0.92	0.92	0.35
ADF	0.35	0.25	0.09
Cellulose	-0.28	0.10	0.04
Lignin	-0.02	-0.01	-0.01
Statistical analysis			
Canonical correlation[1]	0.376		
P > F	0.167		
Wilk's Lambda[2]	0.167		

[3]Opposite canonical variates, include the canonical variates from cattle activity, and the opposite opposite would therefore be canonical variates from forage quality.

with less time spent resting. Similar to cattle in this study, Solanki (2000) found that free grazing goats spent 62% of daytime grazing and 8% walking. Variation in behavioural activities might be linked to the differences in the veld types and in some cases the management practice such as kraaling in other villages. More time was spent grazing at Mnyameni, a coastal village with high herbaceous biomass for a greater part of the year (Lesoli, 2007). Abundance of forage might have resulted in high incidence of selection by animals, hence resulting in more time spent grazing. The dominant species are mostly C_4 grass species which include *S. africanus*, *P. dilatatum* and *E. plana* (Lesoli, 2007). The latter has tough and fibrous leaves (O` Reagain, 1983) and is of intermediate palatability (Leigh, 1960), therefore, it makes grazing difficult, which might explain the extended grazing periods. *S. africanus* is unpalatable and of low nutritive value (4.5% CP) (Njoya et al., 1999), therefore, to satisfy their nutritional requirements, cattle have to spend more time grazing.

Mnyameni is surrounded by other villages and has limited size of virgin grazing lands. Most of the area is abandoned fields and functioning fields are near homesteads. Cattle graze abandoned fields dominated with *Pennisetum clandestinum* and *Cynodon dactylon* in winter (Bennett et al., 2007; Moyo et al., 2008b), hence, there is less time spent walking as most of the time is dedicated to grazing. The management practice of kraaling at Mnyameni deprive cattle an opportunity to graze at night, thus to meet their nutrient requirements cattle have to graze extensively during the day (Smith et al., 2006). This behavioural pattern was observed at West Virginia University farm where restricted time for grazing influenced the grazing time pattern of cows (Gekara et al., 2005). Magwiji lies in the Themeda – Festuca Alpine veld and is dominated by sweetveld grass species which include *Eragrostis chloromelas*, *E. muticus* and *H. contortus. E. muticus* is an unpalatable perennial; its dominance suggests that it is not usually selected by animals when forage is abundant. Animals might instead prefer *E. chloromelas* and *H. contortus* which are nutritious and palatable during the winter period. Animals, therefore, easily satisfy their nutrient requirements leading to extended period of rest. The absence of kraaling might be the key factor in the observed high resting percentage observed at Magwiji. Mandaluniz et al. (2005), studying behaviour of cows grazing at Gorbeia natural park in Spain found that time spent resting is related to daylight period. Resting time was abruptly reduced when percentage of daylight time was reduced.

Cattle at Upper Mnxe were kraaled and the grazing lands are part of the sour veld characterized by forage that loses nutritive value during winter (Low and Rebelo, 1996; van Oudtshoorn, 1999). The decline in quantity and quality of forage in winter and some indirect effects of kraaling might have contributed to more time spent walking in winter in order to secure enough forage for satisfying nutrient requirements. The late growing season, autumn, is characterized by the start of a decrease in the quantity and quality of forage, hence the increased grazing times observed at Upper Mnxe. A similar behaviour was observed in the Sahel region (Schlecht et al., 2003). Ruminants will increase grazing time to adapt to a decrease in forage availability (Allden and Whittaker, 1970; Penning et al., 1991; Rook et al., 1994). Decrease in forage quantity and quality in winter results in cattle walking long distances in search of nutritious forage. This observation was reinforced in a semi-arid range in India (Dhanda and Singh, 2002) where sheep spent more time walking in search of forage while actively grazing in winter. Upper Mnxe is in the highland sourveld, and extensive walking is expected in this veld type, since it loses quality in winter (Ellery et al., 1995). In addition, greater selective behaviour by cattle during the dry season result in animals spending more time walking in search of plants or patches with nutritious vegetation. Ayatunde et al. (1999) reported that cattle grazing Sahelian rangelands exhibit a high degree of diet selectivity.

