Factors affecting the feeding behaviour of free ranging Tswana and Boer goats in the False Thornveld of the Eastern Cape, South Africa.

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ABSTRACT: The study was aimed at investigating the factors affecting the feeding behaviour of 3 free ranging Tswana and 3 Boer goat does in the False Thornveld of the Eastern Cape Province, South Africa. Feeding was observed and recorded during winter (cool dry season) and the summer (hot wet season). Observations included the following categories: browsing, grazing and non-feeding activities (NFA). Browsing activity included bi-pedal stance (recorded separately) and represented the browsing of all woody species. Tree/Bush species browsed at the time of recording were visually identified and recorded separately. Grazing activity represented the grazing of grasses without the identification or recording of species. Non-feeding activities include separate recordings of walking, standing, lying and drinking. Results showed goats spent 21.9 %, 44.7 % and 33.3 % of their day on browsing, grazing and non-feeding activities. Goats spent more time on NFA in the cold-dry season (68.8) than the hot-wet season (31.9). Though diurnal variations were observed across breed and season in terms of browsing and non feeding activities, no diurnal variations were found between the breeds. Knowledge of seasonal and breed variations in feeding behaviour of goats is fundamental to the development of management strategies for small scale farmers aimed at optimal and sustained use of the natural vegetation.
[Lebopa C.K. Boomker E.A, Chimonyo M, Mulugeta S.D. **Factors affecting the feeding behaviour of free ranging Tswana and Boer goats in the False Thornveld of the Eastern Cape, South Africa**. Life Science Journal. 2011;8(S2):70-80] (ISSN: 1097 – 8135). http://www.lifesciencesite.com.

KEYWORDS: Feeding behaviour, Range Tswana goats, Range Boer goats, Season, Diurnal variation
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1. INTRODUCTION

The goat's ability to utilize sparse vegetation and survive in stressful nutritional environments better than other ruminant species (Silanikove, 2000; Lachica & Aguilera, 2003; Iniguez, 2004) makes this species an appropriate candidate as a food producing animal in arid environments (Mellado *et al*., 2004). Goats have certain physical characteristics such as narrow muzzle, mobile upper lip, prehensile tongue, bipedal stance, agility in climbing and physical dexterity that provide them with necessary foraging skills to select preferred plant species (Ngwa *et al*., 2000; Mellado *et al*., 2004) and adapt to different food resources according to its availability (Orihuela & Solano, 1999). Goats are mainly raised in rangelands in semi-deserts and sub-tropic conditions (Tefera *et al*., 2008). Conditions in the rangelands, such as heterogeneity, as well as the seasonal change of potential feeds and nutritional restrictions, induce range ruminants to exhibit strong food selectivity in order to meet the demands for maintenance and production (Agreil & Meuret, 2004; Morand-Fehr *et al*., 2004). The effect of selection by these grazing herbivores changes the species of plants found in various populations, but the mechanism underlying feeding behaviour and diet selection by goats remains poorly understood (Illius *et al.*, 1999). Interaction between ruminant choice rules and plant characteristics trigger consistent and dynamic behavioural adjustments (Agreil & Meuret, 2004). Understanding feeding behaviour and diet selection by ruminants is imperative for efficient rangeland management as well as profitable animal production from rangelands because these parameters affect animal performance and hence production (Torrano & Valderrábano, 2005; Sanon *et al*., 2007). To achieve acceptable levels of animal performance which are compatible with resource preservation, a deep knowledge of feeding behaviour and diet selection is needed (Sanon *et al*., 2007). Efficient utilization of available resources also requires the provision of data on plant density, forage species and

phytomass at any specific site to define its carrying capacity and strategies of feed supplementation according to desired level of production (Lachica & Aguilera, 2003; Yayota *et al.*, 2009). The objective of the study was to determine how the season, time of the day and period of occupation of a camp influence the feeding behaviour of Tswana and Boer goats.

