Feeding behaviour of Xhosa lop-eared, Nguni and Nguni × Boer goat genotypes kept on rangelands of the False Thornveld

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Declaration

I, **Archibold Garikayi Bakare**, vow that this dissertation has not been submitted to any University and that it is my original work conducted under the supervision of Prof. M. Chimonyo. All assistance towards the production of this work and all the references contained herein have been duly accredited.

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Abstract

Feeding behaviour of Xhosa lop-eared, Nguni and Nguni × Boer goat genotypes kept on rangelands of the False Thornveld

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The study was conducted at the University of Fort Hare farm to assess the feeding behaviour of three goat genotypes: Xhosa lop-eared (XLE), Nguni (NGN) and Nguni × Boer crossbred (NBC) genotypes. The time spent on different activities (grazing, browsing and other activities) on rangelands was recorded using stop watches. The micro-histological faecal analysis technique was used to identify and quantify the plant species that were consumed by the goats across the four seasons. Time spent browsing was high in post-rainy season for XLE (55.94 %) compared to NGN (52.97 %) and crossbred NBC (45.95 %) goats. The high browsing activity was also noted for XLE in hot-wet and cool-dry season ($P < 0.05$). The NBC goats on the other hand; devoted most of their time grazing compared to XLE and NGN goats across seasons ($P < 0.05$). Generally, time of day had no effect ($P > 0.05$) on foraging activities among the goat breeds. *Grewia occidentalis*, *Panicum maximum* and *Diospyros lycioides* were the most preferred plant species by all genotypes across seasons in the paddock. It was concluded that crossbreds spent more time grazing as compared to XLE, which are more of browsers. It could, therefore, be recommended that XLE complement with grazers (cattle and sheep) for efficient management of feed resources in rangelands.

Keywords: Plant preference, Species composition, Season, Time sampling method, micro histological faecal technique

List of abbreviations

CA - composition of species in rangelands;

CCF - composition of species consumed and recovered in faeces;

CP - crude protein;

CT - condensed tannins;

DM - dry matter;

MJ - mega joules;

NBC - Nguni × Boer crossbreed;

NDF - neutral detergent fibre;

NGN - Nguni;

NRC - National Research Council;

P - phosphorus;

PDIFF - probability difference;

PI - preference index;

PPT - protein precipitating tannins;

SAS – Statistical Analysis System;

TP - total phenols;

XLE - Xhosa lop-eared.

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CHAPTER 1: Introduction

1.1 Background

An estimated population of about seven million goats (*Capra hircus*) is found in South Africa (FAOSTAT, 2008), where almost half of the total population is kept under smallholder conditions (Coetzee, 1998; Shabalala and Mosima, 2002). These goats exist in natural environments such as rangelands and are a means of life sustenance to resource-poor households, especially in areas where cropping is not feasible. They provide a source of protein (milk and meat) and cash that is used to buy grain, and household utensils among other household necessities (Lebbie, 2004; Haenlein and Ramirez, 2007; Simela and Merkel, 2008).

The ever increasing population of households puts a strain on the finite resources, particularly feed for goats and also their products that are available for human sustenance (Smail, 1997). This calls for the need to improve production from the goats to cope up with high demand for their products and at the same time manage the available feed resources in rangelands much more efficiently. This can possibly be done by assessing feeding behaviour of the goats on rangelands (Demment and Greenwood, 1988; Lachica and Aguilera, 2005). Feeding behaviour can be defined as any action that is directed toward the procurement of nutrients. The optimum intake of nutrients by the goats could be easily attained if feeding habits are understood and controlled (Ngwa *et al*., 2000).

Compared to cattle and sheep, goats utilise a variety of plant species for their nutritional requirements to be met. Choice of plant species for consumption by goats depends on plant species available on rangelands. When feed resources are limited, goats spend more time selecting highly nutritive plant parts, and in the process, may not eat much (Peacock, 1996). Consequently, their performance on rangelands is affected. Other strategies used by goats to get nutritive feed include the use of the bipedal stance, a skill where the goat stands on its hind legs to access tree leaves at a considerable height (NRC, 2007) and climbing trees to access tree leaves (El Aich *et al*., 2007).

In most studies on rangelands of South Africa, little attention has been paid to the feeding behaviour of indigenous breeds such as Nguni (NGN), Xhosa lop-eared (XLE) and their crosses with imported breeds. Studies derived outside South Africa using different goat breeds, came with inconclusive results, leading to an assumption that all goats are browsers (Ngwa *et al*., 2000; Omphile *et al*., 2003). As such, it has long been considered appropriate to mix goats with cattle and sheep (which are largely regarded as grazers) to optimise the use of diverse rangeland resources (Tainton, 1999; Cissé *et al*., 2002). There is, however, evidence to suggest that goats are not exclusively browsers, with breeds showing different feeding strategies on rangelands (Hoste *et al*. 2001). Feeding behaviour might vary due to morphological make up of goat genotypes and also changes in vegetation structure across season. It is, therefore, imperative to assess feeding behaviour of the goat genotypes to achieve good feeding management.

The NGN goat is a small framed breed that has been reported to be hardy and can thrive under local environmental conditions, utilising available feed resources much more efficiently (Dziba *et al*, 2003; Nyamukanza and Scogings, 2008). Few, if any, studies have been done to verify this assertion and to compare their diet selection with other genotypes under rangeland conditions.

The Xhosa lob-eared on the other hand, is a large framed goat breed well known for its attractive coat pattern of various colours. This goat genotype has potential to increase revenue for the resource-poor households from the sale of hides. Indiscriminate crossing with synthetic and exotic breeds also occur, resulting in changes in some morphological traits in goats, such as stature (Masika and Mafu, 2004). These resultant crosses have been reported to dominate most communal areas (Cardellino, 2009). Feeding behaviour of the three goat genotypes co-existing on rangelands, is yet to be studied. The breeds vary in their morphological make up, thus, feeding behaviour of goats on rangelands is likely going to differ. Since seasons influence vegetation structure and nutritional composition, it is crucial to determine the feeding behaviours of the different goat genotypes across seasons.

1.2 Justification

Knowledge of feeding behaviour will assist farmers to partition limited feed resources on rangelands among goat breeds and other livestock species. Appropriate stocking densities can, therefore, be estimated paving way for good rangeland and livestock management practices. In addition, understanding feeding behaviour is also important in selecting breeds which are adapted to local environmental conditions. If breeds are adapted to the local environmental conditions, they perform to expectation giving farmers valuable products (food) and income from sales.

1.3 Objectives

The major objective of the study was to determine feeding behaviour of indigenous XLE goat, NGN goat and NBC on rangelands of the false thornveld. The specific objectives were as follows:

1. Compare time spent foraging by Nguni (NGN), Xhosa lop-eared (XLE) and Nguni x Boer crosses (NBC) on rangelands of the false thornveld.
2. Determine plant feed preferences of XLE, NGN and NBC goats on the rangelands of the false thornveld.

1.4 Hypotheses

The hypotheses tested were that:

1. There are no differences on time spent foraging by the XLE, NGN and NBC goat genotypes on rangelands of the false thornveld.
2. There are no differences on plant feed preferences of XLE, NGN and NBC goats on rangelands of the false thornveld.

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CHAPTER 2: Literature review

2.1 Introduction

Efficient management of the feed resources on rangelands is underpinned by an understanding of the feeding behaviour of goats. This chapter gives emphasis on the feed resources available to goats, performance of goats under rangeland conditions, factors affecting feeding behaviour and also methods of assessing feeding behaviour. The information will give a theoretical background for the research on feeding behaviour of goats in the present study.

2.2 Plant feed resources edible to goats

Goats are well known to utilize diverse plant feed resources on rangelands. *Acacia karroo, Diospyros lycioides, Ehretia rigida, Grewia occidentalis, Rhus longispina and Scutia myrtina* are some of the tree species edible to goats in the study area. The trees can either be deciduous (*A. karroo, D. lycioides, E. rigida, G. occidentalis*) or evergreen (*R. longispina and S. myrtina*) thus, their availability as feed for goats vary with season (Scogings, 1998; Dziba, 2000). A myriad number of grass species can also provide feed for goats. The plant species differ in chemical composition across seasons, resulting in herbivores showing preference for a particular plant in relation to its chemical constituents (Tainton, 1999). Nutritional and anti-nutritional characteristics of different browse trees on rangelands of Eastern Cape in winter and summer are shown in Table 2.1 and Table 2.2, respectively.

Table 2.1: Nutritional characteristics of browse species on rangelands in a False Thornveld

Season	Species	DM (%)	CP (% DM)	NDF	Cellulose	Lignin	Energy (MJ/kg)	P (% DM)
Winter	*Acacia karroo*	89.7	14.4	30.7	6.2	3.4	20.2	0.09
	Diospyros lycioides	86.6	7.8	41.0	9.7	10.3	19.7	0.1
	Ehretia Rigida	89.3	10.9	33.9	2.9	8.6	18.3	0.08
	Grewia occidentalis	89.6	9.6	42.6	16.9	0.6	18.8	0.1
	Rhus longispina	91.3	11.1	33.6	6.8	0	20.7	0.09
	Scutia myrtina	89.6	11.6	42.3	8.8	14.2	20.4	0.09
Summer	*Acacia karroo*	91.1	15.7	29.1	5.3	4.1	20.4	0.11
	Diospyros lycioides	91.3	10.6	40.5	7.0	9.1	19.4	0.11
	Ehretia. Rigida	87.7	13.1	30.5	2.4	2	18.7	0.14
	Grewia occidentalis	90.8	15.0	46.6	12.2	0.5	19.3	0.14
	Rhus longispina	91.2	13.1	37.8	4.3	3.1	21.7	0.12
	Scutia myrtina	89.5	11.9	45.6	9.5	9.6	20.4	0.14

Source: Dziba (2000)

DM- dry matter; CP-crude protein; NDF- Neutral detergent fibre; P-phosphorus; MJ-mega joules

Table 2.2: Anti-nutritional characteristics of browse trees on rangelands in a False Thornveld

Season	Species	TP	CT	PPT
Winter	*Acacia karroo*	54.6	25.8	176.3
	Diospyros lycioides	54.4	32.8	119.2
	Ehretia rigida	42.3	0.4	48.6
	Grewia occidentalis	37.8	24.8	145.5
	Rhus longispina	23.3	9.3	55.7
	Scutia myrtina	98	67.3	237.6
Summer	*Acacia karroo*	171.8	101.7	161.7
	Diospyros lycioides	73.9	42.3	84.3
	Ehretia rigida	97.9	0	0
	Grewia occidentalis	45.2	26.7	77.0
	Rhus longispina	33	17.5	2.5
	Scutia myrtina	157.9	102.8	232.5

(Dziba, 2000)

TP- total phenols; CT- condensed tannins; PPT- protein precipitating tannins.