In Spain, extensive walking was observed when cattle maintained large home ranges in winter and spring (Lazo, 1994). The early growing season (spring) was associated with more time spent resting at Upper Mnxe because of the abundance of nutritious forage. Overall, resting was mostly in summer and spring because of the availability of forage. The increase in the time spent grazing and walking in autumn and winter, respectively, might be a result of kraaling at Upper Mnxe. Cattle had to cope with the limited forage quantity and quality in the reduced time available for grazing. This similar result was reported in cows at Rugballegaard experimental farm in Denmark which had to compensate for the reduction in time at pasture by increasing the proportion of time spent grazing (Kristensen et al., 2007). A similar pattern was also observed in Mpwapwa Zebu cattle in Tanzania (Jung et al., 2002). Mnyameni villagers also kraal their animals, however, time spent grazing, resting and walking was not different across seasons. This suggests that decrease in forage quality in the highland sourveld had a marked effect on the behavioural patterns of cattle. Absence of kraaling allowed night grazing at Magwiji, and that necessitated cattle to fulfill their nutritional requirements without major changes in behavioral activity across seasons.

Cattle exhibited marked diurnal periodicity in their behavioural activities. Similar to this study, cattle were observed to graze heavily in the morning and rest while ruminating in the afternoon (Sneva, 1970; Martin, 1978; Hafez and Bouissou, 1975; Bagshaw, 2001). This behavioural pattern seems to be typical of most ruminants, as similar results were observed with free grazing goats in a semi-arid region in India (Solanki, 2000) and steers in Kansas State in the United States of America (Brandyberry et al., 1991). Afternoon resting may be a mechanism to reduce the effect of heat stress. Grazing time in sheep and cattle has been found to decline with increase in environmental temperature (Bayer, 1990; Fierro and Bryant, 1990; Shinde et al., 1997). Cattle lower physical activity by reducing feeding time. They offset the high temperature by resting (Matias, 1998). Village differences in behavioural activities might be a result of the grazing management practices inherent in these villages. Kraaling at Mnyameni and Upper Mnxe resulted in more time spent grazing in the morning and mid-morning periods. In the afternoon, cattle tended to rest for longer periods. Kraaling result in cattle adjusting their behavioural activities in order to maximize nutrient acquisition. Smith et al.'s (2006) study in Ethiopia found that extending pasture access time from 7 to 11 h did not significantly increase the amount of time spent grazing. This is in contrast to some earlier studies which reported substantial grazing at night, for example it is reported that night grazing can account for up to 25% of total daily grazing time in free-ranging indigenous African cattle (Smith, 1959; Haggar, 1968).

Supplementation of free ranging cattle with cottonseed meal reduced the time spent grazing (Schauer et al., 2005), while more time was spent grazing in non-supplemented cattle. This suggests that cattle have to spend more time walking in search of high quality forage in winter when forage crude protein is low. The concentration of phophorus and crude protein in grasses decreases in winter, and is conspicuous in the sourveld (O`Connor et al., 2004) where protein concentrations sometimes reach levels below the maintenance requirements of ruminants (Tainton, 1999). This might explain the observation in this study where low phosphorus and crude protein concentration was associated with extensive walking. Katjiua and Ward (2006) found that cattle preferred browse with high crude protein and phosphorus content in their study of cattle diet selection during the hot dry season in Namibia. Since cattle are mainly grazers, this suggests that in an area with few browse, cattle will have to walk some distance in search of grass patches to satisfy their phosphorus and crude protein requirements. The association of high NDF concentration in forage and extensive walking periods might also be explained by the need for animals to walk long distances in search of forage of high nutritive value. On the other hand, high NDF and ADF values in forages might have caused cattle to spend more time resting in order to ruminate. Da Silva et al. (2006) observed that increased levels of NDF in goats forage diets resulted in increased time of rumination and mastication.