2. MATERIALS AND METHODS

2.1. Study site

The research was conducted at the University of Fort Hare Research Farm near Alice, in the Eastern Cape Province of South Africa ($32^0$49'S, $26^0$54'E). The research farm is situated 80km inland from the Eastern Cape coastline at an altitude of 500-600 m above sea level. The climate can be regarded as semi-arid with a mean annual rainfall of 574 mm and which varies between 227 mm and 967 mm. The average annual rainfall during the study year (2007) was 506.4 mm. Most of the rain (79 %) fell during the 7 months of the hot-wet season from October to April and the cold-dry season (21%) was relatively dry. The vegetation is representative of Acocks (1975) "False Thornveld of the Eastern Cape" and ranges from grassland through *Acacia karroo* Savannah to dense, clumped, medium short evergreen thicket. The Savannah consists of subtropical thicket vegetation, mainly dominated by deciduous woody shrubs shorter than 1.5m, although the woody layer reaches 4 to 5m (Scogings *et al.*, 1996). Two paddocks (8-9 ha in size) which form part of a wagon wheel system, were rested for at least one growing season prior to the start of the experiment. In each paddock an area of 1ha chosen on the basis of a good balance of bush and grass, and judged to be uniform in terms of vegetation was enclosed. During winter (cold-dry season) and summer (hot-wet season), a 1ha plot was grazed/browsed by the experimental goats during the four-week experimental period. Prior to the start of the experiments in each season, a botanical survey was done for each plot according to the method described by Trollope (1986). In addition, a disc pasture meter (Bransby & Tainton, 1977) was used to estimate the phytomass of grass at the beginning and end of the experiments and the results used to determine stocking rate.

2.2. Experimental animals

The experimental 1ha plot was stocked with 8 Boer and 8 Tswana goats for a period of four weeks. The trial was repeated in two seasons: June/July 2007 (cold-dry season) and October/November 2007 (hot-wet season). At the start of each trial, there was an adaptation period of two weeks on the veld immediately adjacent to the experimental area. For easier identification from the distance, the six animals to be observed were painted on both flanks with unique identification number (±300 mm in size). During the three-week experimental periods, goats had daily access to the experimental plots only, but kraaled at night. Adjacent paddocks with similar vegetation were used for grazing experimental animals during the period between experiments.

2.3. Experimental procedures

Twice a week (Tuesdays and Thursdays), during each of the two experimental seasons, feeding behaviour of six goats (3 Tswana, three 3 Boer) was observed. Feeding behaviour observations were recorded from 0800h to 0935h (assumed to represent morning), 1100h to 1235h (assumed to represent midday) and 1400h to 1535h (assumed to represent afternoon goat activity). As there were only three observers, only three goats could be observed at a time. Observers were randomly allocated to a goat to avoid human bias. Therefore, from 800h to 0815h, the feeding behaviour of three goats (e.g. 3 Tswana) was observed followed by the observations of the 3 Boer goats from 0821h to 0835h. Observations continued at 0900h to 0915h with 3 Boer goats followed by 3 Tswana at (0921h-0935h).. The same procedure was repeated during midday (1100h-1235h) and afternoon (1400h-1535h) observations.

During observations the following activities of the goats were recorded: browsing, grazing and non-feeding activities (walking, lying, standing and drinking). Browsing activity included bi-pedal stance (recorded separately) and represented the browsing of all woody species. Tree/Bush species browsed at the time of recording were visually identified and recorded separately. Grazing activity represented the grazing of grasses without the identification or recording of species. Non-feeding activities include separate recordings of walking, standing, lying and drinking. Each goat was observed for 30 minutes in the morning, midday and afternoon observation periods.

2.4. Statistical analyses

During the 30 minute observation time, the time spent on different activities (grazing, browsing, walking, drinking, lying and standing) by a goat was recorded in minutes and later converted into percentages. The percentage time was arcsine transformed prior to subjecting the data to analysis of variance. The analysis of data was conducted using Generalized Linear Model Procedure of SAS (SAS, 2003). The significance of a factor on a given feeding behaviour was tested at P=0.05. The Tukey

procedure was used to separate means among levels within a significant factor. The means and standard errors were back transformed into percentage for the reporting purpose. The factors defined in the analysis model were breed, days in the grazing camp, time of the day, season and two and three way interactions among these factors.