Chemical composition of grasses also varies with season, particularly for those which are perennials (Hendrickson *et al*., 1997). Fibre content increases with age of the plant, with low proportions of fibre content occurring when grasses are still young and succulent during the rainy season. Fibre content becomes high during the winter season (Hendrickson *et al*., 1997). An opposite trend also occurs for the crude protein levels. High crude protein content occurs when the plants are still young and decreases with age to levels below 7% (Mphinyane, 2001). Some indigenous grasses have also been noted to possess tannin-like substances, whilst others such as *Cynodon dactylon* produce cyanogenic compounds (O'Reagain, 1993). The adverse effects from these anti-nutritional factors make animals foraging on rangelands to become selective.

2.3 Performance of goats on rangelands

Goats consume a variety of plant species that vary in their chemical constituents in rangelands. However, their performance under rangeland conditions is not always satisfactory due to high disease prevalence, parasite challenge and also other restrictions when acquiring nutritive feed (Rumosa Gwaze *et al*., 2009; de Vries, 2008). Rumosa Gwaze *et al.* (2009) observed that high disease prevalence and high parasitic infections in communal areas where goats are reared under rangeland conditions, is attributed to the inability of farmers to buy veterinary medicines for their livestock and also poor livestock management practices. Goats on rangelands for this reason are likely not going to perform to expectation. This results in goats not meeting their nutritional requirements leading to poor growth performance, high kid mortalities and also increased kidding interval (above 258 days), as shown in Table 2.3. Other restrictions when acquiring nutritive feed can be instigated by fluctuations in nutritional characteristics of plant species with season. Underperformance of goats will be more pronounced in dry periods when forage will be of poor quality. Some goat breeds which are adapted to utilisation of vegetation in a particular area when feeding on rangelands use their feeding strategies to feed off low nutrient grasses and incorporate browse species to attain maximum nutrient intake (Sinclair, 1977). Performance of NGN, XLE and also crossbreeds in sweet rangelands of the false thornveld is not known. Information gained from feeding behaviour helps in the understanding how the goats will perform in natural environments.

2.4 Feeding behaviour of goats

To attain optimum nutrient intake from the available feed resources, goats show off different feeding strategies on rangelands. This is normally referred to as feeding behaviour and usually varies across seasons and breeds. Several perspectives have been postulated regarding the feeding behaviour of goats with the argument whether the goat genotypes can be classified as either grazers or browsers (Knights and Garcia, 1997; Hoste *et al*., 2001; El Aich *et al*., 2007). Papanastasis *et al*. (2008) concluded that goats cannot be clearly defined as either browsers or grazers but are opportunistic feeders. Their feed is a combination of grasses and shrub plants or tree leaves. Skillful grazing behaviour and efficient digestive system enable goats to attain maximal feed intake and utilisation in a given condition (El Aich *et al*., 2007). Feeding behaviour exhibited by goats on rangelands is determined by factors which include; breed, season, anti-nutritional factors, morphology of plant parts, social rank, group feeding and human influences.

Table 2.3: Performance of goat genotypes under communal production systems

Breed	Age at first kidding (months)	Kidding interval (days)	Kid mortality (%)	Growth rate (g/day)	Source
Mashona	18-19	370	30	40	Ndlovu and Royer (1988)
Matebele	23	-	30	98	Sibanda (1988)
Nguni	16-18	258	-	-	Webb and Mamabolo (2004)
Landim	-	394	16	-	Kamwanja *et al*. (1985); DAGRIS (2007)
Malawi	15.6	365	-	-	Nsoso *et al*. (2004); Ayoade and Butterworth (1982); Kamwanja *et al*. (1985)

2.4.1 Effect of breed on feeding behaviour

Genetic differences among breeds influence intake as well as feeding behaviour of an animal (Fukasawa *et al*., 2005). Variations exhibited by goat breeds in intake are a result of morphological and physiological characteristics (Provenza *et al*., 2003). Some of the attributes that have emanated in the different goat breeds which cause variation in feeding behaviour are; body size and oral morphological characteristics.

Body size at maturity usually varies among individual animals within and between breeds (Peacock, 1996). Examples of breeds with marked differences are the XLE and NGN goat breeds. The XLE with its large body framework has long legs that enable it to walk long distances searching for nutritive feed. Time spent on by goats on different activities on rangelands is likely going to be affected. Van Soest (1994) also observed animal breeds with smaller body size to be more selective in their feeding behaviour for immature plant material, whereas a considerable large body size promotes gastrointestinal retention and digestive capacity. All these developments in animals with regards to the feeding behaviour help in the achievement of nutritional requirements for a particular animal with size.

Body size as reported by Caumul and Polly (2005) accounts to about 10% of variation in skulls, 7% in mandibles, and 15% in molars. If a particular goat breed has a smaller body size it develops a smaller mouth which enable it to make small bites of browse tree leaves more efficiently, and at the same time limit the size of bite of grass swards (Illius and Gordon *et al.*, 1987). Smaller goat breeds are, therefore, more selective than large goat breeds resulting in the development of mouth and tooth morphology to suit the type of plant material being consumed

(Moore and Lavelle, 1974). Variations in oral morphological traits among different goat breeds exist, which cause preference for different plant species on rangelands. Morphology of mandible, dental wear and chewing muscles are useful for preferences made for different plant species (Pérez-Barbería and Gordon, 1999; Amarala *et al*., 2009). They play an important role in food selection and food communition. The morphometric traits involved in dietary choices are incisor breadth, incisor depth, muzzle width, mandibular depth, premolar row length, molar row length, mandible length, and length of mandibular diastema (Perez-Barberia and Gordon, 1999; Olopade and Onwuka, 2005). These traits can be used to hypothetically classify goat breeds as a grazer, browser or mixed feeder.

Attachment of the muscles to the mandible differs depending on the feeding behaviour of a particular goat breed. Plant materials with high crude fibre content (e.g. grasses) are tough; therefore require higher bite forces during mastication as compared to browse leaves (Kiltie, 1982). Attachment of muscles on the lower jaw areas of goat breeds which are perceived to be grazers will therefore be larger as compared to browsers independent of body size to allow animal to crush high fibrous plant material. The muscles involved in communition of plant feed material are the masseter and temporalis muscles (Frandson *et al*. 2003). Muscular strength and endurance of the chewing muscles is affected by number and type of muscle fibre, and also muscle fatigue (Wegner *et al*. 2000). Other animal related traits that cause variation in feeding behaviour are sensory properties and anatomy of the digestive system an animal.

2.4.2 Effect of season on feeding behaviour

Season influences normal feeding behaviour of goats on rangelands with main emphasis being on vegetation structure and ambient temperatures (Darcan *et al*., 2008). Vegetation structure and ambient temperatures vary across seasons, with low temperatures being experienced in winter as opposed to the summer season.

Silanikove (2000) reported goats to perform well within a certain temperature range referred to as the thermal neutral zone or zone of comfort. Temperatures well above or below the zone of comfort predispose the goat to stress. The high ambient temperatures associated with the hot and wet season, result in a reduction in feed intake, an increase in the respiratory rate and an animal will always be craving for water all the time (Silanikove, 2000; Darcan *et al*., 2008). Currently no research has been conducted to determine degree of heat tolerance on the indigenous goats in Southern Africa. Researches on Hipsi, Aardi and Zumri goat breeds showed varying degrees in heat tolerance (Alamer, 2006). Heat tolerance was also found to vary among goat breeds which include Barbari, Black Bengal, Sirohi, Marwari, Osmanabadi, and Kutchi (Joshi *et al*., 2004). In a bid to dissipate body heat; goats can either stand or lie down on cold surfaces (Mitlöhner *et al*., 2002). In some cases they will seek shade under trees on rangelands (Silanikove, 2000; Mitlöhner *et al*., 2002). During the cool-dry season when low temperatures are experienced, goats respond by increasing feed intake to generate more heat to maintain body core temperatures (Landau *et al*., 2000). Landau *et al*., 2000 also demonstrated that goats consume more herbaceous species during winter, whereas lying down will be reduced as goats will be trying to avoid contact with cold surfaces.

Nature of plant resources influences feeding behaviour of goats on rangelands and this varies with season (Johnson *et al*., 2001). Regions characterised by deciduous trees will have different populations of plant species being altered with season. The shedding of leaves by deciduous trees results in reduced unavailability of foliage to goats (Dziba *et al*., 2003). If an area has very few palatable tree species to goats, the animal will resort to other alternatives, that is, consumption of grasses. Conversely, if there are few palatable grass species they will browse. Goat breeds which are taller can make use of their long legs to walk long distances searching for desirable plant species which are spatially distributed as compared to short breeds. Goat breeds adapted to the particular ecological region will therefore have access to foliages by using their knowledge of the surrounding environment and foraging skills (Schlichting and Pigliucci, 1998; Provenza *et al*., 2003).

2.4.3 Effect of anti-nutritional factors on feeding behaviour

Anti-nutritional factors are substances which, when present in feed, reduce intake and utilization as well as growth of an animal (Amuchie, 2001; Provenza *et al*., 2003; Makkar, 2003). Goats can tolerate the adverse effects of most of these toxins in feed and this makes them consume a wide variety of feed (Peacock, 1996). Condensed tannins (CTs), for example, are a group of phenolic compounds widely distributed in leguminous forages. Their sensitivity has been noted in cattle and sheep, while goats are more resistant (Van de Heidi et al., 1999). Some goat breeds can withstand the adverse effect of tannins and eat more of the tree species. Nyamukanza and Scogings (2008), observed NGN goats to have higher bite rates of *Acacia sp.* foliages containing high levels of tannins compared to the Boer goats. Harrison *et al*. (2006) also describes the presence of enzyme atropinesterase in the circulatory system and in the liver of goats. Upon eating a plant rich in tropane alkaloids such as atropine and scopolamine, the enzyme hydrolyses these alkaloids making plant feed material harmless to the animal. According to Liebenberg and Linn (1980), the level of the enzyme atropinesterase in the goats varies with season (concentration of the enzyme is low in winter) and across breeds. Gleadow and Woodrow (2002) and, Vough and Cassel (2002) also observed high aversion by herbivores on young growing of grass due to high prussic acid content which can cause poisoning if high concentrations enter body system of an animal.

