The potential utilization of *Acacia karroo* in improving communal goat nutrition in the False Thornveld of the Eastern Cape Province, South Africa

By

Maguraushe William

201013445

A dissertation submitted in fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE - ANIMAL SCIENCE

Department of Livestock and Pasture Science

Faculty of Science and Agriculture

Alice

Republic of South Africa

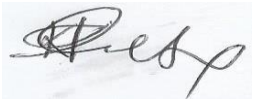
December 2015

Supervisor: Prof. J. F. Mupangwa

Co-supervisor: Prof. V. Muchenje

Declaration

I, Maguraushe William, declare that this dissertation is my original work that has not been submitted to any other University, conducted under the supervision of Prof. J.F. Mupangwa and Prof. V. Muchenje. All assistance towards the production of this work and all the references contained herein have been duly accredited.



11/12/2015

Maguraushe William **Date**

Abstract

The study assessed the difference between the performance of goats browsing on *Acacia karroo* communal browsing lands and open grasslands as well as determining nutritional composition of *A. karroo* leaves in the False Thornveld of Eastern Cape Province of South Africa at different times of the year. A total of 80 communal household goat herds and eight *A. karroo* browse trees were monitored for a period of 12 months in a parallel experiment. In the first experiment, most entries as births were recorded in large herds within the *A. karroo* encroached community, especially during the hot-wet season (November to February). Households with large herd sizes sold and slaughtered significantly ($P<0.05$) more goats than those with small herd sizes in both communities. Mortality was significantly ($P< 0.05$) higher during the hot-wet season in the open grassland. Households keeping small herds in open grassland had the lowest goat production potential (GPP) in the cool-dry season (May to August). The average daily gain (ADG) and body condition scores (BCS) of goats browsing in *A. karroo* encroached areas were generally higher than in open grassland, especially during the cool-dry season. However, the GPP and goat production efficiency (GPE) were not significantly ($P> 0.05$) different between the two communities across the seasons. In the second experiment, all selected *A. karroo* browse trees had crude protein (CP) above 110 g/kg of dry matter (DM) which is sufficient to maintain the requirements of goats at low to medium production. The *A. karroo* browse contained significantly ($P<0.05$) higher ADF (496.4±33.8 g/kg DM), CT (18.4±4.2 g/kg DM), Ca (26.8±0.8 g/kg DM) and Mg (2.9±0.03 g/kg DM) during the cool-dry season than other times of the year. There were no significant ($P>0.05$) differences on the amounts of NDF, TL, SP, P, S, Zn, Mn and Cu throughout the study period. The level of CP (182.4±6.7 g/kg DM) was significantly ($P<0.05$) higher during the hot-wet season than other times of the year. It was suggested that *A. karroo* leaves have the potential to be integrated into communal goat feeding systems in the Eastern Cape

Province, South Africa. It was concluded that the goats which browsed *A. karroo* trees largely performed better in both growth and reproduction parameters than those which grazed in open grassland especially during the cool-dry season. *Acacia karroo* leaves relatively maintain considerable levels of CP and minerals throughout the year which are sufficient to support low to medium communal goat production.

Keywords; browse, goat production potential, efficiency, small ruminant nutrition, nutrient content

Dedication

Michael Maguraushe and Makoni Mavis

Acknowledgements

My sincere gratitude goes to my supervisors Prof. J.F Mupangwa and Prof. V. Muchenje for guidance and the support that they gave me during my studies. I would also like to acknowledge the late Dr. Viola Maphosa for the supervision. My special thanks will go to my wife Mavis Makoni for the encouragement and support she gave me during the studies. I would like to thank the Department of Livestock and Pasture Science staff who include Prof. Beyene, Dr. Mopipi, Mr. D. Pepe, and Ms. N. Moko and post-graduate students namely Adia, Faith, Chido, Marcia, Tinashe, Nkululeko, for their support and encouragement during the project. I will also want to acknowledge the National Research Foundation (NRF – Masters Innovation grant for non-South African citizens, (NRF SA-Mozambique Grant T204) and Govan Mbeki Research and Development Centre (GMRDC) for the financial support. Most importantly I would like to thank Almighty God for giving me strength.

Table of Contents

List of figures

List of tables

List of abbreviations

ADF	Acid Detergent Fibre
ADG	Average Daily Gain
BCS	Body Condition Score
BW	Body Weight
CP	Crude Protein
CT	Condensed Tannins
DM	Dry Matter
GPE	Goat Production Efficiency
GPP	Goat Production Potential
NDF	Neutral Detergent Fibre
SP	Simple Phenolics
TL	Total Lipids

Chapter 1: General Introduction

1.0 Background

Goats are considered to have important and broad range of socio-economic roles in South Africa. These include meat, milk, being used as gifts, traditional rituals such as rites of passage, mohair, cashmere and skins **(**Peacock, 1996; Cronje, 1998; Ng'ambi, 2011). In addition, goats are important in controlling bush encroachment and maintaining open communities in rangelands since they are more of browsers than grazers (Bakare and Chimonyo, 2011; Basha *et al*., 2012).

Underutilisation of bush component, global warming, overgrazing, low fire frequency and fire intensity are among the reasons cited for the persistent invasion of grass swards by *Acacia karroo* in semi-arid regions such as Eastern Cape (NDA, 1988; Nyamukanza and Scogings, 2008). However, under proper management, goats can improve, maintain grazing land and reduce bush encroachment as a biological control method, without causing harm to the environment. The consequences of the increase of wooden plants is also anticipated to trigger biome shifts from grassland to scrub (NDA, 1998; Buitenwerf *et al*., 2012), or may be gradual and reversible increase in trees numbers in rangelands. The encroachment of rangelands by *A. karroo* bush in Eastern Cape is known to greatly reduce rangeland productivity with immense economic implications (Barnes *et al*., 1996).

Goats are considered to be prolific and are known to require low inputs for moderate level of production to reach maturity and are profitable to keep (Mahanjana and Cronjé, 2000; Mamabolo and Webb, 2005). The Eastern Cape Province holds nearly a third of the total goat population of about 6.8 million in South Africa (NDA, 1998; Mahanjana and Cronjé, 2000; Moyo *et al*., 2011).

Mamabolo and Webb (2005) further indicated that the communal goats might be a valuable source of crucial genetic material since many studies reported that these goats adapt to harsh climatic conditions, are able to better utilize the limited and poor quality feed resources. Goats are also known for their resistance to a wide range of diseases such as pulpy kidney, gall sickness and internal parasites (Xhomfulana *et al*., 2009). Communal goat production is mainly found in the subsistence sector in most of Southern Africa. In this sector feed availability and quality are major constraints to goat production because of almost complete dependency on rain-fed natural range (Ndlovu, 1998; Mahanjana and Cronjé, 2000).

Acacia karroo browse tree commonly known as sweet thorn is the dominant invading species in semi-arid savannas of South Africa such as False Thornveld of Eastern Cape and it is an ecological threat of our modern era (Bakare and Chimonyo, 2011; Basha *et al*., 2012). The mean density of *A. karroo* browse tree was between 400 and 800 plants/ha in South Africa in 1995 with the highest being observed in Eastern Cape Province, South Africa (NDA, 1998; Nyamukanza and Scogings, 2008). *Acacia karroo* leaves contain a relatively high proportion of crude protein (CP) in view of the fact that it is leguminous (Fabaceae) which is known to fix atmospheric nitrogen using symbiotic nitrogen-fixing bacteria (Rhizobia). There are also other studies which were carried away to reduce the effects of anti-nutritive factors such as condensed tannins which are found in Acacia leaves that can reduce nutrient intake and digestibility (Paolini *et al*., 2003; Mueller-Harvey, 2006; McSweeney *et al*., 2008). However, these condensed tannins can also cause a significant reduction of gastrointestinal nematodes in goats (Paolini *et al*., 2003). Therefore, it is essential to evaluate potential of *A. karroo* for suitability in small-holder livestock systems where resources to improve goat nutrition are not readily available.

1.1 Problem Statement

The rational management of natural rangelands for the conservation of biodiversity is a necessity. In semi-arid areas such as False Thornveld of Eastern Cape Province, South Africa, nutrient supply in the dry season, particularly protein, is too low to meet goat nutritional requirements for maintenance (Cronje, 1998; Dziba *et al*., 2003; Mapiye *et al*., 2009). Though recently there is a substantial amount of published research concerning the supplementation of livestock using locally available tree foliage such as *A. karroo* leaves, many studies have focused on supplementation at research stations (Masika *et al*., 1998; Dziba *et al*., 2003; Rumosa Gwaze *et al*., 2009).

The knowledge of the relationship between nutritional status of browse trees, goat performance and season is of great importance for communal production systems in many rural areas of Southern Africa. An understanding of *A. karroo* browse tree nutrition on overall communal goat production might guide efficient rangeland management and profitable livestock production. Currently there is paucity of information on the potential utilisation of *A. karroo* in enhancing the communal goat nutrition in the False Thornveld of the Eastern Cape.

1.2 Justification of Study

The knowledge of *A. karroo* browse tree nutrition and performance of communal goats will assist farmers to partition limited feed resources on rangelands among communal goats and other livestock species at different times of the year (Dziba *et al*., 2003). This way, appropriate stocking densities can be estimated, paving way for good rangeland and livestock management practices in relation to available goats and *A. karroo* browse trees within a specific time of the year. During the dry season, goats need supplementary protein in addition to those they get in grass to keep them healthy (Bakare and Chimonyo, 2011; Basha *et al*., 2012). The *A. karroo* leaves contain high protein and they are of high abundance in the

Eastern Cape Province. These trees are well adapted to the local environmental conditions and have potential to be used either as browse or dry season supplement for goats to the expectation of resource poor communal farmers.

1.3 Objectives

The objectives of the study were to;

I. Determine nutritional content of the *A. karroo* leaves at different times of the year in the False Thornveld of the Eastern Cape Province.
II. Compare the performance of goats browsing on *A. karroo* browse trees in communal browsing lands and open grasslands at different times of the year in the False Thornveld of the Eastern Cape Province.

1.4 Hypotheses

The null hypotheses for the study were;

I. There is no difference in the nutritional content of *Acacia karroo* leaves at different times of the year in the False Thornveld of Eastern Cape Province.
II. There are no differences on the performance of goats browsing on *A. karroo* trees in communal browsing lands and open grasslands at different times of the year in the False Thornveld of Eastern Cape Province. Dziba

1.5 References

Bakare, A.G. and **Chimonyo, M**. 2011. Seasonal variation in time spent foraging by indigenous goat genotypes in a semi-arid rangeland in South Africa. *Livestock Science*, 135 (2-3): 251–256

Basha, N.A.D., Scogings, P.F., Dziba, L.E. and **Nsahlai, I.V.** 2012**.** Diet selection of Nguni goats in relation to season, chemistry and physical properties of browse in sub-humid subtropical savanna. *Small Ruminant Research*, 26: 234-341

Buitenwerf, R., Bond, W.J., Stevens, N. and **Trollope, W.S.W.** 2012. Increased tree densities in South African savannas: >50 years of data suggests CO_2 as a driver. *Global Change Biology*, 18: 675-684

Cronje, P.B. 1998. Perspectives on Constrains, Opportunities and Issues Surrounding Research on Goat Production in Southern Africa, Paper presented at the *Research and Training Strategies for Goat Production Systems in South Africa,* Kings Lodge, Hogsback Eastern Cape, South Africa: 22-26 November 1998

Dziba, L.E., Scogings, P.F., Gordon, I.J. and **Raats, J.G.** 2003. Effects of season and breed on browse species intake rates and diet selection by goats in the False Thornveld of the Eastern Cape, South Africa. *Small Ruminant Research*, 47: 17-30

Mahanjana, A.M. and **Cronjé, P.B.** 2000. Factors affecting goat production in a communal farming system in the Eastern Cape region of South Africa. *South African Journal of Animal Science*, 30(2): 134-145