The following statistical model was used on each of the activities:

$$Y_{ijklm} = \mu + B_i + T_j + D_k + S_l + (BT)_{ij} + (BD)_{ik} + (BS)_{il} + (TD)_{jk} + (TS)_{jl} + (DS)_{kl} + e_{ijklm}$$

Where

Y is observation on any of the feeding activities; **μ** is overall mean; $\mathbf{B_i}$ is breed effect (Indigenous Tswana vs improved Boar goat); $\mathbf{T_j}$ is Time of the day effect**:** Morning (0800h-0935h), midday (1100h-1235h) and afternoon (1400h-1535h); $\mathbf{D_k}$ is day in camp effect (1st day to 6th day); $\mathbf{S_l}$ is season effect (the cold-dry season vs the hot-wet season); $\mathbf{(BT)_{ij}}$ **to** $\mathbf{(DS)_{kl}}$ is a two-way interaction of effects among the factors included in the model; **e** is random error term, assumed to be distributed normal with mean of 0 and variance, σ^2_e

3. RESULTS

On average, the goats were observed to spend 21.9 %, 44.7 % and 33.3 % of their day on browsing, grazing and non-feeding activities (walking, standing, lying, drinking). Goats thus spent 33% and 67% of their active feeding time on browsing and grazing respectively.

3.1. Time spent on browsing

The breed, season, time of the day and period of occupation of a camp significantly (P<0.05) influenced the relative time the goats devoted to browsing as shown in Table 1. The average percentage time spent on browsing was significantly higher (P=0.02) in the cold-dry season compared to the hot-wet season. Across seasons, Tswana goats allocated more time (P=0.0001) to browsing than the Boer goats. Time spent on browsing by goats changed significantly during the different times of the day (P=0.005). On average across times of the day, goats spend more time on browsing in the morning compared to midday and afternoon. There were significant differences (P=0.002) in time spent on browsing during the period of occupation of the grazing camp.

Table 1. Mean percent time spent on browsing as influenced by season, breed, time of the day and period of occupation of a camp by goats

Factors	Browsing time (%)	SE
Season		
The cold-dry season	21.7[a]	0.04
The hot-wet season	16.7[b]	0.04
Breed		
Tswana	23.5[a]	0.04
Boer	15.1[b]	0.04
Time of the day		
(0800h – 0935h)	24.3[a]	0.06
(1100h – 1235h)	15.9[b]	0.06
(1400h – 1535h)	17.6[b]	0.06
Period of occupation		
Day 1	28.5[a]	0.11
Day 2	19.3[ab]	0.11
Day 3	22.6[ab]	0.11
Day 4	16.5[b]	0.11
Day 5	15.4[b]	0.11
Day 6	13.9[b]	0.11

Means, within each factor, in the same column with different superscripts are significantly different (P < 0.05).

Tswana goats showed significant seasonal variation in browsing time while the browsing time of Boer goats did not show this seasonal difference (Table 2).

Table 2. Mean percent time spent on browsing by Tswana and boar goats in different season, time of the day and period of occupation of a camp

Factors	Browsing time (%)		SE
	Breed		
	Tswana	Boer	
Season			
The cold-dry season	30.0 [a]	14.4 [b]	0.07
The hot-wet season	17.7[b]	15.7 [b]	0.07
Time of the day			
(0800h – 0935h)	31.4	17.8	0.11
(1100h – 1235h)	17.0	14.8	0.11
(1400h – 1535h)	23.0	12.8	0.11
Period of occupation			
Day 1	33.6	23.5	0.22
Day 2	25.2	14.0	0.22
Day 3	23.3	21.9	0.22
Day 4	22.6	11.1	0.22
Day 5	22.1	9.7	0.22
Day 6	15.6	12.2	0.22

Means in the same column with different superscripts are significantly different ($P < 0.05$).