2.4.4 Morphology of plants

Apart from the anti-nutritional factors, plants have developed structural features which deter herbivores from feeding (Papachristou *et al*., 2005). Thorns, for example, are structural features that have developed on some plant species like *A. karroo, A. Tetracantha* and *R. Longispina*. These thorns, with their sharp ends, can pierce flesh of any approaching herbivore thus restricting its feeding rate (Bond *et al*., 2004). Non-spinescence species (*D. Lycioides, E. rigida* and *also G. occidentalis*) are, therefore, likely to be consumed in large quantities (Dziba, 2000). Other structural features on plants include trichomes and hardened leaves due to deposition of granular minerals in plant tissues. Trichomes on leaves sometimes contain irritants which deter herbivores from feeding. Depositions of the chemical compounds (resins, lignins, silica, and wax) as noted by Robbins et al. (1993), can alter texture of plant tissue material reducing palatability. This results in high aversion by goat on the particular plant material (Perez-Barberia and Gordon, 1999). Scogings, 1998 also observed some plant species to develop new leaves on new shoots, whereas others produce new leaves old on unbrowsable branches. High intake rate were noted for those trees which develop new leaves on new shoot by goats feeding on rangelands (Dziba, 2000).

2.4.5 Effect of social rank on feeding behaviour

In an environment where resources are scarce, goats like all living creatures compete for the available resources in order to survive and reproduce (Kiley, 1978). Social ranking within a population can then play a significant role on the feeding behaviour of goats (Barroso *et al*., 2000). The oldest and biggest goat breeds occupy the highest positions in the social ranking and can benefit more comparing with their subordinates. According to Thouless (1990) the subordinates are always submissive to the dominant ones affecting their feeding behaviour in two ways. Firstly, they move away and stop feeding when their neighbour is socially dominant. Lastly, they take fewer bites as the distance from dominant neighbours decreases. Accessible browse trees and also herbaceous plant material will, therefore, be limited to the dominant animals. Low-ranking goats can only access feed at a later time, thus, affecting behaviour of feeding herbivore on rangelands.

2.4.6 Group feeding

Goats on communal rangelands usually graze in flocks composed of different breeds. In these flocks, social behavioural learning occurs were breeds not accustomed to the feeding technique learn from another different breed or the leader of the group. This learning can also be transferred to offspring and through continual sampling and evaluating of various feed sources, goats can easily adapt to different environmental conditions (Provenza and Balph, 1987; Thorhallsdotir *et al*., 1987). If an animal is introduced to a new environment with new plant species, it will always become reluctant to eat novel foods or familiar foods whose flavours have changed, thus reducing intake.

2.4.7 Human influences

Many farmers in communal areas usually practice mixed farming, which results in competition for land between the cropping and livestock enterprises (Peacock, 1996). Crops, cereals in particular, form a staple diet for people and usually require large fertile lands for cultivation. This normally leaves unproductive and unfertile lands, with low plant biomass being reserved for pastures for livestock. If the condition of the pastureland is poor (with low plant biomass), goats are likely not going to be selective and can be forced to eat the available vegetative matter, thus affecting their normal feeding behaviour on rangelands (Provenza *et al*., 2003). Conversely, when rangelands are in good condition and correct stocking densities are implemented, there will be plenty of forage giving goats a wider selection for plant species (Villalba *et al*., 2004). The production system being implemented by farmers also affects feeding behaviour of goats, particularly learning about consumable plant species on rangelands. Under intensive production system, goats are given more of conventional feeds and these goats will not perform to expectation because of inadequate knowledge of plant species on rangelands (Morand-Fehr, 2005). Shepherding on rangelands influences the expression of the behavioural trends of the flock (Baumont *et al*., 2000). Presence of herders/shepherds whilst following movements of the flock maintains the confidence of the animals and they will, therefore, have a wider selection of plant material on heterogeneous pastures.

2.5 Methods of assessing feeding behaviour of goats

Different methods can be used to assess feeding behaviour of goats on rangelands. The methods can either be direct or indirect. Under communal rangeland system, direct methods can easily be carried out whilst indirect methods require expensive laboratory equipment.

2.5.1 Direct methods of assessing goat feeding behaviour

The direct methods involve; recording time spent on foraging and non-foraging activities on rangelands, and counting the number of bites made by goats (Raats et al., 1996; Orihuela and Solano 1999; Solanki, 2000). The techniques are fairly easy and inexpensive. They show high precision levels in woody species but poor estimation in grass components. On rangelands, it is often difficult to locate and approach closely for accurate observation with the direct observation method (Mphinyane, 2001). Difficulty in species identification and quantification of how much plant material was prehensed are some of the major challenges associated with the procedure.

2.5.1.1 Time sampling method

Time sampling method involves visual animal observations including recording time spent on the different behavioural activities (grazing, browsing, walking and lying down) on rangelands. In this method, stop watches are used by observers for recording time spent on each activity performed by goats on rangelands (Orihuela and Solano, 1999; Solanki, 2000). The time spent feeding and on other activities by goats varies with breed and season as shown in Table 2.4. Feeding behaviour of different goat breeds on rangelands of southern Africa across seasons are not yet established.

2.5.1.2 Bite count method

Another direct method of observing feeding behaviour involves the counting of bites made by goats. A bite in this context is an act of breaking off or picking up a piece of forage (Agreil and Meuret, 2004). Using the method, goats being observed are closely followed by enumerators who record the number of bites made at a particular time (Osolo *et al*., 1996). More reliable estimates from the method are made possible when there is low density vegetation which does not disrupt enumerators (Mengli *et al*., 2006).

2.5.2 Indirect methods of assessing goat feeding behaviour

Indirect methods that can be used to determine composition of diet are micro-histological faecal analysis, oesophageal extrusa method and faecal alkane technique. The techniques require an in-depth knowledge of the histology of plants, particularly epidermal cells. The plant cuticle plays an important role for it resists digestion and enables plant fragments to be recovered from faeces and also when using the oesophageal extrusa technique. The plant fragments can then be compared microscopically with reference material from the rangelands (Leroy *et al*., 2000).

2.5.2.1 Faecal odd chain alkane method

The faecal alkane method makes use of the natural occurring markers, n-alkanes, which are components of plant cuticular wax used for estimating digestibility in grazing ruminants (Dove and Mayes, 1991). The naturally occurring n-alkanes are odd chains (C_{27} - C_{35}) resistant to digestion which can be recovered in faeces (Dove, 1992). Gas chromatography can be used to calculate the concentration of odd-chain alkanes present in forage which can be compared with concentration in faecal samples. The technique has been used in experiments involving sheep and cattle (Dillon and Stakelum, 1990). Using alkanes have been found not provide good estimates of the composition of the diet when herbivores are grazing complex pastures (Dillon and Stakelum, 1990). The method also requires technical expertise to carry out the procedures in the laboratory with also some knowledge of dietary concentrations of a natural odd-chain alkane in plants.

2.5.2.2 Oesophageal extrusa technique

The procedure for carrying out micro-histological oesophageal extrusa involves collection of plant material consumed by goats in a bag placed around the goat's neck after the plug and spatula that seal the fistula had been removed (Raats *et al*., 1996). The oesophageal extrusa gives a representative diet selected by goats than the direct and other indirect methods (Raats *et al*., 1996). The oesophageal technique is unbiased towards indigestible diet constituents (Vavra and Holechek, 1980). Its use is limited because it violates one of the degrees of freedom in animal welfare, that is, freedom from pain caused by the surgical opening made on the oesophageal of goats. The technique has also been found interrupt animals under observation.

2.5.2.3 Micro-histological faecal technique

Micro-histological faecal analysis involves the identification and quantification of epidermal fragments of ingested plant material recovered in faeces (Hooimeijer *et al*., 2005; De Jong, 2006). For studying different goat breeds, faecal samples can be collected per rectum to determine diet preference of a particular breed. The samples can be dried at 60^{o}C or stored in

Table 2.4: Time spent (%) browsing, grazing and other activities by different goat breeds

Breed	Season	Grazing	Browsing	Other	Source
West African dwarf	Summer	13.9	21.8	64.3	Ouédraogo *et al*. (2006)
	Winter	32.5	16	51.5	
Saanen		60.1	35.9	-	Aregheore *et al*. (2006)
Boer		39.0	61.0		Raats *et al*. (1996)
Angora		47.7	0.15	47.3	Hoste *et al*. (2001)

formalin prior to observations. Micro-histological faecal analysis has advantages over oesophageal extrusa in that: it does not place any restriction on animal movement and also does not interfere with the normal feeding behaviour of the animals on rangelands. Several disadvantages are, however, associated with this method. These include; identification of plant fragment being both tedious and time consuming, some species may become unidentifiable in the faeces and fragments may differ between species during digestion so the relative proportion of species appears different.

2.6 Conclusion

Goat breeds have different feeding habits, which result in an overlap in their diet preferences. This can be influenced mostly by season, morphological characteristics each goat breed exhibit and also other plant related factors. It is, therefore, important to determine feeding behaviour of common indigenous goat genotypes on rangeland across seasons. This would enable partitioning of resources among the goat breeds and other livestock species on rangelands. The objective of the current study was to determine feeding behaviour of indigenous XLE, NGN and NBC on rangelands in the False Thornveld.

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CHAPTER 3: Time spent foraging by Xhosa lop-eared, Nguni and Nguni × Boer crossbred raised on rangelands in the False Thornveld across seasons

Abstract

Feeding behaviour of XLE, NGN and NBC goat genotypes was compared in a False Thornveld by recording time spent on browsing, grazing and other non-foraging activities in four seasons (cool-dry; hot-dry; hot-wet and post-rainy). Observations were made before 12 noon and in the afternoon for 8 goats per breed. Four observers monitored the goats at 15-minute intervals for 4 h (0800-1200h) in the morning and 4h (1200-1600 h) in the afternoon using stop watches. The XLE goats spent more time browsing ($P < 0.05$) in the cool-dry and hot-wet season compared to NGN and NBC goats. The NGN goats spent more time browsing ($P < 0.05$) in the hot-dry season. Time spent grazing varied among the goat genotypes with the NBC cross spending more time grazing ($P < 0.05$) in hot-dry, cool-dry and post rainy season. No differences were noted for non-foraging activities across seasons among goat genotypes. Time of day had no effect on time spent on different activities by goat genotypes raised on rangeland. It was concluded that NBC goats spent more time grazing compared to other breeds across season. Conversely, XLE spent more time browsing in cool-dry and hot-wet seasons compared to NGN and NBC goats.