Conclusion

Grazing management intervention programs have to consider the current grazing management practices and the associated livestock foraging behavioural patterns for the intervention to be effective. Traditional grazing practices provide sufficient rangeland access time for animals to achieve daily voluntary food intake, especially in sourveld areas characterized by a decrease in forage quality and quantity. Differences in veld types and management have to elicit various intervention strategies; for example, kraaling of animals in the sourveld deters introduction of rotational grazing camps, since it will limit movement of animals in winter during the search for nutritious forage.

On the other hand, the coastal forest and thornveld have enough forage even during winter, hence there is limited walking, therefore, fragmentation of the grazing lands into camps for rotational grazing is feasible. The present communal grazing management system is adapted in specific areas, and within certain constraints, to local forage resources and livestock needs and behaviour.

ACKNOWLEDGEMENTS

The authors wish to thank the technical staff in the department of Livestock and Pasture Science for their assistance in data collection and Kellogg foundation (P3003636) for funding the study.

REFERENCES

Acocks JPH (1988). Veld types of South Africa. Memoirs Botanical Surv. S. Afr., 57: 1-146.

Allden WG, Whittaker, IAM (1970). The determinants of herbage intake by grazing Sheep: The interrelationship of factors influencing herbage intake and availability. Aust. J. Agric. Res., 21: 755-766.

Ashutosh Dhanda OP, Singh G (2002). Changes in grazing behaviour of native and crossbred Sheep in different seasons under semi-arid conditions. Trop. Anim. Health Prod., 34: 399-404.

Ayantunde AA, Hiernaux P, Fernández-Rivera S, van Keulen H, Udo HMJ (1999). Selective grazing by cattle on spatially and seasonally heterogeneous rangeland in Sahel. J. Arid Environ., 42: 261-279.

Baars RMT, Ottens JJ (2001). Grazing behaviour and diet selection of Barotse cattle on a communally grazed floodplain in west Zambia. Afr. J. Range For. Sci., 18: 5-12.

Bagshaw CS (2001). Factors influencing cattle (*Bos Taurus*) use of streams. PhD Thesis, University of Auckland, Australia.

Bayer W (1990). Behaviour compensation for limited grazing time by herded cattle in Central Nigeria. Appl. Anim. Behav. Sci., 27: 9-19.

Bennett J, Lent PC, Harris PJC (2007). Dry season foraging preferences of cattle and sheep in a communal area of South Africa. Afr. J. Range. For. Sci., 24: 109-121.

Bidwell TG, Engle DM (1992). Relationships of fire behaviour to tallgrass prairie herbage production J. Range Manag., 45: 579-584.

Brandyberry SD, Cochran RC, Vanzant ES, Delcurto T, Corah LR (1991). Influence of supplementation method on forage use and grazing behaviour by beef cattle grazing bluestem range. J. Anim. Sci., 61: 4128-4136.

Da Silva MMC, Branco RH, Rodrigues MT, Rodrigues CAF, Viana V, Morbi FDO, da Silva Matos R, de Souza Duarte M (2006). Effects of dietary fiber from forage of advanced maturity on performance of lactating goats. J. Anim. Sci., p. 84-372.

Ellery WN, Scholes MC, Scholes RJ (1995). The distribution of sweetveld and sourveld in South Africas grassland biome in relation to environmental factors. Afr. J. Range For. Sci., 12: 38-45.

Fierro IC, Byrant FC (1990). Grazing activities and bioenergetics of sheep on native range in Southern Peru. Small Rumin. Res., 3: 135-146.

Gekara OJ, Prigge EC, Bryan WB, Nestor EL, Seidel G (2005). Influence of Sward height, daily timing of concentrate supplementation, and restricted time for grazing on forage utilization by lactating beef cows. J. Anim. Sci., 83: 1435-1444.

Gibb MJ, Huckle CA, Nuthali R, Rook AJ (1999). The effect of physiological state (lactating or dry) and sward surface height on grazing behavior and intake by dairy cows. Appl. Anim. Behav. Sci., 63: 269-287.

Goering HK, van Soest PJ (1970). Forage Fibre Analysis (Apparatus, Reagents, Procedures and some Applications). United States Department of Agriculture, Agriculture Research Services Handbook No. 379, Washington DC, United States of America.