Although Tswana goats spent more time browsing both in the morning and afternoon compared to Boer goats, there was no significant differences ($P>0.05$) between the breeds. The number of days spent occupying a camp did not differ significantly ($P>0.05$) between the Tswana and the Boer goats, but browsing seemed to decrease with advancing period of occupation. Regardless of breed, the time the goats spent browsing was not affected by the time of day during either the cold-dry season or the hot-wet season. However, the amount of time the goats spent browsing in the camp on progressive days became significantly different ($P=0.01$) as the period of occupation increased in the cold-dry season. Goats spent more time browsing during the early days of occupation of a camp. With advancing period of occupation during the cold-dry season, goats decreased their browsing time from 33.3 % on the first day of observations to 11.7 % on the last day of the observations. Similarly during the hot-dry season, browsing decreased with advancing period of occupation of a camp from 23.9 % on the first day of sampling to 16.2 % on the last day of sampling. The decrease in time spent browsing with advancing period of occupation was high during the cold-dry season (21 %) compared to the hot-wet season (8 %). The time of the day on the consecutive days of observation in the camp showed no significant effect ($P>0.05$) on the time goats spent browsing. During each of the six observation days, browsing was high in the morning compared to midday and afternoon feeding periods. Browsing showed a decreasing trend with advancing period of occupation in the morning, at midday and in the afternoon.

3.2. Time spent on grazing

There was a significant difference between seasons ($P<0.0001$) and breeds ($P=0.01$) in the amount of time spent on grazing. However, time of the day and period of occupation of a camp, did not significantly influence the amount of time the goats spent grazing. The average time spent on grazing by goats was significantly higher ($P=0.04$) in the hot-wet season compared to the cold-dry season as shown in Table 3. In general, Boer goats spent more time ($P=0.01$) grazing compared to Tswana goats.

The Tswana and Boer goats did not differ ($P>0.005$) in the amount of time spent grazing during either the cold-dry season or the hot-wet season as shown in Table 4. The amount of time spent grazing at different times of the day did not differ significantly ($P>0.005$) between breeds, although goats spent more time grazing during the afternoon compared to morning and midday. During the early days of occupying a camp, the Boer goats spent significantly more ($P=0.01$) time grazing than the Tswana goats.

Table 3. Mean percent time spent on grazing as influenced by season, breed, time and period of occupation of a camp by goats

Factors	Grazing time (%)	SE
Season		
The cold-dry season	26.8[a]	0.04
The hot-wet season	59.1[b]	0.04
Breed		
Tswana	39.0[a]	0.04
Boer	46.3[b]	0.04
Time of the day		
(0800h – 0935h)	41.9	0.07
(1100h – 1235h)	38.9	0.07
(1400h – 1535h)	47.1	0.07
Period of occupation		
Day 1	35.6	0.12
Day 2	45.1	0.12
Day 3	48.2	0.12
Day 4	45.1	0.12
Day 5	41.6	0.12
Day 6	40.3	0.12

Means, within each factor, in the same column with different superscripts are significantly different ($P < 0.05$).

Table 4. Mean percent time spent on grazing by Tswana and boar goats in different season, time of the day and period of occupation of a camp

Factors	Grazing time (%)			
	Tswana	**SE**	**Boer**	**SE**
Season				
The cold-dry season	24.7	0.07	28.9	0.09
The hot-wet season	54.4	0.07	64.1	0.09
Time of the day				
(0800h – 0935h)	37.1	0.12	46.8	0.13
(1100h – 1235h)	37.2	0.12	40.6	0.13
(1400h – 1535h)	42.8	0.12	51.6	0.13
Period of occupation				
Day 1	31.9	0.27	39.4	0.27
Day 2	32.8[a]	0.27	57.8[b]	0.27
Day 3	42.5	0.27	53.8	0.27
Day 4	38.1	0.27	52.1	0.27
Day 5	45.6	0.27	37.6	0.27
Day 6	43.6	0.27	37.1	0.27

Means in the same row with different superscripts are significantly different ($P < 0.05$).