Keywords: Goat genotypes, Seasons, Sweet rangelands, Time sampling method

3.1 Introduction

Information for comparisons of feeding behaviour of goat breeds on rangelands is scarce. Most studies conducted compared animals of different species, that is, goats with wildlife species; and also goats with cattle and sheep reared on rangelands (Tainton, 1999; Breebaart, 2001). Different species show clear differences on their feeding habits (Provenza, *et al*., 2003). As a result, rangeland resources can be partitioned among the animal species. There is, however, a possibility that feeding behaviour can vary among breeds within the same species. This is normally influenced by several factors interacting at different scales over time (Agreil and Meuret, 2004). Some of the most important factors include the morphological and physiological make up of a breed, and season (Van Soest, 1994; Peacock, 1996; Dziba *et al*., 2003). Seasons influence vegetation structure and nutritional composition of plant species in rangelands. Goat breeds for this reason adapt to different feeding strategies to get feed to meet their nutritional requirements. As a result, time spent on different activities on rangelands is likely going to be affected. It is, therefore, crucial to determine time spent on different activities by the different goat genotypes across seasons.

Time spent on different activities by different goat genotypes give an understanding of how feed resources are utilized. This facilitates in the partitioning of resources among different breeds and other livestock species on rangelands. Farmers can partition resources by designing and implementing effective grazing management systems and formulating economical supplementation programs. The objective of the present study was, therefore, to determine time spent foraging by the XLE, NGN and NBC goat breeds. The null hypothesis was that there are no differences on time spent browsing or grazing by XLE, NGN and NBC goat breeds raised on rangelands.

3.2 Materials and Methods

3.2.1 Study site

The trial was conducted at the University of Fort Hare Farm which is situated 80 km inland from the Eastern Cape coastline in South Africa. The farm is located at latitude of 32°46′ S and 26°51′ E; and is 520 m above sea level. The rangeland is generally flat with a few steep slopes. Vegetation is classified as the "False Thornveld of Eastern Cape" (Acock, 1975). It constitutes diverse plant species of trees and grasses.

3.2.2 Weather patterns of the study site

Temperature patterns recorded during the observation period are shown in Figure 3.1. Approximately 86.9 mm of rainfall was received during the observation period in hot-wet season whilst no rainfall was received in other seasons.

3.2.3 Vegetation assessment

Composition of herbaceous and woody species was determined using the plant step-point method (Evans *et al.*, 1957) and belt transects method (Eggleton *et al.*, 1995), respectively. Using the plant step-point method, approximately 200 points were located to each of the transect lines in the paddock measuring about 200 m in length by dropping a pointed metal rod at each step. The plant nearest to each point was identified and recorded. The belt transects method involved the widening of the line transect to form a continuous belt from which all the woody species were recorded.

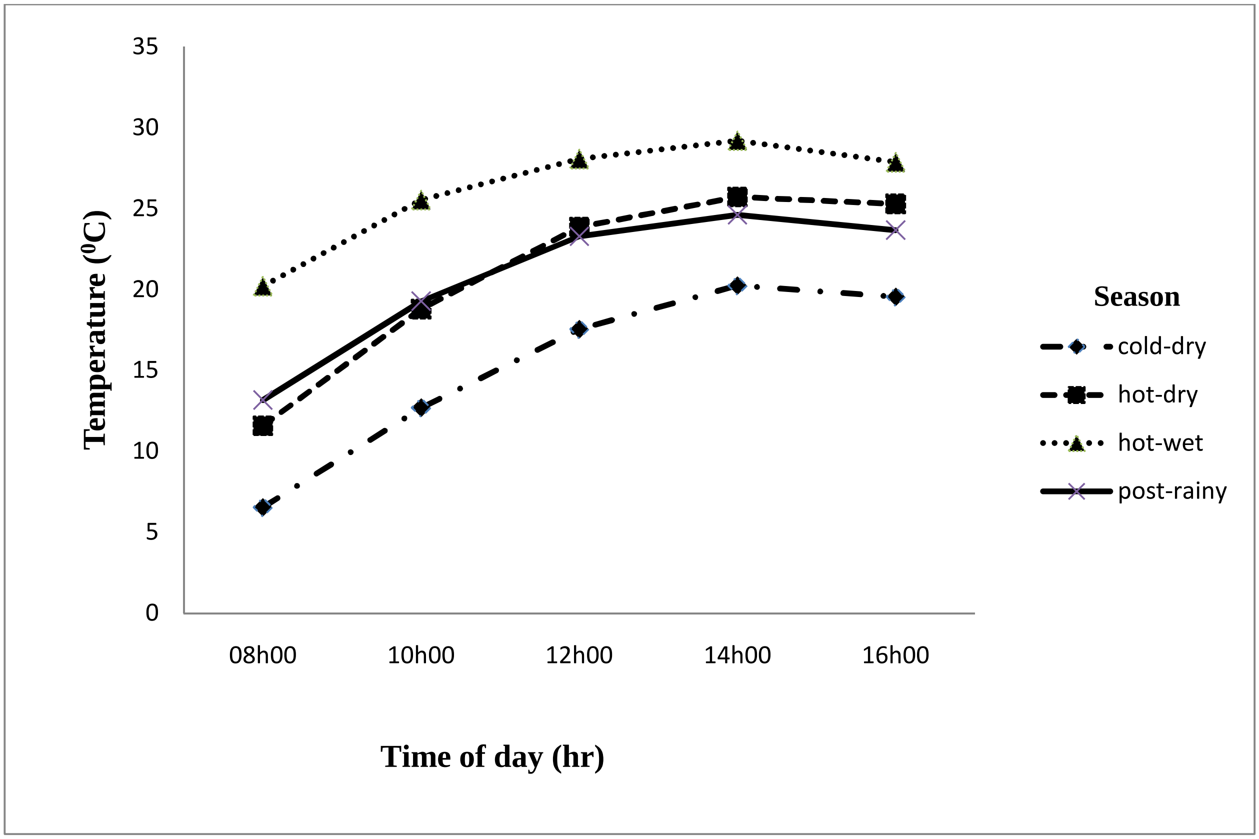

Figure 3.1: Diurnal temperature patterns during observation period across seasons

The plant species composition was calculated as:

Species composition = (M/N) x 100; where

M - Total number of appearances of each plant species

N - Total number of all the different plant species observed

Composition of browse and herbaceous plant species in the study is shown in Table 3.1 and 3.2, respectively.

3.2.4 Adaptation period

The goats were adapted to the rangeland conditions in the paddock of about 20 ha for two weeks. Watering points distributed evenly in the paddock supplied water. The adaptation was done to enable the goats to get used to the presence of observers so that the animals can be closely monitored. A flock size of 50 goats including those identified for the experiment was used.

3.2.5 Management of animals and data collection

Twenty four clinically healthy does aged between 2 to 3 years old, eight from each of the three breeds; XLE, NGN and NBC were randomly selected from a flock of 50 goats. Average weights for the XLE, NGN and NBC were 40.1 ± 1.27, 32 ± 1.27 and 35 ± 1.27 kg, respectively. All the does used were marked on their flanks with paint, which aided in the accurate identification during observation. In the event that paint on the flanks become invisible to observers. The goats had numbers on their ear tags which complement with those on their flanks. This ensured that same goats were used throughout the experiment.

Table 3.1: Average species composition values of woody plant material for all seasons

Browse species	Composition (%)
Acacia karroo	80.70
Azima tetracantha	0.12
Coddia rudis	2.41
Diospyros lycioides	2.53
Ehretia rigida	3.02
Grewia occidentalis	0.48
Lantana camara	0.48
Leucas capensis	0.24
Lippia javanica	1.45
Lycium ferocissimum	2.05
Maytenus heterophylla	1.57
Maytenus polyacantha	0.24
Maytenus capitata	0.24
Rhus longispina	0.36
Rhus reflecta	1.93
Scutia myrtina	2.18

Table 3.2: Average species composition values of herbaceous plant material for all seasons

Herbaceous species	Composition (%)
Digitaria eriantha	28.0
Sporobolus africanus	12.7
Cynodon dactylon	15.7
Sporobolus fimbriatus	14.3
Panicum stapfianum	3.3
Panicum maximum	1.0
Microchloa caffra	1.3
Eragrostis obtusa	0.7
Eustachys mutina	4.7
Themeda triandra	14.3
Setaria neglecta	0.7
Eragrostis chloromelas	0.3
Cymbopogon plurinodis	3.0

The goats were penned after 1600h and released during the day before 0800h. Four observers monitored the goats at 15-minute intervals for 4 h (0800-1200h) in the morning and 4h (1200-1600 h) in the afternoon using stop watches. The same observers monitored the goats across seasons; hot-wet, post-rainy, cool-dry and hot-dry. Activities of feeding behaviour of the goats were recorded for four consecutive days, two times in each season. The activities recorded were grazing, browsing, grazing/walking, standing, walking, lying down and other activities. Description of the activities is in Table 3.3. The time spent on each activity was expressed as a proportion of the total time spent on various activities in each season.

3.2.6 Statistical analysis

The proportion (%) of time spent on different activities was analyzed using the General Linear Model (GLM) procedure of SAS (2003). Comparisons of means were done using the PDIFF option of SAS (2003). The model used was as follows:

$Y_{ijkl} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \delta_k + \alpha\delta_{ik} + \alpha\beta\delta_{ijk} + e_{ijkl}$,

Where; Y_{ijkl} = Time spent on each activity;

μ=overall mean response;

α_i =effect of breed (i=Xhosa, NGN, crossbred NGN × Boer);

β_j= effect of season (j= Cool-dry; Hot-dry; Hot-wet; Post-rainy) ;

δ_k = time of day (k= morning, afternoon);

$\alpha\beta_{ij}$ = interaction of season and breed

$\alpha\delta_{ik}$ = interaction of breed and time of day

$\alpha\beta\delta_{ijk}$ = interaction of breed, season and time of day;

e_{ijkl} = experimental error.

Table 3.3: Description of activities recorded using time sampling method

Activity	Description
Grazing	Consumption of grass material with head pointing downwards
Browsing	Consumption of browse species with head pointing upwards
Grazing/walking	Consumption of herbaceous material whilst moving
Standing	Standing without eating and when ruminating
Lying down	Sitting to rest or ruminate
Walking	Moving from one place to another with head raised up
Other activities	Fighting, mating and drinking water

3.3 Results

3.3.1 Time spent foraging

During the post-rainy season, no differences ($P > 0.05$) were noted on time spent browsing for the goat genotypes before noon (Table 3.4). Differences ($P < 0.05$) were observed in the afternoon when the XLE spent more time browsing (54.18 ± 0.79 %) than the NGN (46.33 ± 0.69 %) and NBC (37.53 ± 0.83 %). Time spent grazing was high ($P < 0.05$) for NBC compared to the XLE and NGN regardless of time of day. For the activities like grazing/walking, lying down, standing, walking and other activities like mating, fighting and drinking water, no differences ($P > 0.05$) among breeds and time of day were observed. This was also observed during the hot-dry season (Table 3.5).