Govender KPS (1998). Report 314/98 Magwiji Ward, Jozana's Hoek, Sterkspruit. Report compiled by the Directorate of Restitution Research, Department of Land Affairs, Pretoria.

Haggar RJ (1968). Grazing behaviour of Fulani cattle at Shika, Nigeria. Trop. Agric., 45: 179-185.

Hafez ESE, Bouissou MF (1975). The behaviour of cattle. In: Hafez ESE(ed) The Behaviour of Domestic Animals. Bailiere Tindal, London.

Harris RJ (1975). A primer of multivariate statistics. Academic press, New York. Pp. 332.

Hassoun P (2002). Cattle feeding behaviour at pasture: a methodology related to on farm measurements. Anim. Res., 51: 35-41.

Hull JL, Lofgreen GP, Meyer JH (1960). Continuous versus intermittent observations in behavior studies with grazing cattle. J. Anim. Sci., 19: 1204.

Jung J, Yngvesson J, Jensen P (2002). Effects of reduced time on pasture caused by prolonged walking on behaviour and production of Mpwapwa Zebu cattle. Grass Forage Sci., 43: 239-251.

Kassahun A, Snyman HA, Smit GN (2008). Livestock grazing behavior along a degradation gradient in the Somali region of eastern Ethiopia. Afr. J. Range For. Sci., 25: 1-9.

Katjiua MLJ, Ward D (2006). Cattle diet selection during the hot-dry season in a semi-arid region of Namibia. Afr. J. Range For. Sci., 23: 59-67.

Keyser N (1997). Geological map of the Republic of South Africa and the Kingdoms of Lesotho and Swaziland. Pretoria: Council for Geoscience.

Kristensen T, Oudshoorn F, Munksgaard L, Søegaar K (2007). Effect of time at pasture combined with restricted indoor feeding on production and behaviour in dairy cows. Anim., 1: 439-448.

Lachica M, Aguilera JF (2003). Estimation of energy needs in the free-ranging goat with particular reference to the assessment of its energy expenditure by the ^{13}C-bicarbonate method. Small Rumin. Res., 49: 303-318.

Lazo A (1994). Social segregation and the maintenance of social stability in a feral cattle population. Anim. Behav., 48: 1133-1141.

Leigh JH (1960). The relative palatability of various varieties of Weeping lovegrass (*Eragrostis curvula* (Schrad) Nees). Grass Forage Sci., 16: 135-140.

Lesoli M (2008). Vegetation and Soil Status, Human Perceptions on the condition of Communal Rangelands of the Eastern Cape, South Africa. MSc thesis, University of Fort Hare, Alice, South Africa.

Low AB, Rebelo AG (1996). Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism. Pretoria, South Africa.

Mandaluniz N, Oregui LM, Aldezabal A (2005). Utilization of gorse and heather communities by cattle in mountain grazing. In: Mosquera-Losada MR, McAdam J and Rigueiro-Rodriguez A (eds) Silvopastoralism and Sustainable Land Management. CABI Publishing, Oxford, United Kingdom. Pp. 157-159.

Matias JM (1998). Behaviour of grazing purebred and crossbred dairy cows under tropical conditions. Appl. Anim. Behav. Sci., 59: 235-243.

Martin CS (1978). Evaluating the impact of cattle grazing on riparian habitats in the national forests of Arizona and New Mexico In: Cope OB (ed) Proceedings of the forum - grazing and riparian/stream ecosystems. Denver, Colorado, Trout Unlimited, Inc.

Martin P Bateson P (1985). Measuring Behaviour. Cambridge University Press, Cambridge. Pp. 193. McNaughton SJ (1990). Mineral nutrition and seasonal movement of African migratory ungulates. Nat., 345: 613-615.