Regardless of the breed, the time goats spent grazing at a particular time of day was not affected by the season. The highest percentage grazing time was recorded during the hot-wet season in the afternoon (61.8%± 0.13) while the lowest percentage grazing time was recorded in the cold-dry season during midday (20.1% ± 0.13). After day 1 the effect of the period of occupation of the camp on the amount of time spent grazing was significantly different ($P=0.04$) between the hot-wet season and the cold-dry season. Goats spent less time grazing during the early days of occupation of a camp during the hot-wet season. With advancing period of occupation, goats increased their grazing time from 43.9 % on the first day of observations to 62.4 % on the last day of the observations. However, during the cold-dry season, grazing decreased with advancing period of occupation of a camp from 27.7 % on the first day of sampling to 20.1 % on the last day of sampling.

3.3. Time spent on non-feeding activities (NFA)

The breed and period of occupation of a camp did not significantly influence the relative time goats devoted to NFA. However, season (P<0.0001) and time of the day (P=0.004) significantly influenced the time goats spent on NFA as shown in Table 5. On average goats spent more time on NFA during the cold-dry season than the hot-wet season. Across seasons, Boer and Tswana goats did not differ significantly in the amount of time allocated to NFA. Time spent by goats on NFA changed significantly during the day (P=0.004). On average, the midday period was dominated by NFA compared to morning and afternoon activities. Goats spent less time on NFA (46.2 %) during the early days (first 3 days) of occupation of a camp. However, with advancing period of occupation (last 3 days), time spent on NFA increased (54.6 %). There was no significant difference (P>0.05) in time spent on NFA during the period of occupation of a camp.

Table 5. Mean percentage time spent on NFA as influenced by season, breed, time of the day and period of occupation of a camp by goats

Factors	Time spent on NFA (%)	SE
Season		
The cold-dry season	68.8 [a]	0.07
The hot-wet season	31.9 [b]	0.07
Breed		
Tswana	51.9	0.07
Boer	48.9	0.07
Time of the day		
(0800h – 0935h)	45.0 [a]	0.11
(1100h – 1235h)	59.4[b]	0.11
(1400h – 1535h)	46.7[a]	0.11
Period of occupation		
Day 1	50.2	0.22
Day 2	47.9	0.22
Day 3	40.5	0.22
Day 4	51.0	0.22
Day 5	53.0	0.22
Day 6	59.8	0.22

Means in the same column with different superscripts are significantly different (P < 0.05)

Table 6. Mean percent time (least square means) spent on NFA by Tswana and Boer goats during different season, time of the day and period of occupation of a camp

Factors	Grazing time (%)		SE
	Tswana	Boer	
Season			
The cold-dry season	66.7	70.9	0.15
The hot-wet season	37.0	27.0	0.15
Time of the day			
(0800h – 0935h)	43.8	46.2	0.22
(1100h – 1235h)	63.9	54.8	0.22
(1400h – 1535h)	47.9	45.6	0.22
Period of occupation			
Day 1	48.6	51.5	0.44
Day 2	55.4	40.4	0.44
Day 3	48.0	33.3	0.44
Day 4	52.7	49.3	0.44
Day 5	49.3	56.6	0.44
Day 6	57.4	62.2	0.44

Means in the same row with different superscripts are significantly different (P < 0.05).