In the hot–dry season, NGN goat breed spent more time browsing ($P < 0.05$) than the XLE and NBC (Table 3.5). Conversely, NBC spent more time grazing ($P < 0.05$) than NGN and XLE goat breeds. No differences ($P > 0.05$) were noted on time spent grazing for NGN and XLE goat breeds regardless of time of day.

Table 3.4: Time spent (%) on different activities by Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crosses (NBC) in the post-rainy season

Breed	Time	b	g	gw	o	l	s	w	se
NGN	AM	59.62[a]	17.01[c]	4.40[a]	0.78[a]	0.00[a]	2.96[a]	15.24[a]	0.691
	PM	46.33[b]	29.43[ab]	7.59[a]	1.03[a]	2.58[a]	3.64[a]	9.41[a]	0.691
XLE	AM	57.70[a]	16.13[c]	7.67[a]	1.37[a]	0.07[a]	2.20[a]	14.87[a]	0.786
	PM	54.18[a]	25.01[b]	6.04[a]	2.07[a]	0.03[a]	2.83[a]	9.84[a]	0.786
NBC	AM	54.38[a]	21.84[bc]	6.00[a]	0.83[a]	0.03[a]	1.53[a]	15.37[a]	0.834
	PM	37.53[b]	34.03[a]	8.20[a]	2.20[a]	3.63[a]	3.50[a]	10.90[a]	0.834

[abc] Values within the same column with different superscripts are significantly different ($P < 0.05$)

b-browsing; g-grazing; gw-grazing/walking; o-other activities; l-lying down; s-standing; w-walking

AM - before 12 noon; PM - afternoon

se - standard error

Table 3.5: Time spent (%) on different activities by Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crosses (NBC) in the hot-dry season

Breed	Time	b	g	gw	o	l	s	w	se
NGN	AM	15.57[a]	55.29[b]	12.97[b]	0.37[a]	-	0.40[a]	15.40[a]	0.589
	PM	13.68[ab]	56.57[b]	15.04[b]	0.63[a]	0.10[a]	0.60[a]	13.38[a]	0.589
XLE	AM	8.72[bc]	56.79[b]	17.33[ab]	0.90[a]	-	1.10[a]	15.17[a]	0.572
	PM	11.12[b]	56.39[b]	15.81[b]	0.60[a]	-	0.60[a]	15.48[a]	0.572
NBC	AM	5.42[c]	63.85[a]	15.73[b]	0.56[a]	-	0.40[a]	14.04[a]	0.654
	PM	4.48[c]	67.22[a]	12.48[b]	0.53[a]	-	0.27[a]	15.03[a]	0.654

[abc] Values within the same column with different superscripts are significantly different ($P < 0.05$)

b-browsing; g-grazing; gw-grazing/walking; o-other activities; l-lying down; s-standing; w-walking

AM - before 12 noon; PM - afternoon

se - standard error

There were no significant differences ($P > 0.05$) among the goat genotypes on time spent browsing during the hot-wet season (Table 3.6). The NGN goats spent more ($P < 0.05$) time grazing in the afternoon than other goat breeds regardless of time of the day. Time spent grazing/walking was high before noon and increased as the day progressed. This was observed for all goat genotypes in the paddocks. The same trend as in grazing/walking activity was also observed for time spent walking by all goat breeds. No differences ($P > 0.05$) were noted for standing, walking and other activities like mating, fighting and drinking water in the paddock for all goat genotypes.

In both morning and afternoon sessions, the XLE goats spent more time browsing ($P < 0.05$) compared to NBC and NGN goat breeds in the cool-dry season (Table 3.7). The NBC on the other hand, spent more time grazing ($P < 0.05$) compared to the XLE and NGN goat breeds in the same season. No significant effects were noted on time spent grazing for each goat breed in paddock before noon and in the afternoon. Time spent on the activity of grazing/walking was less ($P < 0.05$) for the XLE than NBC and NGN goat breeds.

Table 3.6: Time spent (%) on different activities by Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crosses (NBC) in the hot-wet season

Breed	Time	b	g	gw	o	l	s	w	se
NGN	AM	31.50^{a}	41.43^{b}	14.13^{a}	0.73^{a}	0.93^{a}	1.83^{a}	9.43^{a}	0.541
	PM	25.31^{a}	47.81^{a}	8.97^{b}	2.68^{a}	2.68^{a}	4.99^{a}	7.57^{b}	0.594
XLE	AM	31.61^{a}	40.70^{b}	13.24^{a}	0.80^{a}	0.60^{a}	2.23^{a}	10.82^{a}	0.563
	PM	27.63^{a}	40.77^{b}	9.10^{b}	2.77^{a}	4.53^{a}	6.97^{a}	8.23^{b}	0.612
NBC	AM	31.64^{a}	41.25^{b}	13.52^{a}	1.11^{a}	-	1.42^{a}	11.06^{a}	1.012
	PM	28.68^{a}	35.51^{b}	10.84^{ab}	3.10^{a}	6.17^{a}	7.94^{a}	7.77^{b}	1.012

[ab] Values within the same column with different superscripts are significantly different ($P < 0.05$)

b-browsing; g-grazing; gw-grazing/walking; o-other activities; l-lying down; s-standing; w-walking

AM - before 12 noon; PM - afternoon

se - standard error

Table 3.7: Time spent (%) on different activities by Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crosses (NBC) in the cool-dry season

Breed	Time	b	g	gw	o	l	s	w	se
NGN	AM	14.22[b]	49.20[cd]	21.22[a]	1.08[a]	1.01[a]	1.93[a]	11.34[a]	0.229
	PM	11.22[c]	50.84[bc]	22.15[a]	1.16[a]	2.13[a]	2.59[a]	9.90[a]	0.338
XLE	AM	17.08[a]	45.41[e]	20.62[ab]	1.39[a]	0.13[a]	3.66[a]	11.70[a]	0.353
	PM	15.56[a]	46.17[de]	19.75[b]	1.36[a]	1.56[a]	3.76[a]	11.84[a]	0.564
NBC	AM	7.66[d]	54.17[ab]	23.76[a]	0.85[a]	0.62[a]	2.09[a]	10.83[a]	0.394
	PM	5.06[d]	56.83[a]	22.19[a]	1.44[a]	0.33[a]	2.50[a]	11.65[a]	0.639

[abcd] Values within the same column with different superscripts are significantly different ($P < 0.05$)

b-browsing; g-grazing; gw-grazing/walking; o-other activities; l-lying down; s-standing; w-walking

AM - before 12 noon; PM - afternoon

se - standard error

3.4 Discussion

The observation that time devoted to grazing was high in the hot-dry season for all goat breeds than other seasons was anticipated. More time devoted to grazing during the hot-dry season might be attributed to the tree species which shed their leaves. In the present study, *A. karroo* was the most abundant tree species in the paddock, it is a deciduous tree and most of its leaves were shed during the hot-dry season leaving very few shoots for consumption by the goats. Shoots from deciduous trees started to emerge at the onset of the hot–wet season. This left goats with no option but to eat more of the herbaceous material during the hot-dry season. Comparisons of breeds in the hot-dry season has shown NBC to spent more time grazing than other goat breeds in the study. This might be ascribed to the adaptability of the NBC goats to the vegetation type. The NBC probably was able to produce prodiguous quantities of saliva with urea, which can aid digestion of fibrous material (herbaceous material) (Silanikove, 2000). Saliva production by the NBC goats was, however, not measured in this study and it, therefore, warrants further investigation. Unlike the XLE, the NBC goats in the present study had also a small body frame as the NGN goats. The NBC goats, therefore, were also unable to reach browse leaves at higher levels, thus resorted to grazing. The observation that goats did not lie down in the hot-dry season may be attributed to the unavailability of palatable feed in the paddock (Raats *et al*., 1996; Ouédraogo *et al*. 2006). Instead of lying down, goats spent more of their time searching for palatable feed to compensate for a decrease in availability (El Aich *et al*., 2007). This could also account for the less time spent on other non-foraging activities in the paddock.

During the observation period, the post-rainy season was characterised by vegetation with plenty of browse leaves and also herbaceous plant species which were still succulent. Option to spend more time grazing than browsing by goats may be attributed to the accessibility of the plant species. Herbaceous plant species are easily accessible than browse species. Body size of the different goat breeds have been noted to play an important role in accessing tree leaves. This was the case with the XLE goats which spent more time browsing than NGN and NBC goats. The XLE is a large framed goat compared to NGN and NBC goat breeds. It probably took advantage of its large size to stretch its body when assuming the bipedal stance to reach tree leaves at a much higher level especially when browse was limited (NRC, 2007). This observation is in agreement with Shelton (1978) and Dziba (2000) who reported that goats use an advantage of their large body framework to become more of browsers on rangelands. The observation that time spent by goats browsing decreases as the day progresses and at the same time, grazing time in the paddock increased as the day progressed, could be explained as a feeding strategy employed by goats to prevent rumen fill with low quality feed, which would otherwise reduce intake (Solanki, 2000). Provenza *et al*. (2003) also explains such an anomaly to be a resultant of goats trying to detoxify anti-nutritional factors from previous consumption of browse species by dilution from eating herbaceous material.

During the cool season, trees also shed their leaves. This might probably account for more time spent grazing by the goats. These findings are consistent with reports from Landau *et al*. (2000) and Ouédraogo *et al*. (2006) where goats also consumed more herbaceous species during the cool season. The observation that XLE goats spent more time browsing in the cool season than other breeds in the experiment might be a result of breed being adapted to cope up with the anti-nutritional factors in browse species compared to the NBC and NGN goat breeds (Provenza *et al*., 2003). The observation where the breed spent more time browsing was also obtained in hot-dry and also post-rainy season. Such findings where breed differences were observed in the amount of browse consumed were also noted by Nyamukanza and Scogings (2008). Goats during the cool season were expected not to lie down more often to avoid contact with the cold surface (Landau *et al*., 2000). This was not the case in the current study for goats for goats had to lie down probably when ruminating.

The behavioural activity where goats graze whilst moving (grazing/walking) has also been reported by El Aich *et al.* (2007). In the current study, this was observed for all goat breeds across seasons. Time spent grazing/walking was more for the NGN as well as the NBC and less pronounced for the XLE goats on rangelands. Time spent on the grazing/walking activity by the goats on rangelands in the study emanated when goats moved to another grazing patch on rangeland and also when some individual goats were trying to catch up with the rest of the flock as they were feeding.