Mamabolo, M.J. and **Webb, E.C.** 2005. Goat Production Survey - Fundamental Aspects to Model Goat Production Systems in Southern Africa, *Case study - Agricultural Commission*

- *Witfor2005*, Accessed on 21 February 2014, http://www.findthatpdf.com/search-15219395-hPDF/download-documents-goat-production-servey.pdf.htm

Mapiye, C., Chimonyo, M., Dzama, K., Strydom, P.E., Muchenje, V. and **Marufu, M.C**. 2009. Nutritional status, growth performance and carcass characteristics of Nguni steers supplemented with *Acacia karroo* leaf-meal. *Livestock Science*, 126 (1-3): 206–214

Masika, P.J., Mafu, J.V., Goqwana, M.W., Mbuti, C. and **Raats, J.G.** 1998. A comparison of goat growth performance in a communal and commercial farming system in the Central Eastern Cape Province, South Africa, Paper presented at the *Research and Training Strategies for Goat Production Systems in South Africa*, Kings Lodge, Hogsback Eastern Cape South Africa: 22-26 November 1998

McSweeney, C., Collinsa, E., Blackallc, B. L. and **Seawrightd, A.** 2008. A review of anti-nutritive factors limiting potential use of *Acacia angustissima* as a ruminant feed. *Animal Feed Science and Technology*, 147(1-3): 158–171

Moyo, B., Masika, P.J. and **Muchenje, V.** 2011. Effect of supplementing crossbred Xhosa lob-eared goat castrates with *Moringa oleifera* leaves on growth performance, carcass and non-carcass characteristics. *Tropical Animal Health and Production*, 11: 970-978

Mueller-Harvey, I. 2006. Review: Unravelling the conundrum of tannins in animal nutrition and health. *Journal of the Science of Food and Agriculture*, 86: 2010–2037

National Department of Agriculture and the Agricultural Research Council (NDA). 1998. Why Keep Goats, *Animal Nutrition and Animal Products Institute of the ARC*, Accessed on 18 February 2014: www.elsenburg.com/info/nda/goats_info.pdf

Ndlovu, L.R. 1998. Potential of some agroforestry shrubs and tree legumes in communal goat farming systems. Paper presented at the *Research and Training Strategies for Goat*

Production Systems in South Africa, Kings Lodge, Hogsback Eastern Cape South Africa: 22-26 November 1998

Ng'ambi, J.W. 2011. *The role of goats in food supply, poverty alleviation and prosperity in Sub-Saharan Africa.* University of Limpopo, South Africa College of Agriculture and Environmental Sciences, Viewed on 11 November 2014: http://www.unisa.ac.za /Default.asp ?Cmd=ViewContent&ContentID=26891

Nyamukanza, C.C. and **Scogings, P.F.** 2008. Sprout selection and performance of goats fed *Acacia karroo* coppices in the False Thornveld of the Eastern Cape. S*outh African Journal of Animal Science*, 2: 38- 46

Paolini, V., Bergeaud, J.P., Grisez, C., Prevot, F., Dorchies, P.H. and **Hoste, H.** 2003. Effects of condensed tannins on goats experimentally infected with Haemonchus contortus. *Veterinary Parasitology*, 113: 253–261

Peacock, C. 1996. *Improving Goat Production in the Tropics. Manual for development workers*, Oxfarm/Farm-Africa Publication: UK and Ireland

Raats, J.G. 1998. Feeding behaviour of free range goats. Paper presented at the *Research and Training Strategies for Goat Production Systems in South Africa*, Kings Lodge, Hogsback, Eastern Cape, South Africa: 22-26 November 1998

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K.** 2009. Communal goat production in Southern Africa: a review. *Tropical Animal Health and Production*, 41:1157–1168

Xhomfulana, V., Mapiye, C., Chimonyo, M. and **Marufu, M.C.** 2009. Supplements containing *Acacia karroo* foliage reduce nematode burdens in Nguni and crossbred cattle. *Animal Production Science*, 49 (8): 646–653

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K.** 2010. Estimation of goat production potential and efficiency in the resource-poor communal areas of the Eastern Cape Province of South Africa. *Tropical Animal Health and Production*, 42: 1235–1242

Chapter 2: Literature Review

2.0 Introduction

According to the projected growth in global human population, by 2050 the world human population will reach 9.1 billion, 34 percent higher than current estimated 6.3 billion (FAO, 2015). The major contribution in population growth originates from developing countries particularly Sub-Saharan countries (FAO, 2015). The rate of urbanization has been ever increasing and it is also anticipated that in 2050, nearly 70 percent of the world's population will be residing in urban areas (FAO, 2015).

The increase in population growth and urbanization in these developing countries is triggering the increased demand for livestock products, especially meat, eggs and milk at the expense of staple foods (Kaitho, 1997; Satterthwaite *et al*., 2010). However, there is limited land availability for increased food and forage production. The livestock production will need to be intensified especially in resource-limited communal areas such as in the Eastern Cape Province of South Africa if the current human and livestock nutritional standards are to be maintained in the future. In the developing world, the natural rangelands constitute the major proportion of feed for livestock in communal areas.

The poor quality natural pasture grasses in the Eastern Cape Province such as *Themeda trianda* and *Cymbopogon plurinodis* with nutritive value as low as 2% crude protein during the dry season fail to fulfil the nutritional maintenance and production requirements of goats (Mendieta-Araica *et al*., 2011). Diets containing these feeds are often unbalanced for main nutrients, thus cannot meet microflora and host goat requirements. The chemical-based promoters such as probiotics proved to be efficient in stimulating rumen digestion subsequently in increasing goat performances (Mendieta-Araica *et al*., 2011). However, recent consumer concerns of the risk of consuming meat and milk of animals receiving these

additives have encouraged scientists to look for simple, cost-effective and healthy alternatives (Mendieta-Araica *et al*., 2011).

Most of the commercial livestock producers correct these deficiencies by supplementing with high density feeds such as maize, wheat and soya meal. However, the protein sources from these high density feeds are often beyond the economic reach for the majority of small-scale communal farmers in the Eastern Cape Province, South Africa (Cronje, 1998; Mahanjana and Cronjé, 2000; Mapiye *et al*., 2009a). Several browse species that contain high crude protein and mineral content have been documented (Kaitho, 1997). Browse is defined as leaves, shoots, sprouts, twigs, fruits and pods of woody plants which are edible to a varying extend by domestic and wild animals (Raghuvansi *et al*., 2007).

Besides being ruminant feed, browse trees have multiple roles in communal farming systems which include firewood, building, mulch and soil conservation. *Acacia karroo* tree commonly known as the Sweet thorn, is a leguminous tree native to southern Africa. Previous experimental studies have reported that *A. Karroo* improves the meat and carcass quality attributes of goats and cattle (Mapiye *et al*., 2009a; Mapiye *et al*., 2009b; Mapiye *et al*., 2011) and reduces the nematode burden (Xhomfulana *et al*., 2009). There are many advantages of promoting fodder shrubs and trees such as *A. karroo*, because of their wider adaptability to harsh agro-climatic conditions and ability to produce leaf material for a long period (Mahanjana and Cronjé, 2000).

Communal goat production is the main source of income for rural households living in arid and semi-arid regions (Kaitho, 1997). Goats are often described as the "poor man's cow" and they prevail in semi-arid rural parts of the Eastern Cape Province, South Africa (Rumosa Gwaze *et al*., 2009b; Ng'ambi, 2011). The goats seem to be the ideal livestock species for

communal resource-limited farmers, therefore, it is important that they should play a direct role in bridging the protein gap prevalent in most families of the developing countries.

Factors such as climate change, desertification, bush encroachment, drought and global warming justify the need to intensify the performances of these indigenous goats using simple and cost-effective interventions suitable for resource-limited communal farmers (Rumosa Gwaze *et al*., 2009b; Salem, 2010). There is need for a serious reflection on the re-adjustment and establishment of new feeding strategies targeting the improvement of communal goat production without detrimental effects on the environment (Rumosa Gwaze *et al*., 2009b; Salem, 2010).

The rural community development aims should focus on rangeland conservation while making an effort for greater communal goat production. The ability of goats to adapt to a wide range of agro-climatic conditions could possibly be accounted for by their higher tolerance for wide range of plant species (Mahanjana and Cronjé, 2000; Mapiye *et al*., 2009a; Ngambu *et al*., 2013). This can enable them to utilise *A. karroo* in the False Thornveld of Eastern Cape. *Acacia karroo* tree is known to constitute between 55% and 80% of all browsable woody plant species in the Eastern Cape Province.

2.1 Communal goat production in South Africa

2.1.1 Eastern Cape Indigenous Goats

The indigenous goats provide a diversified genetic pool which can be used to address the concerns related to the consumer requirements and livestock production systems (Ben Salem and Smith, 2008; Rumosa Gwaze *et al*., 2009b). The ability of indigenous goats to adapt to different environmental conditions and wide range of economic traits increase their value (Kosgey and Okeyo, 2007; Rumosa Gwaze *et al*., 2009b). Unlike exotic breeds, indigenous goat breeds are known to utilize low quality feeds. The nutrition of goats depends mainly on

the utilization of woody plants such as *A. karroo* trees which are native to the Eastern Cape Province (Dziba *et al*., 2000). Goats spend nearly half of their feeding time browsing. However, goats are mixed and opportunistic feeders and therefore, will both graze and browse depending on food quality and availability (Kosgey and Okeyo, 2007; Rumosa Gwaze *et al*., 2009b).

There are several goat genotypes in the Eastern Cape region. These are mainly Nguni, Xhosa lob-eared, Boer and their crosses. The Nguni 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*., 2000; Nyamukanza and Scogings, 2008). The medium to large framed Xhosa lob eared breed strain were originally found in the medium to lower rainfall areas of the Eastern Cape. The breed is becoming extinct in communal farming areas. The bulk of the population of goats is made up of the Boer and Xhosa lob eared crosses. Only a handful of breeders in South Africa preserved some of these original multi-coloured, lob eared goats. Boer goats are medium to large framed and have white bodies and distinctive brown heads. The Boer goats are mainly common in commercial farming sector (Masika *et al*., 1998).

Goats are important browsers in the Eastern Cape Province, which keeps nearly one third of the goat population of South Africa (Dziba *et al*., 2003). The ability of these indigenous communal goats to adapt to harsh agro-climatic conditions makes them important from an ecological perspective in controlling *A. karroo* bush encroachment in Eastern Cape Province. Factors such as under-utilisation of the *A. karroo* bush component and low fire frequency could continue to cause the invasion of the grass sward. However, communal goats can effectively control sprouts and regrowth of *A. karroo* trees.

2.1.2 Communal goat functions

Communal goats are known to have numerous functions which include the provision of meat, cashmere, milk, skins and manure (Dziba *et al*., 2000; Sebei *et al*., 2004; Mamabolo and Webb, 2005). Goat skins are also used to make containers, carpets, mats, drums and tents (Webb and Mamabolo, 2004; Peacock, 2005; Rumosa Gwaze *et al*., 2009b). In addition, traditional healers and dancers also use the goat hides as costumes during their traditional operations.

Goats are known to have multiple crucial socio–economic roles in communal areas which include being used as gifts, direct source of income through sales and traditional rituals such as rites of passage. In other Southern African regions, chevron is ranked second to beef in quantity. In Eastern Cape Province, chevron is consumed on exceptional traditional occasions such as the celebration of traditional marriage, funeral and passage rites, Easter holiday, Christmas day and thanks giving ceremonies for the birth (Peacock, 2005; Rumosa Gwaze *et al*., 2009b; Ng'ambi, 2011).