Tswana and Boer goats did not differ significantly (P=0.05) in the amount of time allocated to NFA during either the cold-dry season or the hot-wet season as shown in Table 6. Although Boer goats were observed to spent more time on NFA during the cold-dry season compared to the Tswana goats, the difference was not significant (P>0.05). In the hot-wet season, time spent on NFA declined for both breeds (Tswana 37.0 ± 0.15; Boer 27.0 ± 0.15) with Tswana goats spending more time on NFA than Boer goats. Tswana and Boer goats did not differ significantly (P>0.05) in the amount of time spent on NFA at different times of the day. Tswana goats spent more time on NFA during midday compared to Boer goats. NFA were lower in the morning (Tswana 43.8; Boer goats 46.2 ± 0.22) and afternoon (Tswana 47.9; Boer goats 45.6 ± 0.22) and Tswana goats spent more time on NFA than Boer goats during both these time periods. The time spent on NFA by the two breeds did not differ significantly (P>0.05) over the period of occupation of the camp. It however seems that for both breeds, time spent on NFA increased with advancing period of occupation. Regardless of the breed, there were no significant differences between the cold-dry season and the hot-wet season in the time goats spent on NFA during the different times of day. The highest percentage time spent on NFA was recorded during the cold-dry season at midday (80.3 %) while the lowest was recorded in the hot-wet season in the morning (25.3 %).

4. DISCUSSION

In the present study the proportion of time spent browsing was lower (33 %), and that spent grazing higher (67 %) than the averages found by Malecheck & Provenza (1981) and Raats (1996). These results are supported by Odo *et al*, (2001) where Saanen goats were also found to select more grass (63 %) than bush (32 %). The results of the current study, however, contradict those of several authors (Berhane & Eik, 2006; Aharon *et al*., 2007; Yayneshet *et al.*, 2008) where goats were found to prefer browse to grass. This indicates that shifting between browsing and grazing is largely dependent on prevailing conditions (Lu, 1987) such as the amount and distribution of rainfall and the occurrence of frost. In this regard, Bjelland & Grøva (1997) in a study with Boer goats in the False Thornveld of the Eastern Cape, found that time spent browsing during the cold-dry season was substantially higher (52 %) than the 27 % recorded by Raats (1996). In the present study, time spent browsing in the cold-dry season was also higher (46 %) than that recorded by Raats (1996) and closer to the 52 % recorded by Bjelland & Grøva (1997) and Sanon *et al*. (2007). During the hot-wet season, bush consumption was substantially lower (24 %) than the 86 % recorded by Raats (1996).

The changes in time spent browsing (the cold-dry season 46 %; the hot-wet season 24 %) and grazing (the cold-dry season 54 %; the hot-wet season 76 %) in this study showed that feed availability, as reflected in the number of days in the camp, had a marked influence on feeding behaviour. This is supported by work done by several researchers (Raats & Tainton, 1992; Steel, 1996; Taylor & Kothaman, 1990) who also found that as the availability of feed decreased more time was spent grazing. Steel (1996) found that season influences browse:graze ratio markedly. Omphile *et al*. (2003) found a contribution of about 80 and 50 % browse in the diets of goats during the dry and wet seasons respectively in an *Acacia* bush savannah in southeast Botswana. Seasonal variations in browse:graze ratio were also found in Spain and Texas (Devendra & McLeroy, 1982). In the present study, grass consumption was higher in the hot-wet season (76 %) than in the cold-dry season (54 %) while browse consumption was higher in the cold-dry season than in the hot-wet season (46 % and 24 % respectively). These results are supported by Taylor & Kothman (1990) and Odo *et al.* (2001) who found goats to select more grass during the hot-wet season than the cold-dry season. Orihuela & Solano, (1999) states that the major growth of warm season grasses occur during the hot-wet season (rainy season). Schwartz & Ellis (1981) found that season has a major impact on the dietary preference of species and grazing tends to increase during the season when the herb layer is actively growing (El Aich *et al*., 2007; Sanon *et al*., 2007). Actively growing grasses have high digestibility (Codron *et al*., 2007), are succulent and less coarse.