Moyo B, Dube S, Lesoli MS, Masika PJ (2008a). Communal area grazing strategies: Institutions and traditional practices. Afr. J. Range

For. Sci., 25: 47-54.
Moyo B, Dube S, Lesoli MS, Masika PJ (2008b). Basal cover, biomass and herbaceous species composition, and soil properties of key grazing patches in mesic bush, sweet and sour veld of the Eastern Cape, South Africa. In: Proceedings of the 41rd Annual Congress of the Grassland Society of Southern Africa (21 - 21 July) Badplaas, South Africa.
Njoya A, Mbanya NJ, Nguemdjom A, Kamga P, Ndi C, Kameni A, Nfi A (1999). Cattle productivity on smallholder farms in the western highlands of Cameroon. In: Development of feed supplementation strategies for improving the productivity of dairy cattle on small holder farms in Africa. Proceedings of Research Coordination of a Coordinated Research Project organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture held in Vienna, Austria, 7-11 September1998.
O`Connor TG, Uys RG, Mills AJ (2004). Ecological effects of fire-breaks in the montane grasslands of the Southern Drakensberg, South Africa. Afr. J. Range For. Sci., 21: 1-9.
O` Reagain PJ (1993). Plant structure and the acceptability of different grasses to Sheep. J. Range Manag., 46: 232-236.
Penning PD, Parsons AJ, Orr RJ, Treatcher TT (1991). Intake and behaviour responses by Sheep to changes in sward characteristics under continuous stocking. Grass Forage Sci., 46: 15-28.
Provenza FD, Balph DF (1990). Applicability of five diet selection models to various foraging challenges ruminants encounter. In: Hughes RN (ed) Behavioral Mechanisms of Food Selection. NATO ASI Series: Ecological Sciences 20. Springer-Verlag, Berlin, Germany. Pp. 423-459.
Rook AJ, Huckle CA, Penning PD (1994). Effects of sward height and concentrate supplementation on the ingestive behaviour of spring calving dairy cows grazing grass clover swards. Appl. Anim. Behav. Sci., 40: 101-112.
SAS Institute (1990). SAS/STAT Users guide: statistic version 6.12. Cary, North Carolina, SAS Institute Inc.Schauer CS, Bohnert DW, Ganskopp DC, Richards CJ, Falck SJ (2005). Influence of protein supplementation frequency on cows consuming low-quality forage: Performance, grazing behaviour, and variation in supplement intake. J. Anim. Sci., 83: 1715-1725.
Schlecht E, Kadaoure I, Becker K (2003). Moving across village landscapes: Seasonal changes of grazing orbits of cattle, sheep and goats in the Sahel. Trop. Subtrop. Agroeconom., 3: 427-431.
Senft RL, Coughenour MB, Bailey DW, Rittenhouse LR, Sala OE, Swift DM (1987). Large herbivore foraging and ecological hierarchies. BioScience 37: 789-799.
Shinde AK, Karim SA, Patnayak BC, Mann JS (1997). Dietary preference and grazing behaviour of sheep on Cenchrus ciliaris pasture in semi arid region of India. Small Rum. Res., 26: 119-122.
Smith CA (1959). Studies on the northern Rhodesia *Hyparrhenia* veld 1: The grazing behaviour of indigenous cattle grazed at light and heavy stocking rates. J. Agric. Sci., 52: 369-375.
Smith DG, Cuddeford D, Pearson RA (2006). The effect of extended grazing time and supplementary forage on the dry matter intake and foraging behaviour of cattle kept under traditional African grazing systems. Trop. Anim. Health Prod., 38: 75-84.
Sneva FA (1970). Behavior of yearling cattle on eastern Oregon Range. J. Range Manag., 23: 155-157.
Solanki GS (2000). Grazing behaviour and foraging strategy of goats in semi-arid region in India. Trop. Ecol., 41: 155-159.
Statistics South Africa., (1999). Rural Survey 1997. Pretoria.
Steel RDG, Torrie JH (1987). Principles and Procedures of statistics. A Biometric Approach. McGraw-Hill, New York.
Tainton NM (1999). Veld Management in South Africa. University of Natal Press, Pietermaritzburg, South Africa.
Van Oudtshoorn F (1999). Guide to Grasses of Southern Africa. Briza Publications, Pretoria.
Zar JH (1996). Biostatistical Analysis. Prentice Hall. Pp. 282-283.