Unlike cattle, ownership of goats in South Africa is more common among communal farmers than commercial farmers. Due to their natural resistance to a range of diseases such as footrot gall sickness, enterotoxaemia, coccidiosis and brucellosis, goats are able to adapt in degraded rangelands in communal areas (Webb and Mamabolo, 2004; Rumosa Gwaze *et al*., 2009a). In view of the fact that these goats are prolific and need low inputs for a moderate level of production, most resource-limited communal farmers own them (Webb and Mamabolo, 2004; Rumosa Gwaze *et al*., 2009a; Ng'ambi, 2011). These goats can be used as biological bush encroachment control in communal browsing and grazing lands. There is also a possibility of acquiring more income for resource-limited communal farmers by value-addition of goat products such as production of cheese, flavoured milk and meat products and leather clothing (Ng'ambi, 2011).

2.1.3 Communal goat management systems in southern Africa

The most popular system of rearing goats in communal areas of South Africa is herding during the day and penning at night (Rumosa Gwaze *et al*., 2010). Due to the complex land ownership in communities residing in rural areas, the goat herds from different households in the entire village or community usually graze or browse together in communal grazing or browsing lands as a single interbreeding herd with uncontrolled mating. Communal grazing or browsing land is available for grazing or browsing of livestock of any member of a more or less defined group of individuals such as village (Rumosa Gwaze *et al*., 2009b). However, goat herds from different households of the same village may graze or browse independently if there is large grazing land or browsing communal land.

Severe rangeland degradation in communal areas may lead to intake of poor quality feed by indigenous goats which usually restrict the performance of these goats (Peacock, 1996). In communal goat production set up, supplementation is not usually practised. The browsing or grazing timetable of goats depends on the timetable of the shepherds (Loforte, 1999; Rumosa Gwaze *et al*., 2010). Goat tethering is common in communal areas of Southern Africa. (Banda *et al*., 1993; Webb and Mamabolo, 2004). A tethered goat is tied to something (such as a fence or post) so that it stays in a very restricted area and is not able to roam freely. However, a tethered goat must be provided with adequate feed, water and shelter. In other communal areas in southern Africa, goats are tethered according to the timetable of the shepherd. However, goat tethering restricts feed choices for communal goats and could result in poor performance such as weight loss, increased mortality, poor reproductive performance and poor body condition (Banda *et al*., 1993; Webb and Mamabolo, 2004)

2.1.4 Constraints to increased goat production

The management of goats and production systems in communal farming systems differ significantly with commercial systems. There are diverse reasons for keeping goats in

communal systems (Mapiye *et al*., 2009a). However, there are several constrains which are faced by these communal farmers regarding the productivity of goats (Masika *et al*., 1998; Kosgey and Okeyo, 2007). The challenges in communal goat production differ with countries, geographical locations and regions. According to Raghuvansi *et al*. (2007) and Ben Salem and Smith (2008), limited forage availability particularly in the dry season, prevalence of diseases, internal and external parasites, poor management and marketing are the major challenges for communal goat production. The communal small-scale farmers often experience low productivity due to high abortions, mortalities and weight loss.

Factors which include poor housing, poor soil fertility for forage production and fragile market chains for goats and goat products limit communal goat production (Banda *et al*., 1993; Webb and Mamabolo, 2004). In addition, there are also institutional challenges such as delivery of agricultural extension services, training and marketing of goats and goat products which are hinder communal goat production (Kosgey, 2004; Ben Salem and Smith, 2008). Failure of government services to fund both research and training of small ruminant programmes has been, and still is, a major constraint (Kosgey, 2004).

High kid mortality in communal, as compared to commercial, goat production could be due to inadequate colostrum consumption by kids as a result of poor doe nutrition (Peacock, 1996). Poor housing negatively impacts goat productivity as goats will be exposed to extreme weather conditions. The poor performance of communal goats such as low growth rate and weight gain could also be attributed to inbreeding as a result of uncontrolled breeding in communal grazing or browsing lands (Mapiye *et al*., 2009a).

Communal goat productivity in semi-arid areas such as in the False Thornveld of Eastern Cape is restricted mainly by inadequate feed, particularly during the prolonged dry season and droughts (Peacock, 1996; Raghuvansi *et al*., 2007; Ben Salem and Smith, 2008). The

quantity and quality of these grasses became more critical in the dry season imposing more serious constraints to the development and productivity of these goats. Reduced fodder availability especially during the dry season could be due to rangeland management reasons which include inappropriate stocking density, incorrect ratio for browsing and grazing livestock species in mixed communal grazing systems (Raghuvansi *et al*., 2007; Ben Salem and Smith, 2008).

Marketing strategy also constrain communal goat production in southern Africa. In communal areas, there are no ready markets for goats hence the resource-limited communal farmers will resort to the informal markets (Rumosa Gwaze *et al*., 2009b). Informal markets can also lead to under-estimation of communal goat production. In communal production systems, the pricing of goats is based on an arbitrary scale with reference to visual assessment of the goat. In addition, these transactions are not captured in official governmental statistics; as a result, the contribution of communal goat production to gross domestic product (GDP) can be underestimated at national level.

2.2 Feeding and nutrient availability of communal goats

Factors such as rangeland fires, droughts, inappropriate grazing and browsing result in poor rangeland conditions, which will then limit the availability of fodder in the communal grazing and browsing lands. Just like any other ruminants in the tropical areas, goats are hindered by shortage of good quality feed, especially in the prolonged dry season (Raghuvansi *et al.*, 2007; Ben Salem and Smith, 2008). Indigenous goats are well known to utilize diverse plant feed resources on rangelands.

In the False Thornveld of Eastern Cape, *A. karroo, Diospyros lycioides, Ehretia rigida, Grewia occidentalis, Rhus longispina and Scutia myrtina* are some of the browsable tree species. The availability of these browse trees to goats varies with seasons. *Diospyros*

lycioides, *E. rigida*, *G. occidentalis* are deciduous whilst *A. karroo, R. longispina and S. myrtina* are evergreen (Dziba, 2000; Rumosa Gwaze *et al*., 2009b). The browse species differ in chemical composition across seasons, resulting in goats showing preference for a particular browse tree in relation to its chemical constituents (Raghuvansi *et al*., 2007; Mapiye *et al*., 2011). Some nutritional characteristics of different browse trees on rangelands of Eastern Cape in winter and summer are shown in Table 2.1.

2.2.1 Feeding behaviour of goats

In order to attain optimum nutrient intake from the available feed resources, goats show different feeding strategies on rangelands (Raats *et al*., 1998; Bakare and Chimonyo, 2011; Basha *et al*., 2012). This is normally referred to as feeding behaviour and usually varies across the seasons and breeds. Several perspectives have been postulated regarding the feeding behaviour of goats and different goat genotypes can be classified as either grazers or browsers (Raats *et al*., 1998; Basha *et al*., 2012). However, 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.

Browsing behaviour exhibited by goats on rangelands is determined by factors which include; breed, season, availability of browse, anti-nutritional factors, morphology of plant parts, social rank, group feeding and human influence (Raats *et al*., 1998; Bakare and Chimonyo, 2011; Basha *et al*., 2012). On average, Nguni and Xhosa lob-eared goat breeds spend about 70% of their feeding time browsing in the False Thornveld of Eastern Cape (Bakare and Chimonyo, 2011).

Table 2.1 Nutrient content of leaves of common browse species in the False Thornveld of Eastern Cape at different times of the year

	[i]DM		[ii]CP (g/kg DM)		[iii]NDF (g/kg DM)		**Sources**
Season	Winter	Summer	Winter	Summer	Winter	Summer	
A. karroo	897	911	144	168	417	308	Mapiye *et al.* (2011)
D. lyciode	866	913	78	106	410	405	Nyamukanza and Scogings (2008)
E. rigida	893	877	109	131	399	304	Dziba (2000)
G. occidentalis	896	908	96	150	426	466	Mapiye *et al.* (2011)
R. longispina	913	912	110	136	336	378	Mapiye *et al.* (2009b)
S. myrtina	866	895	119	119	423	450	Dziba (2000)

[i] DM – Dry matter of dried leaf material

[ii] CP – Crude protein

[iii] NDF – Neutral detergent fibre

2.2.2 Diet selection of goats on rangelands

Goats on rangelands consume a variety of plant species that vary in their chemical constituents. However, their performance under rangeland conditions is not always satisfactory due to high disease prevalence, parasites and other restrictions when acquiring nutritive feed (Rumosa Gwaze *et al*., 2009a; Basha *et al*., 2012). The high abundance of *A. karroo* browse trees will likely to limit the time spent by an individual goat looking for *A. karroo* tree to browse. For this reason, goats on these rangelands are likely to perform to expectation even if the highly nutritious browse species are available but in low quantities (Loforte, 1999; Rumosa Gwaze *et al*., 2009b; Basha *et al*., 2012). This results in goats meeting their nutritional requirements leading to better growth performance, low kid mortalities and reduced kidding interval (below 258) days (Rumosa Gwaze *et al*., 2009b; Basha *et al*., 2012).

The fluctuations in nutritional characteristics of plant species with season could be reason for reduced goat performance especially during the dry season (Raghuvansi *et al*., 2007; Basha *et al*., 2012). Under-performance of goats will be more pronounced in dry periods when forage quality decreases. Other goat genotypes 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 (Raghuvansi *et al*., 2007; Bakare and Chimonyo, 2011).

2.2.3 Effect of season on browsing

Most goats which are reared by resource poor farmers in communal production systems of South Africa rely on rangelands as a source of feed (Dziba *et al*., 2003; Rumosa Gwaze *et al*., 2010). These rangeland plants vary in their chemical composition and structure with season. Nature of browse plants influences preference of goats on rangelands and this varies with

season. In the wet season, there is characteristic abundance of forage of high quality that starts to diminish with time into dry season.

Regions with deciduous trees have different populations of plant species being altered with season. The shedding of leaves by deciduous trees results in reduced availability of foliage to goats (Humphries *et al*., 1998; Dziba *et al*., 2003). If an area has very few palatable tree species, the animals will resort to other alternatives, that is, consumption of grasses. Conversely, if there are few palatable grass species, they will browse. Many studies have reported fluctuations in quality and quantity of forage with season, consequently, affecting the performance of goats on these rangelands (Humphries *et al*., 1998; Rumosa Gwaze *et al*., 2009b)

The dry matter intake (DM) of a goat can be increased by feeding a little at regular intervals, particularly if each feed is different and interesting to the goat (Humphries *et al*., 1998). The ability of goat to utilise the large quantities of forage is mainly due to its rumen which is proportionally larger as compared to sheep and cattle (Humphries *et al*., 1998; Rumosa Gwaze *et al*., 2009b). There is also evidence that suggest that goats efficiently digest the forage better than cattle and sheep. Unlike cattle, goats make use of forage of low to medium nutritional value by selecting the more digestible plant parts with its narrow muzzle (Bakare and Chimonyo, 2011). According to Ramirez (1999), communal goats consume even more browse during summer.

2.2.4 Protein requirement for goats

Several studies have shown that the protein requirement of goats for maintenance is approximately similar to other ruminants. In many instances, authors suggest allowances of 60 – 80g digestible crude protein per 100kg of live weight for maintenance (Mowlem, 1996; NRC, 2000). Several countries introduced new systems based on predicting the supply of

microbial and feed protein to the intestines, the digestion of protein and absorption of amino acids from the intestines, and the efficiency of utilisation of absorbed amino acids for maintenance and production (Mowlem, 1996). However, protein requirement is generally related to that of energy which is estimated to be 9g of rumen degradable protein per mega joule (MJ) of metabolizable energy (ME) (Mowlem, 1996).

2.1.5 Effect of anti-nutritional factors on goats

Anti-nutritional factors are substances which, when present in feed, reduce intake and utilization as well as growth of an animal (Mupangwa *et al*., 2000). Unlike sheep and cattle, goats can tolerate the adverse effects of most of these anti-nutritive substances in feed and this allows them to consume a wide variety of feed (Peacock, 1996; Paolini *et al*., 2003; Basha *et al*., 2012). Condensed tannins (CTs), for example, are a group of phenolic compounds widely distributed in leguminous forages (Mupangwa *et al*., 2000). Although the sensitivity of tannins has been noted in both cattle and sheep, goats are more resistant (Paolini *et al*., 2003; Dube *et al*., 2009; McSweeney *et al*., 2008). Some goat breeds can withstand the adverse effect of tannins and eat more of the tree species. Nyamukanza and Scogings (2008), observed that Xhosa lob eared goats have got higher bite rates of *A. karroo* leaves containing high levels of tannins compared to the Boer goats.