The similarities in time spent on non-foraging activities in the present study for different breeds agree with literature on the influence of social behavioural learning (Provenza and Balph, 1987; Thorhallsdotir *et al*., 1987; Barroso *et al*., 2000). In these reports, goats not accustomed to the feeding technique learn from another breed when foraging in a flock.

3.5 Conclusions

The NBC goats spent more time grazing on herbaceous plant species in the hot-dry and cool-dry season regardless of time of day compared to XLE and NGN goat breeds. Conversely, XLE goats spent more time feeding on browse species in the post–rainy, cool–dry and hot-dry season.

It is, therefore, recommended that the XLE goats should be incorporated in a mixed livestock system to reduce competition for limited herbaceous material on rangelands. Since the goat genotypes vary their time spent browsing and grazing on rangelands, it is important to ascertain plant species selected by the different goat genotypes for efficient management rangelands.

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CHAPTER 4: Seasonal variation in plant preferences of Xhosa lop-eared, Nguni and Nguni × Boer crossbred goats raised on rangelands of the False Thornveld

Abstract

Plant preference of three goat genotypes; Xhosa lop-eared (XLE), Nguni (NGN) and Nguni × Boer crossbred (NBC) was studied using the micro-histological faecal analysis technique. Faecal samples were collected from rectum of goats in four seasons; hot-dry (September to October), hot-wet (November to February), cold-dry (June to August), and post-rainy season (March to May). The faecal samples were prepared for observation and plant fragments identified using a microscope at 400 × magnification. Greater proportions ($P < 0.05$) of *A. karroo* fragments were identified in faeces of the XLE goats in the hot-dry season compared to NGN and NBC goats. The NBC goats had a higher ($P < 0.05$) proportion of *Sporobolus africanus* and *S. fimbriatus* in faeces compared to other breeds. No significant differences ($P > 0.05$) were found on the proportion of plant fragments identified in faeces of all goat genotypes during hot-wet season. The NBC goats had low ($P < 0.05$) proportions of plant fragments of *D. lycioides* and *E. rigida* identified in faeces and had a higher proportion of *Sporobolus africanus* in the cold-dry season compared to NGN and XLE goats. The XLE and NBC goat genotypes had higher proportions of *S. fimbriatus* and *P. maximum* plant fragments during the post-rainy season. *Grewia occidentalis*, *Panicum maximum* and *Diospyros lycioides* had greater preference index values for all goat genotypes, compared to other plant species. The XLE goats selected more browse than herbaceous plant species compared to other breeds. Xhosa lop-eared goats, therefore, show a potential to browse more than the NGN and NBC goats. Use of the XLE goats in mixed livestock system with livestock species perceived to be grazers on rangelands of the False Thornveld is recommended.

Keywords: Plant preference, Species composition, Season, micro-histological faecal technique

4.1 Introduction

Plant preferences are discriminations exerted by an animal between plant species and plant components (Newman *et al*., 1995). The concept of feed preferences typically applies to goats since they prefer to alternate between different feeds whilst feeding on rangelands (Abdel-Moneim and Abd-Alla, 1999). From Chapter 3, the XLE goats spent more time browsing compared to NGN and NBC goat breeds. On the contrary, it was observed that NBC goats spent more time grazing compared to XLE and NGN goats. Variations in time spent browsing and grazing could possibly signify some differences of nutritional wisdom across goat genotypes, which might enable them to select different plant species to meet their nutritional needs and at the same time avert from plants that cause toxicosis (Provenza *et al*. 2003). Plant species preference may also vary across seasons due to fluctuations in chemical constituents of plant species and also forage accessibility, a result of the animals' ability to reach a certain height of tree when browsing.

Preference for plant species by goats on rangelands can be studied using the micro-histological faecal analysis technique (Hooimeijer *et al*., 2005; De Jong, 2006). The technique does not interfere with the normal feeding behaviour of the animals whilst feeding on rangeland and does not place any restrictions on animal movements. Knowledge of dietary preferences could allow optimal forage allocation to the different goat genotypes and other livestock species, selecting species for reseeding deteriorated rangelands and predicting the outcome of overgrazing by different livestock species (Holechek *et al*., 1982). The objective of the current study was to compare plant preferences of the XLE, NGN and NBC goat genotypes on sweet rangelands in the False Thornveld in South Africa.

4.2 Materials and Methods

4.2.1 Study site, experimental animals and their management

The study site and management of the goats are described in Chapter 3. Twelve clinically healthy goats, 4 from each breed of the XLE, NGN and NBC were used in the study.

4.2.2 Micro-histological faecal analysis

4.2.2.1 Collection of faecal material

Before collection of the faecal samples, goats were allowed to adapt to the rangeland conditions for a period of two weeks. Faecal pellets were collected as per rectum of the goat before they were kraaled after 1600h. The faecal samples were dried in an oven at 65^{o}C for 24 hours and milled through a 1mm screen. The samples were stored in a dry environment awaiting preparation for observation under microscope.

4.2.2.2 Preparation of faecal material

Approximately 2 g of ground faecal samples were digested in 10ml of 55 % nitric acid over a water bath for 2-3 minutes, and then placed in 200ml boiling water. The boiling water was regularly stirred to facilitate the clearing of cuticular fragments. The fragments were allowed to settle at the bottom and supernatant liquid decanted. A wide-mouthed pipette was used to take a grab sample which was transferred onto a slide. On each slide, at least 100 epidermis fragments were identified and measured. Enumeration method used involved counting the number of fragments of each plant species on slide quadrats, as described by De Jong (2006). Slides were viewed under a microscope at a magnification of × 400.

4.2.2.3 Preparation of reference plant material

All grasses, shrubs and trees in the paddock were identified and leaves collected for use as reference plant material. Reference plant materials were necessary for the identification of plant epidermal cells of different plant species, which have been consumed by goats and later recovered in faeces. Portions of the fresh plant material were preserved in formalin acetic. Leaf or plant material was cut into thin strips (10 X 10 mm) and boiled in 10% nitric acid to separate the epidermis from the mesophyll layer (McAllister and Bornman, 1972). The strips were then washed using running water to remove residual acid and the epidermis peeled off using a forceps. Abaxial and adaxial surfaces were peeled off from the plant strips and mounted on slides with a stain. The specimen was viewed under a microscope at a magnification of 400×. Photomicrographs were taken to help in the matching process of epidermis of plant material from the faeces.

4.2.3 Preference index

Plant species composition on rangelands where goats foraged was assessed (Chapter 3). The values obtained were used to calculate preference index together with values from faecal analysis. A preference index (PI) was calculated using the formula:

PI= CCF/CA; where

CCF is the percentage of plant species recovered in faeces; and

CA is the composition of plant species available in rangelands.

Preference index indicates the extent of utilization of plant species in relation to their availability (Petrides, 1975). Preference index values greater than 1.0 indicate a plant species was selected by the goat. A negative selection of a particular plant species is indicated by a preference index value less than 1.0. Zero indicates the plant species was not consumed.

4.2.4 Statistical analysis

Following arcsine transformation to normalise the data, the proportions of plant fragments identified in faeces were analyzed by using the GLM procedure of SAS (2003). Comparisons of means were done using the PDIFF option of SAS (2003). Model used was as follows;

$Y_{ijk} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + e_{ijk}$,

Where;

Y_{ijk} = proportion of plant species in faeces

μ=overall mean response;

α_i =effect of breed ($_i$=XLE, NGN, NBC);

β_j= effect of season($_j$= cool-dry; hot-dry; hot-wet; post-rainy);

$\alpha\beta_{ij}$ = interaction between breed and season;

e_{ijk} = experimental error.

4.3 Results

4.3.1 Diet composition in faeces

Twenty five plant species were identified in faeces of all the goat genotypes. Of the 25 plant species, 13 were browse species whilst the remaining 12 were herbaceous plant species (Table

3). *Acacia karroo* was the most consumed browse species on rangelands as evidenced by the higher proportion of plant fragments identified in faeces of all goat genotypes across seasons. *Sporobolus fimbriatus, S. africanus* and *T. triandra* contributed a higher proportion for the herbaceous species in the diet of all goat genotypes across seasons. Goats seemed not to prefer the plant species, *C. rudis, L. camara, L. javanica* and *S. neglecta* as they were not identified in faeces across seasons.

During the post-rainy season, significant differences ($P < 0.05$) among genotypes on the proportion of plant fragments identified in faeces were observed for *S. fimbriatus* and *P. maximum* (Table 4). The XLE and NBC goat genotypes had higher proportions of *S. fimbriatus* and *P. maximum* plant fragments compared to the NGN goats. Other differences on proportion of plant fragments found in faeces of goats were for *E. rigida, L. capensis, R. refracta, M. caffra, E. chloromelas, E. obtusa* and *C. plurinodis* when plant fragments were not identified for a particular goat breed ($P < 0.05$). Nguni goats consumed *E. rigida* whilst XLE and NBC goat genotypes did not. On the other hand, NBC and NGN goat genotypes rejected *L. capensis* and *R. refracta* respectively. The trend where one goat genotype did not consume a plant species as opposed to other goat genotypes also occurred for the herbaceous species; *M. caffra, E. chloromelas, E. obtusa* and *C. plurinodis.*

In the hot-dry season, the NBC goats craved for herbaceous than browse species compared to XLE and NGN goat breeds (Table 5). Consumption of herbaceous species was indicated by the high ($P < 0.05$) proportion of plant fragments of *S. africanus, S. fimbriatus* and *C. plurinodis* identified in faeces compared to XLE and NGN goat breeds. The XLE goats had a higher proportion of *A. karroo* in faeces than NBC and NGN goat breeds. Plant fragments of the browse species; *M. capitata, R. reflecta* and *L. ferocissimum* were not identified in faeces by NBC goats indicating they did not constitute their diet. Rejection of browse species was also observed for *M. polyacantha* and *R. longispina* for NGN and XLE goat genotypes. *Digitaria eriantha* and *E. mutina* are herbaceous material rejected by XLE and NBC genotypes but consumed by NGN goats.

No significant differences ($P > 0.05$) were found on the proportion of plant fragments identified in faeces of all goat genotypes during hot-wet season (Table 6). Differences were observed when a particular goat breed did not consume a plant species in relation to other goat genotypes. In the cold-dry season, NGN and XLE had higher ($P < 0.05$) proportions of plant fragments of *D. lycioides* and *E. rigida* in their faeces compared to NBC goats (Table 7). On the contrary, NBC goats had a higher ($P < 0.05$) proportion of *S. africanus* in faeces than XLE and NGN breeds. Other differences occurred when fragments of a particular plant species were not identified for a particular goat genotype ($P < 0.05$).