The increase in consumption of browse in the cold-dry season compared to in the hot-wet season is supported by Devendra & McLeroy (1982) and Sanon *et al*., (2007) who reported that goats tend to prefer the less coarse grass which is found in the hot-wet season. They are of the opinion that browse forms the main source of feed for ruminants in the dry season. This could be attributed to the early and fast growth rate of grasses after the early rain in the hot-wet season, when legumes are still germinating, leaving legumes fresher, less coarse and more succulent at the onset of the dry season. Orihuela & Solano, (1999), state that in early autumn and the cold-dry season, only browse may still be green while the grass dries out. In this study, goats made a shift

in their feeding activity by increasing browse species in their diet when herbaceous species were rare.

Browsing showed a decline with advancing period of occupation both during the cold-dry season and the hot-wet season. Grazing however only showed a decline with advancing period of occupation in the cold-dry season. In the hot-wet season, grazing increased with advancing period of occupation. The browse:graze ratio showed a clear decline with feed availability during both the cold-dry season (0.5 to 0.1) and the hot-wet season (0.3 to 0.2). Grass was clearly the preferred feed for goats both in the cold-dry season (54 %) and the hot-wet season (76 %). Despite this browse consumption was higher in the cold-dry season (45 %) and lower in the hot-wet season (24 %). McCammon-Feldman *et al.* (1981), state that the nutritive strategy of goats appears to be to select grass when the protein content and digestibility of the grass is high. However, they switch to browse if the overall nutritive value of browse is high. The initial preference for browse over grass in the cold-dry season during the observation days in this study, suggests the nutritional value of browse was higher than that of grasses, which is expected due to the dormant state of grasses during the cold-dry season. Goats were observed to switch to grazing during the later days of occupation of a camp due to depletion of browse. During the cold-dry season, the decrease in the availability of the most preferred feeds also induced goats to diversify their diets. The botanical composition of the goat's diet varies in accordance with seasonal availability (Animut & Goetsch, 2008) with more species being utilized as the availability decreases. The natural seasonal changes may modify the behaviour patterns of goats (Taylor & Kothman, 1990) affecting proportions of grass or bush consumption according to their availability.

Genotypic variation can also influence preference and selectivity (Ellis *et al*., 2005). Experiments have shown differences among populations of livestock, with population representing the genetic diversity arising from subspecies to breeds and breed crosses (Odo *et al*., 2001). In the present study, significant differences were found between the feeding behaviour of the Tswana and the Boer goats. Both breeds devoted the same amount of time (Tswana 66.5 %; Boer 66.2 %) on the range to active foraging. The figures are much higher than that reported by Askin & Turner (1972) for Angora goats (31 %) but are closer to that reported by Mill (1990) for Tunasian goats (77 %) and Aharon *et al*. (2007) on Mamba and Boer goats. In both seasons goats devoted much of the active feeding time to grazing or selection of herbaceous vegetation. The Tswana and Boer goats spent the weighted average of 39.0 % and 46.2 % respectively, of their feeding time grazing. Selection of herbaceous vegetation was also notably higher in the hot-wet season (Tswana 54.4 %; Boer 64.1 %) due to an abundance of lush herbaceous vegetation generally higher in nutritional value. These findings are not consistent with many reports where goats were found to select more browse material than grass (Perevolotsky & Haimov, 1992; Perevolotsky *et al*., 1998; Berhane & Eik, 2006; Aharon *et al*., 2007; Yayneshet *et al*., 2008). The difference between breeds in their time allocations to grazing herbaceous species was notable in the hot-wet season when Boer goats allocated an extra 10 % of their time to grazing compared to Tswana goats, while in the cold-dry season they only allocated an extra 4 % of their time to grazing**.** Both breeds decreased time spent on browsing with advancing period of occupation of a camp. Tswana goats decreased browsing and increased grazing with decline in feed availability compared to Boer goats. This might indicate that Tswana goats have a higher adaptation potential to changes in the vegetation than the Boer goat.