The presence of enzyme atropinesterase in the circulatory system and proline-rich salivary protein in the buccal cavity of goats act to counteract tannin effect. Upon eating a plant rich in phenolic substance such as *A. karroo*, the enzymes hydrolyse these phenolic substances, making plant feed material harmless to the goat (Paolini *et al*., 2003; Dube *et al*., 2009; Basha *et al*., 2012). The level of the enzyme atropinesterase in goats varies with season (concentration of the enzyme is low in winter) and breed (Peacock, 1996; Paolini *et al*., 2003; Basha *et al*., 2012). The anti-nutritional characteristics of different browse trees in the False Thornveld of Eastern Cape in winter and summer are shown in Table 2.3.

2.3 *Acacia karroo* browse tree

2.3.1 Description and ecology of *A. karroo* browse tree

Acacia karroo, commonly known as the sweet thorn is a tree indigenous to southern Africa. It is the most widely distributed of all thorn trees in South Africa, and occurs mainly along rivers and drainage lines (Joffe, 2001).The *A. karroo* tree is a legume and is known to associate symbiotically with Gram-positive *Rhizobium* in the root nodules. The size and shape of *A. karroo* browse trees vary up to a height of approximately 11 meters in favourable environments (Joffe, 2001). The colour of the bark of younger *A. karroo* tree is red. The bark is also used to tan leather. That is why it gives the end product a reddish colour. However, as the tree grows, the bark will darken and become course (Joffe, 2001).

The leaves of *A. karroo* are dark green and finely textured. During the early hot-wet season, *A. karroo* trees develop scented yellow pompon flowers (Pooley, 1993; Barnes *et al*., 1996; Joffe, 2001). The seed pods are crescent shaped, flattened, 5-10 centimetres long, 5-8 millimetres wide and they hang in bundles. The seeds are greenish in colour and they turn brown when becoming dry. The thorns are straight, paired, long in younger than old trees and greyish to white in colour (Barnes *et al*., 1996). The *A. karroo* trees usually have some leaves on the branches at most times of the year, even during periods of drought. The *A. karroo* tree tolerates drought because of a long taproot which enables it to use water and nutrients from deep within the soil profile (Barnes *et al*., 1996). According to Barnes *et al.* (1996) *A. karroo* can adapt well from sea level to 1800m on soils ranging from sand to heavy clays, in areas with an annual rainfall lower than 200mm to as high as 1500mm. However, it is difficult to handle due to its thorns, and it is an aggressive colonizer, easily taking over grasslands.

Table 2.2: Anti-nutritional characteristics of common browse trees on rangelands in a False Thornveld of Eastern Cape (g/kg DM)

	Parameter						Sources
Season	Winter	Summer	Winter	Summer	Winter	Summer	
Browse Species	[i]TP	TP	[ii]CT	CT	[iii]PPT	PPT	
A. karroo	54.6	43.0	17.8	14.1	15.4	11.9	Mapiye *et al*. (2011)
D. lycioide,	54.4	49.8	10.4	10.1	7.6	4.6	Nyamukanza and Scogings (2008)
E. rigida	42.3	38.4	13.5	15.0	11.4	8.4	Dziba (2000)
G. occidentalis	37.6	27.1	9.3	8.1	2.4	2.2	Mapiye *et al*. (2009b)
R. longispina	23.3	18.5	16.3	14.4	5.3	3.9	Nyamukanza and Scogings (2008)
S. myrtina	9.8	8.4	6.8	7.1	1.8	0.6	Dziba (2000)

[i]TP - Total phenols

[ii]CT- Condensed tannins

[iii]PPT- Protein Precipitating Tannins

2.3.2 Feasibility of *A. karroo* leaves in improving communal goat production

The mean density of *A. karroo* trees in Eastern Cape Province of South Africa is ever increasing from 400 plants/ha (Barnes *et al*., 1996). The *A. karroo* tree is widely distributed in the Eastern Cape Province and its seeds can be planted and propagated with ease (Scogings and Mopipi, 2008). The studies by Aganga *et al*. (2000) and Mapiye *et al*. (2009b) showed that *A. karroo* leaf meal contains crude protein of about 100 to 160 g/kg of dry matter. Due to the ability of *A. karroo* tree to grow and coppice early (Barnes *et al*., 1996) it is feasible to harvest approximately 1 kg of its leaf-meal per annum from 1.5 m tall trees (Mapiye *et al*., 2011). Approximately 1000 kg/ha/annum *A. karroo* leaf-meal can be harvested from 500 and 1000 plants/ha which is the proposed optimum plant density for *A. karroo* trees (Barnes *et al*., 1996).

According to NRC (2000), a growing goat weighing about15 to 25 kg need approximately 90 to 130 g/kg dietary crude protein for it to gain between 20 and 35 g/day (Mapiye *et al*., 2009b). However, further research is needed on nitrogen availability and utilisation in order to approximate the quantity of *A. karroo* leaf-meal needed per day for optimum performance of goats. Given the low goat herd sizes in the rural households reported by Rumosa Gwaze *et al*. (2009) the use of *A. karroo* leaf-meal to supplement communal goats could be a possible and practical technology for resource-limited small scale farmers. However, before *A. karroo* leaf-meal utilization as goat supplement it is vital to evaluate the nutritive value of *A. karroo* leaves harvested at different times of the year, growth stages and geographical locations.

2.3.3 Nutritive and anti-nutritive value of *A. karroo* leaves

Several Acacia species in Southern Africa such as *A. karroo* have been reported by previous researchers as important sources of forage for herbivores, particularly during dry periods. *Acacia karroo* leaves contain low to moderate detergent fibre (NDF) and acid detergent fibre (ADF), between 350 to 550 and 200 to 350 g/kg DM, respectively (Tefera *et al*., 2008;

Mapiye *et al*., 2009a; Rumosa Gwaze *et al*., 2009). The *A. karroo* leaves have relatively higher crude protein levels of between 110 and 230 g/kg dry matter (DM) as compared to other indigenous browse trees (Aganga *et al*., 2000; Dube, 2000; Tefera *et al*., 2008).

The mineral profile of *A. karroo* leaves compare favourably with other Acacia species such as *A. nilotica* and *A. Tortilis* (Tefera *et al*.,2008; Mapiye *et al*., 2009a; Rumosa Gwaze *et al*., 2009a). The content of Ca, Mg, Fe and Zn in *A. karroo* leaf-meal prepared by the previous researchers (Mapiye *et al*., 2009a; Rumosa Gwaze *et al*., 2009a) proved that the levels are within recommended levels for goat production (NRC, 2000).

Tannins form stable complex structures with proteins subsequently reducing their availability to goats (Mupangwa *et al*., 2000). Previous researchers reported high levels of condensed tannins (55 to 110 g/kg DM) in *A. karroo* browse tree leaves (Dube *et al*., 2001; Mokoboki *et al*., 2005; McSweeney *et al*., 2008). The level of condensed tannins (CT) in *A.* karroo leaves is reported to be above the recommended level of 20–80 g CT/kg DM which is believed to be valuable to livestock (Mueller-Harvey, 2006). The variance of phenolic substances in a particular tree could be as a result of many other factors which include tree age, soil type and season of the year (Mueller-Harvey, 2006; McSweeney *et al*., 2008).

In low fertility soils, the levels of these phenolic substances in *A. karroo* leaves are usually elevated during the dry season particularly in leaves of the older trees (Scogings and Mopipi, 2008). However, there are numerous techniques that have been used to ease the negative effects of these tannins, these include air drying and/or the use of urea, potassium hydroxide, calcium hydroxide ammonia and sodium hydroxide. Although air drying is less effective compared to other methods, it is easy, cheap and a practical alternative for resource-limited communal goat farmers

2.4 Summary

Regarding the abundance of *A. karroo* browse tree in the Eastern Cape Province and its high crude protein content, it can be mixed with locally available feed energy sources to supplement goats during the dry season. Besides being cheap to resource-limited communal farmers, the use of *A. karroo* as supplement to goats promotes production of organic meat (chevron) which is on global demand. The utilization of *A. karroo* will consequently improve livelihoods of rural communities in Southern Africa and global food security. However, these resource-limited goat farmers need information for the utilization of *A. karroo* browse tree to improve the nutrition of goats. This can be done through training, research and agricultural extension programs on how to propagate, harvest, supplement and conserve *A. karro* trees.

2.5 References

Aganga, A.A., Adogla-Bessa, T., Omphile, U.J. and **Tshireletso, K**. 2000.Significance of browses in the nutrition of Tswana goats. .*Archivos de Zootecnia*, 49: 469–480

Bakare, A.G. and **Chimonyo, M.** 2011. Seasonal variation in time spent foraging by indigenous goat genotypes in a semi-arid rangeland in South Africa. *Livestock Science*, 135 (2-3): 251–256

Banda, J.W., Ayoade, J.A., Karua, S.K. and **Kamwanja, L.A.** 1993. The local Malawi goat. In: **Chupin, D., Daldin, J., Roland, N.** and **Gumprecht, T.** (edition), *Ticks in a changing world, World Animal Review*: FAO

Barnes, R.D., Filer, D.L. and **Milton S.J.** 1996. *Acacia karroo*: monograph and annotated bibliography. *Tropical Forestry Papers No. 32. Oxford Forestry Institute*, Oxford University Press UK

Basha, N.A.D., Scogings, **P.F., Dziba**, **L.E.** and **Nsahlai**, **I.V.** 2012**.** Diet selection of Nguni goats in relation to season, chemistry and physical properties of browse in sub-humid subtropical savanna. *Small Ruminant Research*, 26: 234-341

Ben Salem, H. and **Smith, T.** 2008. Feeding strategies to increase small ruminant production in dry environments. *Small Ruminant Research*, 77: 174–194

Buitenwerf, R., Bond, W.J., Stevens, N. and Trollope, W.S.W, 2012. Increased tree densities in South African savannas: >50 years of data suggests CO_2 as a driver. *Global Change Biology*, 18: 675-684

Cronje, P.B. 1998, Perspectives on Constrains, Opportunities and Issues Surrounding Research on Goat Production in Southern Africa, Paper presented at the *Research and*

Training Strategies for Goat Production Systems in South Africa, Kings Lodge, Hogsback Eastern Cape South Africa: 22-26 November 1998

Dube, J.S., Reed, J.D. and **Ndlovu, L.R**. 2001. Proanthocyanidins and related phenolics in Acacia leaves of Southern Africa. *Animal Feed Science and Technology*, 91: 59–67

Dube, S., Lesoli, M.S. and **Fatunbi, A.O.** 2009. The efficacy and safety of bromacil based herbicide for the control of the invasive bush species in South African rangelands. *African Journal of Biotechnology*, 8 (9): 1776-1781

Dziba, L.E. 2000. *Diet selection and foraging efficiency of Boer goats and Nguni goats in the False Thornveld of the Eastern Cape, South Africa*. MSc (Agric) thesis, University of Fort Hare, South Africa: Alice

Dziba, L.E., Scogings, P.F., Gordon, I.J. and **Raats, J.G**. 2003. Effects of season and breed on browse species intake rates and diet selection by goats in the False Thornveld of the Eastern Cape, South Africa. *Small Ruminant Research*, 47: 17-30

Food and Agriculture Organization of the United Nations (FAO). 2015. The State of Food Insecurity in the World 2015. *Meeting the 2015 international hunger targets:* taking stock of uneven progress, Accessed on 14 June 2014: http://www.fao.org/3/a-i4646e.pdf