Table 4.1: Plant species identified in faecal samples of Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crossbred (NBC) goats in the post-rainy season

Plant species	NGN	XLE	NBC
Browse species			
Acacia karroo	45.69 ± 0.033[a]	38.56± 0.079[a]	36.79± 0.091[a]
Diospyros lycioides	2.54 ± 0.25[a]	6.43±0.19[a]	7.55±0.21[a]
Ehretia rigida	1.02 ± 0.18[a]	0	0
Grewia occidentalis	6.09 ± 0.25[a]	5.51±0.21[a]	4.72±0.23[a]
Leucas capensis	0.51 ± 0.19[a]	0.92±0.19[a]	0
Rhus reflecta	0	2.14± 0.13[a]	0.94±0.15[a]
Scutia. Myrtina	8.63± 0.16[a]	1.84± 0.15[a]	4.72± 0.28[a]
Herbaceous species			
Sporobolus africanus	16.24±0.17[a]	11.02±0.17[a]	10.38±0.20[a]
Sporobolus fimbriatus	6.60±0.17[b]	10.10±0.17[a]	8.02±0.19[a]
Panicum maximum	3.05±0.19[b]	5.78±0.19[a]	1.89±0.22[ab]
Microchloa caffra	0	1.84±0.080[a]	0
Eragrostis obtusa	0	0.92±0.074[a]	0
Themeda triandra	8.63±0.10[a]	13.13±0.10[a]	16.98± 0.12[a]
Eragrostis chloromelas	1.02±0.24[a]	0	0
Cymbopogon plurinodis	0	1.84±0.21[a]	8.02± 0.25[a]

[ab] Values within the same row with different superscripts are significantly different ($P < 0.05$)

Table 4.2: Plant species identified in faecal samples of Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crossbred (NBC) goats in the hot-dry season

	NGN	XLE	NBC	Standard error
Browse species				
Acacia karroo	26.48^{b}	38.59^{a}	21.60^{b}	0.079
Diospyros lycioides	8.45^{a}	7.76^{a}	3.67^{a}	0.214
Ehretia rigida	2.74^{a}	3.06^{a}	0.65^{a}	0.176
Grewia occidentalis	7.08^{a}	4.71^{a}	5.18^{a}	0.183
Leucas capensis	2.74^{a}	3.53^{a}	1.73^{a}	0.192
Lycium ferocissimum	1.60^{a}	1.88^{a}	0	0.113
Maytenus polyacantha	0	0.24^{a}	0.22^{a}	0.071
Maytenus capitata	$1.83^{a}0$	2.35^{a}	0	0.097
Rhus longispina	0	0	0.22^{a}	0.1
Rhus reflecta	0.23^{a}	0.71^{a}	0	0.132
Scutia myrtina	11.19^{a}	5.41^{a}	4.54^{a}	0.223
Herbaceous species				
Digitaria eriantha	0.46^{a}	0	0	0.099
Sporobolus africanus	7.08^{b}	7.06^{b}	20.95^{a}	0.170
Sporobolus fimbriatus	5.25^{b}	4.00^{b}	12.31^{a}	0.167
Panicum maximum	7.53^{a}	4.71^{a}	4.32^{a}	0.187
Eragrostis obtusa	0.23^{a}	0.94^{a}	0.22^{a}	0.075
Eustachys mutina	0.23^{a}	0	0	0.074
Themeda triandra	12.56^{a}	9.18^{a}	14.69^{a}	0.102
Eragrostis chloromelas	2.74^{a}	3.06^{a}	0.65^{a}	0.167
Cymbopogon plurinodis	1.60^{b}	2.82^{b}	9.07^{a}	0.208

[ab] Values within the same row with different superscripts are significantly different ($P < 0.05$).

Table 4.3: Plant species identified in faecal samples of Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crossbred (NBC) goats in the in hot-wet season

	NGN	XLE	NBC	Standard error
Browse species				
Acacia karroo	22.98[a]	30.81[a]	21.87[a]	0.079
Diospyros lycioides	12.13[a]	10.75[a]	8.66[a]	0.214
Ehretia rigida	0.85[a]	0.67[a]	2.28[a]	0.176
Grewia occidentalis	4.89[a]	4.70[a]	7.06[a]	0.187
Leucas capensis	4.68[a]	1.79[a]	5.92[a]	0.192
Rhus longispina	0	5.37[a]	0	0.01
Rhus reflecta	1.06[a]	0.45[a]	0.46[a]	0.132
Scutia myrtina	0	4.48[a]	0.46[b]	0.099
Herbaceous species				
Digitaria eriantha	2.34[a]	0	0	0.085
Sporobolus africanus	11.91[a]	12.09[a]	15.72[a]	0.170
Sporobolus fimbriatus	10[a]	10.97[a]	8.88[a]	0.167
Panicum maximum	2.98[a]	2.91[a]	2.96[a]	0.187
Eragrostis obtusa	0	0	0.23[a]	0.074
Eustachys mutina	1.06[a]	0	0	0.056
Themeda triandra	15.74[a]	9.85[a]	14.58[a]	0.102
Eragrostis chloromelas	0.85[a]	0.67[a]	2.28[a]	0.098
Cymbopogon plurinodis	8.51[a]	4.48[a]	8.66[a]	0.208

[ab] Values within the same row with different superscripts are significantly different ($P < 0.05$)

Table 4.3: Plant species identified in faecal samples of Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crossbred (NBC) goats in the cool-dry season

	NGN	XLE	NBC	Standard error
Browse species				
Acacia karroo	27.14[a]	32.00[a]	24.67[a]	0.079
Azima tetracantha	0	0.43[a]	0	0.021
Diospyros lycioides	9.52[a]	7.08[a]	1.10[b]	0.214
Ehretia rigida	3.33[ab]	8.79[a]	2.64[b]	0.176
Grewia occidentalis	6.43[a]	1.93[a]	3.96[a]	0.183
Leucas capensis	2.86[a]	3.86[a]	2.20[a]	0.192
Lycium ferocissimum	1.43[a]	1.50[a]	0.44[a]	0.113
Maytenus heterophylla	0	0.43[a]	0	0.021
Maytenus polyacantha	0	0	0.44[a]	0.112
Maytenus capitata	0	1.29[a]	0.22[a]	0.097
Rhus reflecta	2.14[a]	2.79[a]	0	0.132
Scutia myrtina	5.00[a]	4.93[a]	8.81[a]	0.139
Herbaceous species				
Digitaria eriantha	1.19[a]	1.50[a]	1.10[a]	0.099
Sporobolus africanus	9.05[b]	7.08[b]	18.06[a]	0.170
Cynodon dactylon	0.24[a]	0	0	0.079
Sporobolus fimbriatus	8.57[a]	3.00[a]	8.37[a]	0.167
Panicum stapfianum	0	0.21[a]	0	0.015
Panicum maximum	5.48[a]	5.36[a]	6.39[a]	0.187
Eragrostis obtusa	0.71[a]	1.07[a]	2.86[a]	0.0745
Eustachys mutina	0	0	0.66[a]	0.0564
Themeda triandra	14.29[a]	13.94[a]	10.79[a]	0.102
Eragrostis chloromelas	0.71[a]	1.07[a]	2.86[a]	0.089
Cymbopogon plurinodis	1.90[a]	1.72[a]	4.41[a]	0.208

[ab] Values within the same row with different superscripts are significantly different ($P < 0.05$)

4.4.2 Plant preference indices

Eleven plant species were selected by the three goat breeds on rangelands. Six browse species were selected by all goat breeds on rangelands (Table 4.5). These include *D. lycioides, E. rigida, G. occidentalis, M. capitata, R. longispina* and *S. myrtina*. *Grewia occidentalis* was the most preferred browse species selected by all goat breeds across seasons, with high preference index values compared to other browse species. The XLE goats selected more browse species, some of which were not selected by the NGN and NBC goat breeds. The browse species which were not selected by NGN and NBC are *R. longispina* and *E. rigida*. The NBC goats only selected three browse species namely *D. lycioides, G. occidentalis* and *S. myrtina*. *Coddia ruddis, L. camara, L. capensis* and *L. javanica* herbaceous plant species were unacceptable to all goat breeds.

Variations have been noted on the different herbaceous plant species selected by goats on rangelands (Table 4.6). The herbaceous plant species were selected by the goat breeds were *C. pluridonis, E. obtusa, P. maximum, S. africanus* and *T. triandra*. The NGN goats selected *C. pluridonis* and *P. maximum* while XLE selected *E. obtusa* and *P. maximum*. Unlike the XLE and NGN goat breeds, the NBC goats proved to have a higher preference for herbaceous plant species. It selected five herbaceous plant species, which include *C. pluridonis, E. obtusa, P. maximum, S. africanus* and *T. triandra*. *Panicum maximum* was the most preferred herbaceous plant species by all breeds with higher preference index values. *Setaria neglecta* was unacceptable to all goat breeds.

Table 4.4: Plant preference indices (PI) of browse species for the Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crossbred (NBC) goats

	NGN			XLE		NBC	
	CA	**CCF**	**PI**	**CCF**	**PI**	**CCF**	**PI**
Browse species							
Acacia karroo	80.70	30.65	0.38	35.40	0.44	27.44	0.34
Azima tetracantha	0.12	0	0	0.11	0.94	0	0
Coddia ruddis	2.41	0	0	0	0	0	0
Diospyros lycioides	2.53	8.46	3.34	8.13	3.21	5.26	2.08
Ehretia rigida	3.02	2.00	0.66	3.24	1.07	1.43	0.47
Grewia occidentalis	0.48	6.17	12.78	4.21	8.73	4.92	10.20
Lantana camara	0.48	0	0	0	0	0	0
Leucas capensis	0.24	0	0	0	0	0	0
Lippia javanica	1.45	0	0	0	0	0	0
Lycium ferocissimum	2.05	0.76	0.37	0.85	0.42	0.11	0.06
Maytenus heterophylla	1.57	0	0	0.11	0.07	0	0
Maytenus polyacantha	0.24	0	0	0.06	0.24	0.17	0.71
Maytenus capitata	0.24	0.47	1.95	0.91	3.77	0.06	0.24
Rhus longispina	0.36	0	0	1.36	3.77	0.06	0.16
Rhus reflecta	1.93	0.88	0.46	1.55	0.80	0.34	0.18
Scutia myrtina	2.17	6.11	2.81	4.21	1.94	4.75	2.19

CCF: percentage of plant species recovered in faeces.