Ruminants display diurnal patterns in time spent grazing and in other activities such as ruminating, being idle and lying down (Odo *et al.*, 2001; Torrano & Valderrábano, 2005; Schlecht *et al.*, 2006). In the present study for both breeds and seasons, a diurnal pattern of foraging was observed. Although goats spent more time grazing than browsing in this study, browsing was significantly high in the morning compared to midday and afternoon while grazing appeared to be high in the afternoon. Dumont *et al*. (1995) in a study on the direct observation of biting for studying grazing behaviour of goats and llamas on garrigue rangelands also observed diurnal variations in diets of both animals where the mornings were spent browsing and afternoons grazing. Torrano & Valderrabano (2005) also observed diurnal pattern of plant utilization where longer time was devoted to browsing earlier in the morning than during the rest of the day. Solanki (1994) on the other hand observed a distinct diurnal pattern for selectivity of forages, with grasses being preferred more in the morning (80 %) followed by bushes (18 %) while in the evening bushes were more preferred (69 %) and grasses (30 %). Diurnal variation feeding behaviour is reported by Steel (1996), stating that when goats are first let out on to pastures in the mornings, they will initially feed unselectively, and later become increasingly selective. In contrast, Benham (1984) cited by Dumont *et al* (1995), states that it is better for ruminants to be selective in the morning than the afternoon. This is

supported by results from this study where goats wandered more in the morning (17 %) than the afternoon (12 %), indicating that the level of selection was high in the morning than the afternoon. In the early part of the day, a selective feeding behaviour prevents the rumen from being filled with slowly digestible material that would later limit intake, whereas unselective feeding in the afternoon tops up the rumen ready for the night when little or no feeding is performed (Dumont *et al*, 1995).

It has been reported that diurnal feeding pattern in goats may be modified by factors such as forage availability (Schlecht *et al*., 2006; Sanon *et al*., 2007), environmental stress such as heat and rain (Torrano & Valderrabano, 2005; Sanon *et al*., 2007), frequency of feeding and amount of feeding (Morand-Fehr, 1981; Lu 1988). In the present study, for both breeds and seasons, non-feeding activities were higher during midday compared to morning and afternoon but there were no breed differences. Other studies have also revealed that goats avoid grazing or browsing during the hotter part of the day (Sharma *et al*., 1998).

5. CONCLUSIONS

Results from this study illustrate the complex dynamics of the feeding behaviour of the goats grazing on heterogeneous vegetation with diverse botanical composition**.** Both Tswana and Boer goats spent more time grazing and browsed less when feeding in the False Thornveld of the Eastern Cape. This study confirms the modification of feeding behaviour, in terms of grazing, browsing and non-feeding activities, as an efficient tool for goats to adapt to quantity and quality of their ingesta, in order to meet their requirements. The decrease in the most preferred feeds induced goats to diversify their diets. This indicates that the natural seasonal changes modify the feeding pattern of goats affecting proportions of grass or bush consumption according to their availability. A diurnal pattern of foraging observed in this study for both breeds indicates that goats were more selective in the morning than in the afternoon. . This was one foraging strategy that goats utilised to select the most nutritious diets in the morning and limit rumen fill in the morning. This allowed for unselective feeding in the afternoon to fill up the rumen for the evening. The variation in preference for grass and browse with different seasons, breeds, the time of the day and period of occupation of a camp, should be taken into account when designing management practices in range areas. Knowledge of feed availability, feeding behaviour and feed preference of free ranging Tswana and Boer goats is fundamental for small scale farmers to develop management strategies aimed at optimum sustained use of the natural vegetation and for the survival of these breeds in the semi arid environment. Further research need to be carried out with a larger sample size as this may produce different results.

ACKNOWLEDGEMENTS

The technicians in both the departments of Anatomy and Physiology (University of Pretoria) and Livestock and Pasture Science (University of Fort Hare) are thanked for their assistance, as well as the NRF and Universities of Pretoria and the North West for financial assistance. I also thank Dr M. van Der Linde and Mr Paul van Staden for assistance with statistical analysis of the data. The authors would also like to thank the University of Fort Hare for logistical support they gave during the research.

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6/1/2011