Humphries, W.R., Morrice, P.C. and Mitchell, A.N. 1998. Copper Poisoning in Angora goats. *Veterinary Records*: 121-129

Joffe, P. 2001. *Creative Gardening with Indigenous Plants: A South African Guide*. Briza. Pretoria, South Africa

Kaitho R.J. 1997. *Nutritive value of browses as protein supplement(s) to poor quality roughage*. PhD Thesis, Department of Animal Nutrition, Wageningen Agricultural University: Wageningen, Netherlands

Kosgey, I.S. and **Okeyo, A.M**. 2007. Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. *Small Ruminant Research*, 70(1): 76–88

Loforte, P. 1999. *Goat production and productivity in the smallholder sector in the Boane district, Mozambique*. MSc Thesis, University of Pretoria: Pretoria, South Africa

Mahanjana, A.M. and **Cronjé, P.B**. 2000. Factors affecting goat production in a communal farming system in the Eastern Cape region of South Africa. *South African Journal of Animal Science*, 30(2): 149-154

Mamabolo, M.J. and **Webb, E.C.** 2005. Goat Production Survey - Fundamental Aspects to Model Goat Production Systems in Southern Africa. *Case study, Agricultural Commission – Witfor*, Accessed on 21 February 2014: http://www.findthatpdf.com/search-15219395-hPDF/download-documents-goat-production-servey.pdf.htm

Mapiye, C., Chimonyo, M., Dzama, K., Strydom, P.E., Muchenje, V. and **Marufu, M.C**. 2009a. Nutritional status, growth performance and carcass characteristics of Nguni steers supplemented with *Acacia karroo* leaf-meal. *Livestock Science*, 126 (1-3): 206–214

Mapiye, C., Chimonyo, M., Dzama, K., Stydom, P.E. and **Muchenje, V**. 2009b. Meat Quality of Nguni Steers Supplemented with *Acacia karroo* Leaf-meal. *Meat Science*, 84: 621-627

Mapiye, C., Chimonyo, M., Marufu, M.C. and **Dzama, K**. 2011. Utility of *Acacia karroo* for beef production in Southern African smallholder farming systems: A review. *Animal Feed Science and Technology*, 164 (3-4):135–146

Masika, P.J., Mafu, J.V., Goqwana, M.W., Mbuti, C. and **Raats, J.G. 1998.** A comparison of goat growth performance in a communal and commercial farming system in the Central Eastern Cape Province, South Africa. Paper presented at *Research and Training Strategies for Goat Production Systems in South Africa,* Kings Lodge, Hogsback Eastern Cape South Africa: 22-26 November 1998

McSweeney, C., Collinsa, E., Blackallc, B. L. and **Seawrightd, A.** 2008. A review of anti-nutritive factors limiting potential use of Acacia angustissima as a ruminant feed. *Animal Feed Science and Technology*, 147(1-3): 158–171

Mendieta-Araica, B., Sporndly, R., Reyes-Sanchez, N. and **Sporndly, E**. 2011. Moringa (*Moringa oleifera*) leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. *Livestock Science*, 137: 10–17

Mokoboki, H.K., Ndlovu, L.R., Ngambi, J.W., Malatje, M.M. and **Nikolovav, R.V**. 2005. Nutritive value of Acacia tree foliages growing in the Limpopo Province of South Africa. *South African Journal of Animal Science*, 35(4): 221–228

Mowlem, A. 1996. *Goat Farming: Feeding and Nutrition*. 2nd edition. Farming Press, UK: 37-53

Mueller-Harvey, I. 2006. Review: unravelling the conundrum of tannins in animal nutrition and health. *Journal of the Science of Food and Agriculture*, 86: 2010–2037

Mupangwa, J.F., Ngongoni, N.T., Hamudikuwanda, H., Acamovic, T. and **Topps, J.H.** 2000. Content of soluble and bound condensed tannins of three tropical herbaceous forage legumes. *Animal Feed Science and Technology*, 83(2): 139-144

National Research Council (NRC). 2000. Nutrient Requirements of Beef Cattle. *7th revised edition, National Academy Press*, Washington DC, USA

Ng'ambi, J .W. 2011. *The role of goats in food supply, poverty alleviation and prosperity in Sub-Saharan Africa.* University of Limpopo, South Africa College of Agriculture and Environmental Sciences, Viewed on 05 September 2015: http://www.unisa.ac.za /Default.asp ?Cmd=ViewContent&ContentID=26891

Ngambu, S., Muchenje, V. and **Marume**, **U.** 2013. Effect of *Acacia karroo* Supplementation on Growth, Ultimate pH, Colour and Cooking Losses of Meat from Indigenous Xhosa Lop-eared Goats. *.Asian-Australasian Journal of Animal Science*, 26(1): 128–133

Nyamukanza, C.C. and **Scogings, P.F.** 2008. Sprout selection and performance of goats fed *Acacia karroo* coppices in the False Thornveld of the Eastern Cape. S*outh African Journal of Animal Science*, 2: 38- 46

Paolini, V., Bergeaud, J.P., Grisez, C, Prevot, F., Dorchies, P. and **Hoste, H.** 2003. Effects of condensed tannins on goats experimentally infected with *Haemonchus contortus. Veterinary Parasitolology*, 113: 253-261

Peacock, C. 1996. *Improving Goat Production in the Tropics. Manual for development workers*, Oxfarm/Farm-Africa Publication: UK and Ireland

Pooley, E. 1993. *The Complete Field Guide to Trees of Natal, Zululand & Transkei Natal Flora Publications Trust*. Durban, South Africa

Raats, J.G. 1998. Feeding behaviour of free range goats. Paper presented at the *Research and Training Strategies for Goat Production Systems in South Africa*, Kings Lodge, Hogsback, Eastern Cape, South Africa: 22-26 November 1998

Raghuvansi, S.K.S., Prasad, R., Mishra, A.S., Chaturvedi, O.H., Tripathi, M.K., Misra, A.K., Saraswat, B.L. and **Jakhmola, R.C.** 2007. Effect of inclusion of tree leaves in feed on nutrient utilization and rumen fermentation in sheep. *Bioresource Technology*, 98: 511-517

Ramirez, R. G. 1999. Feed resources and feeding techniques of small ruminants under extensive management conditions. *Small Ruminant Research*, 34: 215-230

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K.** 2009a. Communal goat production in Southern Africa: a review. *Tropical Animal Health and Production*, 41:1157–1168

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K**. 2010. Estimation of goat production potential and efficiency in the resource-poor communal areas of the Eastern Cape Province of South Africa. *TropicalAnimal Health and Production*, 42: 1235–1242

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K**., 2009b. Prevalence and loads of gastrointestinal parasites of goats in the communal areas of the Eastern Cape Province of South Africa. *Small Ruminant Research,* 84: 132–134

Salem, H.B. 2010. Nutritional management to improve sheep and goat performances in semiarid regions. *Revista Brasileira de Zootecnia*, 39: 337-347

Satterthwaite, D., McGranahan, **G.** and **Tacoli, C**. 2010. Urbanization and its implications for food and farming. *Philosophical Transactions B of the Royal Society*, 365: 2809–2820

Scogings, P.F. and **Mopipi, K**. 2008. Effects of water, grass and N on responses of *Acacia karroo* seedlings to early wet season stimulated browsing: leaf N, fibre and tannin concentrations. *Journal of Arid Environments*, 72: 1666–1674

Sebei, P.J., McCrindle, C.M.E. and **Webb, E.C**. 2004. Factors influencing weaning percentages of indigenous goats on communal grazing. *South African Journal of Animal Science*, 34: 130–133

Tefera, S., Mlambo, V., Dlamini, B.J., Dlamini, A.M., Koralagama, K.D.N. and **Mould, F.L.** 2008. Chemical composition and in vitro ruminal fermentation of common tree forages in the semi-arid rangelands of Swaziland. .*Animal Feed Science and Technology*, 42: 99–110

Webb, E.C. and **Mamabolo, M.J**. 2004. Production and reproduction characteristics of South African indigenous goats in communal farming systems. *South African Journal of Animal Science*, 34:236 – 239

Xhomfulana, V., Mapiye, C., Chimonyo, M. and **Marufu, M.C.** 2009. Supplements containing *Acacia karroo* foliage reduce nematode burdens in Nguni and crossbred cattle. *Animal Production Science*, 49 (8): 646–653

Chapter 3: Nutritional content of *Acacia karroo* leaves at different times of the year in the False Thornveld of Eastern Cape

Abstract

Eight *Acacia karroo* browse trees in False Thornveld of Eastern Cape were monitored for their nutritional content at different times of the year. Leaf samples were collected monthly from June 2014 to May 2015 for each selected *A. karroo* browse tree. The samples were analyzed for dry matter (DM), ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fibre (ADF), total lipids (TL), condensed tannins (CT), total phenols (TP), Calcium (Ca), Phosphorous (P), Magnesium (Mg), Sulphur (S), Zinc (Zn), Iron (Fe), Manganese (Mn) and Copper (Cu). The *A. karroo* browse contained significantly ($P<0.05$) higher ADF (496.4±33.8 g/kg DM), CT (18.4±4.2 g/kg DM), Ca (26.8±0.8 g/kg DM) and Mg (2.9±0.03 g/kg DM) during the months of the cool-dry season (May to August) than other times of the year. There were no significant ($P>0.05$) difference on the amounts of NDF, TL, TP, P, S, Zn, Mn and Cu throughout the study period. The level of CP (182.4±6.7 g/kg DM) was significantly ($P<0.05$) higher during the hot-wet months (November to February) than other times of the year. It was concluded that *A. karroo* leaves have the potential to be integrated into communal livestock feeding systems in the Eastern Cape Province.

Keywords; goats production, seasonal forage quality, crude protein, mineral, browse

3.0 Introduction

Livestock in southern Africa often survive under poor dietary conditions due to dependence on indigenous pastures. In South Africa, Acacia species are widely used as natural protein sources for livestock especially during the dry season. Several researchers reported that *A. karroo* leaves are rich in several nutrients (Mokoboki *et al*., 2005; Mapiye *et al*., 2010). *Acacia karroo* browse tree are abundant in the Eastern Cape Province of South Africa.mainly

because of its ability to adapt and grow in severe and dry conditions (Abdulrazak *et al*., 2001). In semi-arid environments, leguminous forage trees such as *A. karroo* are a crucial source of feed for animals especially during the dry season.

The anti-nutritional factors in *A. karroo* leaves such as tannins, diterpenes, and saponins are the major limitations of this feed resource since these chemicals are known to suppress feed intake and utilization by animals (Nyamukanza and Scogings, 2008). The presence of proline-rich proteins in the saliva of goats enables them to tolerate and utilize species that contain phenolic compounds better than sheep and cattle (Nyamukanza and Scogings, 2008). Goats are unique in that they adapt to changes that occur in the chemical composition and structure of vegetation with season. They have 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 browse the thorn species such as *A. karroo*. Indigenous goat breeds can become a valuable tool in the conservation of the False Thornveld of Eastern Cape if they are properly managed (Nyamukanza and Scogings, 2008). The structures as well as the chemical composition of the natural browse species such as *A. karroo* vary with season and veld management (Bakare and Chimonyo, 2010).

Both quantity and quality of these browse trees tend to diminish with time into the cool-dry season subsequently affecting the productivity of livestock especially in the resource-limited communal sector (Berhane and Eik, 2006; Rumosa Gwaze *et al*., 2009; Bakare and Chimonyo, 2010). Frequently, the encroaching *A. karroo* dominates the presence of understory palatable grass species, due to bush thickets which are often impenetrable (Wiegand *et al*., 2006). Trollipe (1974) reported that a serious bush encroachment problem has developed in the semi-arid communal areas of the Eastern Cape which significantly reduced the grazing capacity of natural rangelands. Consequently, communal farmers face difficulties in finding control measures for the bush encroached since the causes are complex

and diverse. Trollipe (1974) suggested that fire regimes can be used as natural and non-capital intensive technique of controlling *A. karroo* encroachment for rangeland management purposes. However, harvesting and drying of *A. karroo* leaf meal could be utilized to reduce bush-encroachment consequently improving animal feed. It has been reported that natural pastures fluctuate significantly in nutritive value, such as crude protein values which can drop from 12% in the rainy to as low as 2% in the dry season (Mupangwa, 1996).