CA: composition of plant species available in rangelands.

Table 4.5: Plant preference indices of herbaceous species for the Nguni (NGN), Xhosa lop-eared (XLE) and the Nguni x Boer crossbred (NBC) goats

		NGN		XLE		NBC	
Herbaceous species	**CA**	**CCF**	**PI**	**CCF**	**PI**	**CCF**	**CA**
Cymbopogon plurinodis	3.00	3.23	1.08	2.73	0.91	6.68	2.23
Cynodon dactylon	15.67	0.06	0	0	0	0	0
Digitaria eriantha	28.00	1.06	0.04	0.40	0.01	0.29	0.01
Eragrostis obtusa	0.67	0.24	0.35	0.74	1.11	0.86	1.29
Eustachys mutina	4.67	0.35	0.08	0	0	0.17	0.04
Microchloa caffra	1.33	0	0	0.45	0.34	0.06	0.04
Panicum stapfianum	3.33	0	0	0.06	0.02	0	0
Panicum maximum	1.00	4.82	4.82	4.74	4.74	4.01	4.01
Sporobolus africanus	12.67	11.09	0.88	9.46	0.75	16.83	1.33
Sporobolus fimbriatus	14.33	7.76	0.54	7.05	0.49	9.60	0.67
Setaria neglecta	0.67	0	0	0	0	0	0
Themeda triandra	14.33	13.07	0.91	11.65	0.81	14.45	1.01

CCF: percentage of plant species recovered in faeces.

CA: composition of plant species available in rangelands.

4.4 Discussion

Among the forage species that where available in rangelands, *A. karroo* was the most consumed plant species by all the breeds, as larger proportions of the plant fragments were identified in the faeces across seasons. Although *A. karroo* had larger proportions of the plant fragments identified in faeces, it was negatively selected (PI < 1.0). This could be due to a high species composition of about 80% found relative to plant fragments identified in faeces of goats. The high occurrence of *A. karroo* in faeces might be a result of subsequent encounter of goat breeds with this browse species (Raats *et al*., 1996). Furthermore, *A. karroo* is a leguminous tree with high protein levels, thus this might account for the high intake rate exhibited by the goat genotypes on the plant species across seasons (Dziba *et al*., 2003). Digestibility of protein in *A. karroo* was, however, not estimated warranting further investigations on the adverse effects of tannins on digestibility. Presence of spinescence on the plant species (*A. karroo*) might have not offered a defensive mechanism to act against herbivory.

A significant proportion of *D. lycioides* was also found in faeces of all goat genotypes, which was not anticipated. *Diospyros lycioides* is regarded as an unacceptable plant species to goats mainly due to its lower digestibility (Raats *et al*., 1996; Scogings, 1998; Dziba, 2000). Morphology of the plant species might probably explain such an anomaly. *Diospyros lycioides* is a deciduous non spinescence tree species and usually starts to develop new shoots at the onset of the rainy season. New leaves on this tree species develop on new shoots. As reported by Dziba (2000), those plant species which produce new leaves on new shoots allow goats to make higher intake rates. This supports findings in the present study for the high preference index values obtained for *D. lycioides* for all goat genotypes feeding on rangelands. *Ehretia rigida, G. occidentalis, L. capensis* and *S. myrtina* contributed a significant proportion to the diet of the goats although in small proportion compared to *A. karroo*. This might also be due to their availability in rangelands, which was very low compared to *A. karroo*.

Grewia occidentalis, on the other hand, has proved to be a very palatable plant species with high preference index values compared to other plant species for all the goat genotypes. Just like *Diospyros lycioides*, it is a non-spinescence tree species which develops new leaves on new shoots. High preference values for *G. occidentalis* compared to *D. lycioides* might be a result of low lignin and antinutritional factors in *G. occidentalis* than *D. lycioides.* This conforms to Raats *et al*. (1996), Gǿthesen (1997) and Dziba (2000) who also reported goats feeding on rangelands to select *G. occidentalis* than other plant species. The low proportion of the *Grewia occidentalis* plant fragments found in the faecal samples of the goats is attributed to the species composition in the paddock, which was low.

The observation that *E. rigida* had low preference index values was not expected. Only the XLE goats selected plant species whilst NGN and NBC goat breeds did not. *Ehretia rigida*, as reported by Dziba (2000), has low levels of anti-nutritional factors which impart a bitter taste in the mouth of goats. In addition, the plant species is also a non-spinescence species. A possible reason for the XLE goats to consume the plant species might be due to its large body framework. Very few *E. rigida* plant species that the goats came across developed new leaves at a considerable height that enabled the XLE goats to reach some of the leaves than NGN and NBC goat breeds.

Sporobolus africanus, S. fimbriatus, P. maximum and *T. triandra* are perennials; hence their fibre and protein content may vary with season (Van Oudtshoorn, 1992). This probably influenced intake of the plant species in the present study resulting in differences in proportion of plant fragments for *S. fimbriatus* and *S. africanus* recovered in faeces of goats with season. Also, fibrous material high in lignin content as noted by Van Lieverloo et al. (2009) can escape digestion; hence more fragments are recovered in faeces. This could probably justify the high proportions of *S. fimbriatus* and *S. africanus* obtained in the current study. *Panicum maximum* and *T. triandra* are very palatable plant species to goats, hence also high proportions of fragments have been identified in faecal samples of goats. Proportions of *P. maximum* fragments in faeces of goat genotypes were low. However, goats seem to crave for the plant species as preference index values greater than one were obtained.

The observation that NBC goats preferred more herbaceous plant material rather than browse species when compared XLE and NGN breeds might be a resultant of the breed producing prodiguous quantities of saliva with urea to facilitate the digestion of fibres in herbaceous species (Robbins *et al*., 1995). Low proportions of some indigenous grasses identified in faeces might be a result of tannin-like substances and also cyanogenic compounds especially in *C. dactylon*, which result in aversions (O'reagain, 1993). The findings are consistent with Danckwerts (1989) observations that grasses do use other mechanisms (anti-nutritional factors) rather than low digestibility to deter herbivores.

The XLE and NGN goat breeds preferred browse species compared to the NBC goats. Utilization of the browse species such as *A. karroo, S. myrtina and A. tetracantha*, may be a result of XLE and NGN being adapted to coping with the anti-nutritional compounds common in woody vegetation (Provenza *et al*., 2003; Nyamukanza and Scogings, 2008). The bipedal stance is another foraging strategy that enables the goats to utilize browse trees; particularly the XLE which is large framed (NRC, 2007). Plant species not consumed by the goat genotypes were either scarce or not found along their feeding course.

4.5 Conclusions

From the current study, it can be concluded that NBC goats preferred more herbaceous plant species, including *T. triandra* and *S. africanus* which were not selected by XLE and NGN goat breeds. Conversely, The XLE goats selected more browse species, *R. longispina* and *E. rigida* not selected by NGN and NBC goats on rangelands. *Grewia occidentalis, D. lycioides* and *P. maximum* were the most preferred plant species by all the goat genotypes. Over utilization of different plant species can be predicted which will in turn allow reseeding of deteriorating rangelands to be done.

4.6 References

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CHAPTER 5: General discussions, Conclusions and Recommendations

5.1 General discussions

Feeding behaviour of the indigenous goat genotypes on rangelands is poorly understood resulting in some inconclusive results being forwarded relating to whether the goats can be classified as either browsers or grazers. This lack of knowledge on the feeding behaviour of goats has resulted in poorly managed rangelands and that has led to the rangeland deterioration. Appropriate knowledge on feeding behaviour aids in the partitioning of rangeland resources to reduce competition for limited resources especially under communal rangeland conditions where mixed livestock farming system is practised. The study, therefore, compared time spent foraging and plant feed preferences of XLE, NGN and NBC breeds on rangelands.

In chapter 3, the direct method of observation, involving the use of stop watches to determine time spent on different activities on rangelands was used. Using this method, differences have been noted among breeds on time spent foraging on rangelands. The XLE goats spent more time browsing compared to other breeds. The NBC goats on the other hand, devoted most of its time on the grazing activity compared to other breeds. Stature of the goat breed, most likely influenced feeding behaviour of goats on rangelands. This gave the XLE goats an added advantage when assuming the bipedal stance to reach tree leaves at considerable height when assuming the bipedal stance. Time spent browsing was high in post-rainy season whilst grazing time was high in hot-dry and cold-dry season.

Time spent on the different foraging activities does not give adequate information relating to the exact plant species preferred by the goat genotypes for efficient management of rangeland resources. The micro-histological faecal analysis technique was, therefore, used to determine the plant species preferred by the goat genotypes in chapter 4. Differences among the breeds were observed when using the technique, particularly on few plant species that have been consumed by goats. The XLE goats selected more browse species with an additional of *R. Longispina* and *E. Rigida* not selected by other goat breeds in the current study. The NBC goats preferred herbaceous material. Probably preference for herbaceous material might be a result of the inability of the NBC goats to detoxify anti-nutritional factors, therefore, did not consume browse species. *Grewia occidentalis* was the most preferred plant species by all goat genotypes on rangelands. The techniques have provided relevant information which might facilitate in efficient management and improvement of rangeland resources.

5.2 Conclusions

Feeding behaviour of indigenous XLE, NGN and NBC goats on rangelands was different. The XLE goats showed potential to utilize browse trees by spending more time browsing and selecting more browse species compared to other breeds in the current study. The NBC goats, however, showed a potential to utilize herbaceous plant material, therefore, will pose some competition to other grazers such as cattle and sheep for the limited herbaceous plant resources on communal rangelands. Time spent browsing was high in post-rainy season whilst grazing time was high in hot-dry and cold-dry season. *Grewia occidentalis* was the most preferred plant species by all goat breeds on rangelands.

5.3 Recommendations and further research

Since XLE goats were more of browsers compared to other goat breeds, it can be recommended that the breed be incorporated in mixed livestock production system. This would enable optimal/efficient management and utilization of rangeland resources since the livestock species would be having different feeding habits. Knowledge on plant feed resources should, therefore, be imparted to farmers so that they can propagate the plant species most preferred by the goats, particularly *G. occidentalis*. This will also enable the farmers to estimate stocking densities basing on the plant species acceptable to the animals.

More work is required on the following aspects to determine:

1. Bite sizes, the cranio-dental anatomy and bite counts in the indigenous goat genotypes.
2. Effects of feeding behaviour on productive and reproductive performance of the indigenous goat genotypes.
3. Impacts of mixing different livestock species on feeding behaviour.