The limited quantity and poor quality forage especially during the dry season results in diminished livestock productivity in semi-arid environments such as the False Thornveld of Eastern Cape. However, the majority of resource-limited communal farmers cannot afford conventional supplements and *A. karroo* leaf meal may be a potential alternative to these expensive conventional supplements. Knowledge of the changes in the nutritional status of browse trees with seasons is important in guiding rational management of the natural rangelands for the conservation of biodiversity (Anderson *et al.*, 2000). It is therefore a requirement to establish the nutritive and anti-nutritive status of *A. karroo* in order to determine the best time of the year to harvest leaf meal as well as to study goat foraging behaviour. Parameters such as dry matter (DM), neutral detergent fibre (NDF), condensed tannins (CT), ash, crude protein (CP), acid detergent fibre (ADF), mineral content, and total phenolic compounds (TP) can be used to determine the best time to harvest the leaf meal. The objective of this study was to characterize the nutritional content of *A. karroo* at different times of the year in the False Thornveld of Eastern Cape Province of South Africa.

3.1 Materials and Methods

3.1.1 Description of study site

The study was conducted in a grazing camp of the University of Fort Hare's Honeydale Research Farm (32°46'S; 26°51'E), in the False Thornveld of the Eastern Cape. The site is

located along R63 King Williams' Road in Alice approximately 90 km inland from the India Ocean costal line with an altitude of 500–620m above sea level. The grass species which dominated the camp were mainly *Digitaria eriantha, Pennisetum clandestinum, Themeda triandra, Panicum maximum* and *Cynodon dactylon*. *Acacia karroo* trees dominated other browse species in the camp. The topography of the chosen site was largely level and close to several artificial watering points. The site represents a semi-arid environment with low mean annual rainfall of nearly 480 mm which is distributed throughout the four seasons with most rain during the hot-wet (summer) season. During the study period, lower and upper mean temperatures were observed in May (4.6°C) and February (27.1°C), respectively.

3.1.2 Sampling of experimental trees and leaves

The sampling area resembled *A. karroo* encroached communal grazing lands in Nkonkobe Municipality in the Eastern Cape Province. A total of eight *A. karroo* browse trees with the average height of 1.2±0.5 meters and age of 4±1.5 years were selected and marked with paint on the bark. Leaf samples were hand-plucked monthly from selected browse tree from July 2014 to June 2015. The months which were covered during monitoring were categorized into four seasons namely cool-dry winter months (May to August), spring hot-dry months (September to October), summer hot-wet months (November to February) and autumn post-rainy months (March to April) (Ellery *et al*., 1995; Mapiliyao *et al*., 2012). Immediately after collection the leaves and they were air dried. The samples were then milled through 1 mm mesh using electric powered laboratory grinder before laboratory analysis.

3.1.3 Chemicals Analysis

The chemical composition of the leaf meals was determined according to the Association of Official Analytical Chemists (AOAC 1990). The DM values obtained were of dry leaf meal. Ash was obtained by igniting the samples in a muffle furnace at 600^0C overnight. The total lipids, crude protein (CP), total lipids (TL), simple phenolic (SP) substances, Calcium (Ca),

Phosphorous (P), Magnesium (Mg), Sulphur (S), Zinc (Zn), Iron (Fe), Manganese (Mn) and Copper (Cu) were determined by dry forage calibrated Fourier Transformed near-infrared reflectance spectroscopy (NIRS) (Metrohm Applikon Process Analyze, ADI 201Y Series single method, Netherlands). The NIRS which was used had a range which corresponds to a wavelength range of between 700 and 2500nm on the visible light side of the divided infrared spectrum (software- WinISI, ISI, 2014). All scanned spectra were repeated three times for each leaf sample before calculating the sample mean. Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were analyzed using a simplified version of the ANKOM procedure utilizing a polyester bag (PBT) and (Ankom Daisy II, ANKOM Technology Corp., Fairport, NY) (AOAC 1990).

3.1.4 Statistical Analysis

The DM, ash, NDF, ADF, CP, TL, CT, SP, Ca, P, Mg, S, Fe, Zn, Mn and Cu results were analysed using repeated measures of ANOVA using linear model (GLM) procedures of SAS (2010). Mean separation was done using the least squares mean PDIFF option of SAS (2010). The model used was as follows:

$Y_{ik} = \mu + S_i + E_{ik}$

Where:

Y_{ij} – is the responsive variable (amount of DM, ash, NDF, ADF, CP, TL, CT, TP and Ca …)

S_i – Effect of season of the year (i = cool-dry, hot-dry, hot-wet and post-rainy)

μ - Overall mean common to all observation

E_{ijk} – residual error common to all observations

3.2 Results

3.2.1 Chemical Composition of *A. karroo* leaves at different times of the year

There were few leaf samples during the cool-dry period. The highest number of samples was observed during the hot-wet season as shown in Table 3.4. There were no significant ($P>0.05$) differences in dry matter (DM) content across the seasons. There were no significant ($P>0.05$) differences on ash contents across the seasons. Although the ash content tended to be higher during the cool-dry season (64.7±12.1 g/kg DM), it was lower during the hot-wet season (47.8±21.2 g/kg DM). There were no significant ($P>0.05$) differences observed on NDF content across the seasons. Although the NDF was tended to be higher during the post-rainy season (544.2±8.9 g/kg DM), it was lower during the hot-wet season (481.0±42.3 g/kg DM). There were significant ($P<0.05$) differences observed on the amount ADF in the leaves across the seasons. The content of ADF was significantly ($P<0.05$) higher during the cool-dry season (277.4±26.1 g/kg DM) than the other seasons which were similar.

The CP content was significantly ($P<0.05$) different across the seasons. The hot-wet season had a higher CP ($P<0.05$) (182.4±6.7 g/kg) content than cool dry (146.1±19.2 g/kg DM) and hot dry seasons which did not differ ($P>0.05$) between themselves. There were no significant ($P>0.05$) differences on total lipid (TL) across the seasons and it ranged from 23.4±9.3 g/kg DM during the cool-dry season to 26.8±3.8 g/kg DM during the hot-wet season. There were also significant ($P<0.05$) differences on the amounts of condensed tannins (CT) observed across the seasons. The CT was significantly ($P<0.05$) higher during the cool-dry season (18.4±4.2 g/kg DM) than the other seasons. There were no significant ($P>0.05$) differences on simple phenolic substances observed across the seasons.

Table 3.3: Least squares means for chemical constituents (g/kg DM) of *A. karroo* leaves at different times of the year

	Season			
	Cool-dry	**Hot-dry**	**Hot-wet**	**Post-rainy**
Samples	23	25	29	22
[i]DM	912.4±19.2	902.7±12.2	897.6±13.8	901.8±37.8
Ash	64.7±12.1	57.5± 9.0	47.8±21.2	51.6±11.8
[ii]NDF	496.4±33.8	521.6±16.2	531.0±42.3	542.3±7.5
[iii]ADF	297.4^{b}±26.1	276.2^{a}±13.1	259.4^{a}±20.1	266.2^{a}±27.9
[iv]CP	146.1^{a}±19.2	157.1^{a}±34.3	182.4^{b}±6.7	167.8^{ab}±18.2
[v]TL	23.4±9.3	23.9±10.4	26.8±3.8	25.7±2.3
[vi]CT	18.4^{b}±4.2	15.9^{a}±2.5	13.6^{a}±1.7	15.7^{a}±2.7
[vii]SP	9.6±0.8	8.2±0.1	8.1±1.5	9.4±2.1

[abc] Means within a row with different superscripts are significantly different (P<0.05).

3.2.2 Mineral content of *A. karroo* leaves at different times of the year

The macro-mineral content of the leaves at different times of the year are shown in Table 3.5 below. There were significant differences observed on Ca content across the seasons (P<0.05). Calcium content was significantly (P<0.05) higher during the cool-dry period (26.8±0.8 g/kg DM) and lower during the hot-wet season (12.9± 0.9 g/kg DM). There were no significant (P>0.05) differences observed on the level of phosphorus (P) across the

[i] DM – Dry Matter
[ii] NDF – Neutral Detergent Fibre
[iii] ADF – Acid Detergent Fibre
[iv] CP – Crude Protein
[v] TL – Total Lipids
[vi] CT – Condensed Tannins
[vii] SP - Simple Phenolic

seasons. Although P content tended to be high during the post-rainy season (4.5±0.05 g/kg DM) it was low during the cool-dry season (3.9±0.06 g/kg DM) There were significant (P<0.05) differences on the level of Magnesium (Mg) across the seasons. The level of Mg was significantly (P<0.05) higher during the cool-dry period (2.9±0.03 g/kg DM) than the other seasons which were similar. There were no significant (P>0.05) differences observed on Sulphur (S) content across the seasons with values ranging from 1.8±0.01 g/kg DM in cool dry season to 2.9±0.14 g/kg DM in hot-wet season.

Table 3.4: The least square means for the macro-mineral content of *A. karroo* leaves at different times of the year (g/kg DM)

	Season			
	Cool-dry	**Hot-dry**	**Hot-wet**	**Post-rainy**
Samples	23	25	29	22
[i]Ca	26.8^{b}±0.8	20.6^{ab}±0.4	12.9^{a}± 0.9	17.2^{a}±1.0
[ii]P	3.9±0.06	4.2±0.07	3.8±0.10	4.5±0.05
[iii]Mg	2.9^{b}±0.03	2.5^{a}±0.09	2.1^{a}±0.06	2.2^{a}±0.8
[iv]S	1.8±0.01	2.6±0.05	2.9±0.14	1.9±0.04

[abc] Means within a row with different superscripts are significantly different (P<0.05)

Iron (Fe) was the dominating micro-mineral element across all seasons of the year as shown in Table 3.6. There were significant (P<0.05) differences in Fe content of the leaves across the seasons. Iron content was significantly (P<0.05) higher during the hot-wet period (217.6± 42.9 mg/kg DM) and lower during the cool-dry season (152.8±34.6 mg/kg DM). There were

[i] Ca - Calcium
[ii] P - Phosphorus
[iii] Mg - Magnesium
[iv] S - Sulphur

no significant (P>0.05) differences observed on the level of Manganese (Mn) across the seasons although Mn content tended to be high during the post-rainy season (87.0±5.81 mg/kg DM) and lower during the cool-dry season (66.1± 9.5 mg/kg DM) as shown on Table 4.3. There were no significant (P>0.05) differences on the level of Zinc (Zn) across the seasons. Although the level of Zn was tended to be high during the hot-dry period (20.4±0.9 mg/kg DM), it was generally low during the post-rainy season (12.2±1.83 mg/kg DM). There were also no significant (P>0.05) differences observed on copper (Cu) content across the seasons although the Cu levels tended to be high during the cool-dry season (14.6±2.3 mg/kg DM) and low in post-rainy season (11.4±1.09 mg/kg DM) as shown on Table 3 .6.

Table 3.5: Least square means for micro-mineral composition of *A. karroo* leaves at different times of the year (mg/kg DM)

	Season			
	Cool-dry	**Hot-dry**	**Hot-wet**	**Post-rainy**
Samples	23	25	29	22
[i]Fe	152.8^{a}±34.6	164.6^{a}±27.8	217.6^{b}± 42.9	187.1^{ab}± 24.3
[ii]Mn	66.1± 9.5	82.7±13.6	75.1±8.48	87.0±5.81
[iii]Zn	11.2±3.2	20.4±0.9	16.7±1.43	12.2±1.83
[iv]Cu	14.6±2.36	11.8±1.04	9.7± 0.51	11.4±1.09

[abc] Values within a row with different superscripts are significantly different (P<0.05).

[i] Fe - Iron

[ii] Mn - Manganese

[iii] Zn - Zinc

[iv] Cu- Copper

3.3 Discussion

3.3.1 Chemical composition of *A. karroo* leaves at different times of the year

The nutritional composition of the *A. karroo* leaves at different times could be due to influence of many different factors which include soil mineral status, soil moisture availability, climate and stage of leaf growth (Aganga *et al*., 2000; Rubanza *et al*., 2005). The ash content was not significantly different across the seasons of the year. However, the elevated ash levels during the cool-dry season could be due to dilution effect due to higher biomass in other seasons. The numbers of leaf samples taken during the whole study were uneven across the seasons due to absence of enough leaf material to constitute a leaf sample of at least 5g on each of the selected *A. karroo* trees. As a result, more leaf samples were obtained during the hot-wet season. The reported values for ash content across all seasons are within the range of 4.1 to 7.0 g/kg DM observed by other previous studies on *A. angustissima* (Hove *et al*., 2001), *A. karroo* leaf-meal (Xhomfulana *et al*., 2009; Ngambu *et al*., 2013).

The observed levels of NDF and ADF in *A. karroo* browse trees are consistent with what has been reported in previous work with *A. karroo* with values of 502 to 531.5 ± 17.93 and g NDF/kg DM (Nyamukanza and Scogings, 2008; Mapiye *et al*., 2010) and 264 to 289.9 g ADF/kg DM (Abdulrazak *et al*., 2001; Mapiye *et al*., 2010), respectively. The NDF observed during the post-rainy (512.3±7.5 g/kg DM) tended to be high than other seasons. The increase in both NDF and ADF content during post-rainy to cool-dry season may be due to accumulation of structural carbohydrates in old leaf cells due to leaf maturity (Hove *et al*., 2001). In spite of this, the high NDF and ADF values could have been caused by variation of levels of petioles and twigs in each leaf sample analyzed. The NDF which mainly consists of cellulose, hemicellulose, and lignin, could be increased due to active channeling of

photosynthate into the production of cell-wall polysaccharides or lignin may increase in leaf DM accumulation in following cool-dry season (Raven *et al*., 1999; Dubouzet *et al*., 2013).

The CP was highest during the hot-wet season (182.4±6.7 g/kg DM) and lowest during the cool-dry season (146.1±19.2 g/kg DM). This was expected during the hot-wet season due to the availability of soil moisture and temperatures conducive for photosynthesis which will promote growth of new leaves (Raven *et al*., 1999; Dubouzet *et al*., 2013). However, the values for all the seasons were above 110 g/kg DM which is recommended for finishing steers (NRC, 2000). With such levels of CP across all seasons of the year, *A. karroo* trees can be used throughout the year to improve communal goat nutrition especially for resource-limited small-scale farmers. In addition, these CP values observed in this study are relatively higher than other Acacia species (Abdulrazak *et al*., 2000; Aganga *et al*., 2000; Ngwa *et al*., 2002; Mokoboki *et al*., 2005). The TL tended to be high during the hot-wet season (26.8±3.8 g/kg DM) and low during the cool-dry season (23.4±9.3 g/kg DM). The observed TL values were close range to those reported by the previous studies (Taiz and Eduardo, 1998; Raven *et al*., 1999; Dubouzet *et al*., 2013).

The condensed tannins were highest (18.4±4.2 g/kg DM) during the cool-dry season and least during hot-wet season (13.6±1.7 g/kg DM). The observed range of values for condensed tannins was lower than 55–110 g/kg DM reported by Dube *et al.* (2001) and Mokoboki *et al*. (2005). However, the range is within the 10–60 g/kg DM which is regarded as valuable to ruminant digestive tract (Mueller-Harvey, 2006). The nutritional status of livestock can be enhanced through anthelmintic properties of tannins and phenolic substances in *A. karroo* plants (Niezen *et al*., 1998; Mapiye *et al*., 2009). During the cool-dry season, the total phenolic compounds were elevated to 9.6±0.8 g/kg DM. Scogings and Mopipi (2008) reported that old *A. karroo* leaves in the cool-dry season had high concentration of phenolic

substances mainly in infertile soils of semi-arid environments such as the False Thornveld of Eastern Cape.

3.3.2 Mineral content of *A. karroo* leaves at different times of the year

In the current study, the observed mineral profile in *A. karroo* browse tree leaves compare favorably with other Acacia species. In comparison with other Acacia species such as *A. tortilis* and *Acacia nilotica*, the relative levels for Ca, P and Mg at different times of the year were relatively higher (Ngwa *et al*., 2002; Tefera *et al*., 2008; Mapiye *et al*., 2011). Calcium was the dominating macro-mineral element across all seasons of the year. The observation that amounts of both Ca and Mg in *A. karroo* leaves were relatively high during the cool-dry period is in agreement with research done by Barnes *et al*. (1996) and Mapiye *et al*. (2011) who attributed it to the soil type.

The presence of substantial amounts of these macro-mineral in *A. karroo* browse trees could be due to relatively higher uptake from the soil derived mainly from shale and mudstone which have elevated amounts of these minerals (Tefera *et al*., 2008; Mapiye *et al*., 2011). The levels of P across the seasons were very low as compared to Ca. Previous research also reported low values of P for many Acacia species (Abdulrazak *et al*., 2001; Tefera *et al*., 2008). The Ca: P ratio is of greater importance than absolute values since Ca is directly correlated to P metabolism. However, the Ca: P ratio observed in the experiment was lower than that, which was obtained by Tefera *et al*. (2008), implying that *A. karroo* leaf-meal harvested at any time during the year contain adequate P for different livestock species. Therefore, there is no need to increase the amount of P when using *A. karroo* leaf-meal as a supplement to goats.

In the current study, the observed levels of Fe, Zn and Mn in *A. karroo* leaves were relatively high across all seasons of the year and are above the recommended levels for goats (NRC,

2000). The highest concentration of Fe in *A. karroo* leaves have been attributed to the presence in the atmosphere of sedimentary powder from activities of pollution and other human activities such as agriculture, mining and roads (Dulama *et al*., 2012). The Zn concentrations across all the seasons in this study were relatively close to tolerable dietary level for goats of 150-250 mg/ kg DM (NRC, 2000). The amounts of Zn (22.3 mg/kg DM), Mn (32 mg/kg DM) and Cu (14 mg/kg DM) observed during post-rainy season are consistent with what has been reported for *A. karroo* leaf-meal harvested and prepared at the University of Fort Hare farm between February and March 2008 (Mapiye *et al*., 2010).

3.4 Conclusion

The nutritional content of *A. karroo* trees monitored during the study reveals that *A. karroo* can enhance the nutrition of goats throughout the year due to its high CP levels. There was little variation in nutritional contents of *A. karroo* at different times of the year. Therefore, it can be concluded that *A. karroo* leaves can be harvested for supplementation of livestock at any given time of the year. However, high biomass harvest would be achieved during the hot-wet to post-rainy season due to abundant leaf material.

3.5 References

Abdulrazak, S.A., Nyangaga, J. and **Fujihara, T**. 2001. Relative palatability to sheep of browse species, their *in sacco* degradability and *in vitro* gas production characteristics. *Asian-Australasian Journal of Animal Sciences*, 1: 1580-1584

Aganga, A.A., Adogla-Bessa, T., Omphile, U.J. and **Tshireletso, K**. 2000. Significance of browses in the nutrition of Tswana goats. *Archivos de Zootecnia*, 49: 469–480

Anderson, F.O., Feger, K.H., Huttl, R.F., Krauchi, N., Mattson, L., Satlnas, O. and **Sjoberg, L**. 2000. Forest ecosystem research and priorities for Europe. *Forest Ecology Management*, 132: 111–119

Association of Official Analytical Chemists. 1990. *Official analytical m*ethods, 15th Edition, Washington DC: USA

Bakare, A.G and **Chimonyo, M**. 2010. Seasonal variation in time spent foraging by indigenous goat genotypes in a semi-arid rangeland in South Africa. *Livestock Science*, 135: 251-256

Berhane, G., and **Eik, L.O**. 2006. Effect of vetch (*Vicia sativa*) hay supplementation to Begait and Abergelle goats in northern Ethiopia III, Forage selection and behaviour. *Small Ruminant Research*, 64: 241–246

Dube, J.S., Reed, J.D. and **Ndlovu, L.R**. 2001. Proanthocyanidins and related phenolics in Acacia leaves of Southern Africa. *Animal Feed Science and Technology*, 91: 59–67

Dubouzet, J.G., Strabala, T.J and **Wagner, A.** 2013. Potential transgenic routes to increase tree biomass. *Plant Science*, 212: 72–101

Dulama, I., Popescu, I.V., Stihi, C., Radulescu, C., Cimpoca, G.H.V., Toma, L.G., Stirbescu, R. and **Nitescu, O**. 2012. Studies on accumulation of heavy metals in acacia leaf by EDXRF. *Romanian Reports in Physics*, 64(4): 1063–1071

Ellery, W.N., Scholes, R.J., and **Scholes, M.C**. 1995. The distribution of sweetveld in South Africa's grassland biome in relation to environmental factors. *African Journal of Range and Forage Science*, 12: 38–45.

Hove, L., Topps, J.H., Sibanda, S. and **Ndlovu, L.R.** 2001. Nutrient intake and utilization by goats fed dried leaves of the same legumes *Acacia angustissima*, *Calliandra calothrysus* and *Leucaena leucocephala* as supplements to native pasture hay. *Animal Feed Science and Technology*, 91: 95–106

Mapiliyao, L., Pepe, D., Marume, U. and **Muchenje, V.** 2012. Flock dynamics, body condition and weight variation in sheep in two ecologically different resource-poor communal farming systems. *Small Ruminant Research*, 104: 45– 54

Mapiye, C., Chimonyo, M., Dzama, K., Muchenje, V. and **Strydom, P.E.** 2010. Meat quality of Nguni steers supplemented with *Acacia karroo* leaf-meal. *Meat Science*, 84: 621–627

Mapiye, C., Chimonyo, M., Marufu, M.C. and **Dzama K.** 2011. Utility of Acacia karroo for beef production in Southern African smallholder farming systems: A review. *Animal Feed Science and Technology*, 164 (3–4): 135–146

Mokoboki, H.K., Ndlovu, L.R., Ngambi, J.W., Malatje, M.M. and **Nikolovav, R.V**. 2005. Nutritive value of Acacia tree foliages growing in the Limpopo Province of South Africa. *South African Journal of Animal Science*, 35(4): 221–228

Mueller-Harvey, I. 2006. Review: unravelling the conundrum of tannins in animal nutrition and health. *Journal of the Science of Food and Agriculture*, 86: 2010–2037

Mupangwa J.F. 1996. Pasture seed production of promising grasses and legumes at Domboshawa, Zimbabwe, **Ndikumana J.** and **de Leeuw**, **L**. Sustainable Feed Production and Utilization of Smallholder Livestock Enterprises in Sub-Saharan Africa. *Proceedings of the Second African Feed Resources Network (AFRNET), Harare, Zimbabwe, 6–10 December 1993.* African Feed Resources Network Nairobi, Kenya: 201

National Research Council (NRC). 2000. Nutrient Requirements of Beef Cattle. 7th revised edition, *National Academy Press*, Washington, DC: USA

Ngambu, S., Muchenje, V. and **Marume**, **U.** 2013. Effect of *Acacia karroo* Supplementation on Growth, Ultimate pH, Colour and Cooking Losses of Meat from Indigenous Xhosa Lop-eared Goats. *Asian-Australasian Journal of Animal Science*, 26(1): 128–133

Ngwa, A.T., Nsahlai, I.V. and **Bonsi, M.L.K.** 2002. The rumen digestion of dry matter, nitrogen and cell wall constituents of the pods of *Leucaena leucocephala* and some Acacia species. *Journal of the Science of Food and Agriculture*, 82: 98–106

Niezen, J.H., Waghorn, T.S., Raufaut, K., Robertson, H.A. and **McFarlane, R.G.** 1998. Lamb weight gain and faecal egg count when grazing one of the seven herbages and dosed with larvae for six weeks. *Proceedings of New Zealand Society of Animal Production*, 54: 15–18

Nyamukanza, C.C. and **Scogings, P.F.** 2008. Sprout selection and performance of goats fed *Acacia karroo* coppices in the False Thornveld of the Eastern Cape. *South African Journal of Animal Science*, 2: 38-46

Raven, P.H., Ray F.E. and Susan E.E. 1999. Biology of Plants, 6thEdition, W. H. Freeman and Company, New York: USA

Rubanza, C.D.K., Shem, M.N., Otsyina, R., Bakengesa, S.S., Ichinohe, T. and **Fujihara, T.T.** 2005. Polyphenolics and tannins effect on in vitro digestibility of selected Acacia species leaves. *Animal Feed Science and Technology*, 119: 129–142

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K**. 2009. Communal goat production in Southern Africa: a review. *Tropical Animal Health and Production*, 41: 1157–1168

Scogings, P.F. and **Mopipi, K**. 2008. Effects of water, grass and N on responses of Acacia karroo seedlings to early wet season stimulated browsing: leaf N, fibre and tannin concentrations. *Journal of Arid Environments*, 72: 1666–1674

Statistical Analysis Software (SAS) STAT® 9.22 User's Guide. 2010. SAS Institute Inc;Cary, NC: USA

Taiz, L. and **Eduardo, Z**. 1998. Plant Physiology, 2nd edition, *Sunderland, MA*: Sinauer Associates, United States of America.

Tefera, S., Mlambo, V., Dlamini, B.J., Dlamini, A.M., Koralagama, K.D.N. and **Mould, F.L.** 2008. Chemical composition and in vitro ruminal fermentation of common tree forages in the semi-arid rangelands of Swaziland. *Animal Feed Science and Technology*, 42: 99–110

Trollipe, W. S. W. 1974. The role of fire in preventing bush encroachment in the Eastern Cape. *Proceedings of the Grassland Society of South Africa*, 9:67–72

Wiegand, K., Saltz, D. and **Ward, D**. 2006. A patch-dynamics approach to savanna dynamics and woody plant encroachment − Insights from an arid savanna. *Perspectives in Plant Ecology, Evolution and Systematics*, 7: 229−242

Xhomfulana, V., Mapiye, C., Chimonyo, M. and **Marufu, M.C.** 2009. Supplements containing *Acacia karroo* foliage reduce nematode burdens in Nguni and crossbred cattle. *Animal Production Science*, 49 (8): 646–653

Chapter 4: The comparative performance of goats browsing on *Acacia karroo* communal browsing lands and open grasslands at different times of the year in the False Thornveld of Eastern Cape, South Africa

Abstract

A total of eighty communal households' goat herds were monitored for a period of twelve months to determine the effect of season, rangeland type and herd size on average daily gain (ADG), body condition score (BCS), births, purchases, sales, deaths, goat production potential (GPP) and goat production efficiency (GPE) in *Acacia karroo* encroached and open grassland communal areas in False Thornveld of Eastern Cape Province of South Africa. Most entries as births were recorded in large herds in the *A. karroo* encroached community especially during the hot-wet season ($P< 0.05$). Farmers with large herd sizes sold and slaughtered significantly more goats compared to those with small herd sizes. Mortality was significantly high in the hot-wet season in the open grassland. Households possessing small herds in open grassland had the lowest ($P< 0.05$) GPP in the cool-dry season than other times of the year. The ADG and BCS of monitored goats in *A. karroo* encroached areas were generally higher than for those in open grassland especially during the cool-dry season. However, the GPP and GPE were not significantly ($P>0.05$) different between the two communities across the seasons. It was concluded that goats which browsed *A. karroo* largely performed better in both growth and reproduction in comparison to those which grazed open grassland especially during the cool-dry season.

Keywords; goat production potential, efficiency, season, open grassland, *Acacia karroo*, growth performance, bush encroachment, small scale farmers

4.0 Introduction

The most important agricultural sector in many countries of southern Africa is considered to be livestock production (Webb and Mamabolo, 2005). In the Eastern Cape Province of South Africa, goats are among the major socio-economically critical livestock species (Rumosa Gwaze *et al*., 2009b; Bakare and Chimonyo, 2011). According to Moyo *et al*. (2013) besides being protein source for humans, goats provide source of income to livelihood, risk mitigation and accumulation of wealth. In the developing world, there is increased demand of livestock and livestock products such as milk, hides and meat due to ever growing human population (Sanon *et al*., 2008). In addition, lean meat (chevron) and milk products from goats have been on the demand due to human health issues associated with fat such as cardiovascular diseases and obesity (Rumosa Gwaze *et al*., 2009c; Moyo *et al*., 2013).

In the Eastern Cape Province, there were about 2.3 million goats in the year ending 2009 which translates to approximately 37% of the whole goat population in the country (Oni *et al*. 2010; Moyo *et al*., 2013). According to Webb and Mamabolo (2005) indigenous goats breeds such as Nguni, Xhosa ear-lobbed and Boer goats constitute a precious genetic reserve due to their ability to adapt to arid and semi-arid environmental conditions. Indigenous goats are able to better utilize the low and frequently poor quality feed resources. These goats have natural resistance to a range of diseases such as gall sickness, pulpy kidney and internal parasites. However, in many tropical countries such South Africa the productivity of these animals is relatively low due to diseases, nutrition, genotype and suboptimum management especially for resource limited communal farmers (Simela and Merkel 2008; Sanon *et al*., 2008; Oni *et al*., 2010).

The negative effects of seasonal fluctuations on forage quantity and quality are the main causes of malnutrition especially in resource limited communal farmers (Oni *et al*., 2010).

During the dry seasons natural pastures become mature, dry and inadequate, with low nutritive value as low as 2% crude protein that fails to fulfil the nutritional maintenance requirements of goats (Mupangwa, 1996; Mendieta-Araica *et al*., 2011). These circumstances occur in many regions of the southern Africa, where goats are normally raised in traditional systems roaming freely in fallow land, forest and grassland.

The main feed resources of goats in False Thornveld of Eastern Cape Province are native grasses which are mainly *Themeda trianda, Cymbopogon plurinodis, Sporobolus fimbriatus* (Danckwerts *et al*., 1985), *Panicum maximum, Digitaria eriantha, Eragrostis spp., Cynodon dactylon and Pennisetum clandestinum* (Nyamukanza and Scogings, 2008; Ngambu *et al*., 2013), and legumes that occur naturally in grasslands and browse forage mainly from *A. karroo* tree. According to Ndemanisho *et al*. (2006), the proper utilisation of tree and shrub forage has beneficial effects on ruminant nutrition. In addition, supplementing goats with nutritious feed could increase average daily gain (ADG), carcass weight and dressing percentage, resulting in the improvement of the meat quality (Safari *et al*. 2009).

Supplementation of indigenous Xhosa lob-eared goats using *A. karroo* leaf-meal improved the growth performance and the meat quality from those goats (Ngambu *et al*., 2013). Other communal farmers around the world prefer to supplement their livestock with crop residues and low-quality standing hay, which are low in nitrogen, high in lignocellulose (Gebregiorgis *et al*. 2011; Moyo *et al*., 2013). The commercial or resourceful communal farmers add urea on these crop residue based diets in order to provide alternative nitrogen. However, Antonelli *et al*. (2004) reported that urea has toxic effects to animals if feeds are improperly mixed and animals are not adapted. Inadequate feed lead to low growth as well as delayed animal sexual maturity, poor reproductive performance, poor meat quality and low milk yield.

Browsable shrubs such as *A. karroo* have been observed to be a good source of protein for communal goats particularly for resource limited farmers. The *A. karroo* tree contains some polyphenolic compounds for instance tannins with an anthelmic effect on gastrointestinal parasites (Kahiya *et al*., 2003; Xhomfulana *et al*., 2009; Marume *et al*., 2012). Upon re-alimentation with high quality diets, goats can compensate for an earlier period of a low nutritional plane through increased feed intake and enhanced efficiency of feed utilization.

Several studies have explored alternative sources of protein from forage trees and shrubs that can be fed to goats, such as *Pterrocarpus lucens, Acacia senegal* (Sanon *et al*., 2008), *Acacia etbaica, Dichrostachys cinerea* (Yayneshet *et al*., 2008), *Acacia karroo* (Marume 2010; Moyo *et al*., 2013; Ngambu *et al*., 2013) and *Manihot esculenta* (Oni *et al*. 2010) have increased in recent years. *Acacia karroo* browse is abundant in most communal rangelands of Eastern Cape Province and it is preferred by goats for browsing. This browse species is easily accessible to farmers and can be prepared and fed as leaf-meal (Mapiye *et al*., 2009; Ngambu *et al*., 2013). The *A. karroo* leaves can contain up to 230g/kg CP and can be considered as a cheap source of proteins in communal goat production (Mapiye *et al*., 2009).

Though recently there is substantial amount of published research concerning the supplementation of small ruminants in tropical areas of Africa using locally available tree foliage, the bulk of the studies have been carried out under artificial or controlled conditions, mainly at research stations (Webb and Mamabolo, 2005). Communal herd monitoring can be useful if it involves the participation of willing farmers (Rumosa Gwaze *et al*., 2010) and it takes advantage of indigenous resources such as *A. karroo*. The knowledge can be used to introduce new technologies subsequently; these results are often applicable to communal production systems in many rural areas of Eastern Cape. The objective of this research was to compare the performance of goats browsing on *A. karroo* dominated communal browsing lands to those on open grasslands in False Thornveld of Eastern Cape in different seasons.

4.1 Materials and Methods

4.1.1 Description of study sites

The study was conducted in four villages within two municipalities which fall under the administration of Amathole District of the Eastern Cape Province. The municipalities were Mbhashe (GPS coordinates; 32° 6' 0", 28° 18' 0" SE, altitude; 580 - 710m) and Nkonkobe (GPS coordinates 32° 47′ 0, 26° 50′ 0″ SE, altitude 500 - 620 m). The areas were selected with the help of government extension officers in order to determine the level of *A. karroo* bush encroachment in Nkonkobe and openness in Mbhashe among Eastern Cape Province rangelands.

Vegetation in all sites was representative of Acocks (1975) 'False Thornveld of Eastern Cape' and range from grassland to dense, clumped, medium-short, evergreen thicket (Masika *et al*., 1998). In Nkonkobe, bush-clump thorn savanna consisted of semi-arid, subtropical thicket and *A. karroo* woodlands on soils derived mainly from shale and mudstone. According to Scogings and Mopipi (2008), mean annual rainfall of Nkonkobe is approximately 617 millimetres. Of the annual rainfall, 80% falls during the months of October to April, while 20% falls during the cold months of June to August. The most common grass species are *Themeda trianda, Setaria sphacelata, Themeda trianda, Cymbopogon plurinodis, Microchloa caffra, Elionurus muticus and Heteropogon contortus.* The dominant tree species are *Acacia karroo, Scutia myrtina and Maytenus polyacantha* (Ellery *et al*., 1995). *Acacia karroo* constituted at least 80% of woody plant population in Nkonkobe municipality (Bakare and Chimonyo 2011).

The communities that were selected in the *A. karroo* encroached site of Nkonkobe were *Skolweni and Ncera*, while the communities in the open grasslands site of Mbhashe were *Ngubezulu* and *Bonkolo*. According to Palmer and Ainslie (2006), many of these

communities under Mbhashe municipality are characterized by predominantly open grasslands and normally receive about 534mm of rain per year, with most rainfall occurring mainly during summer. The average midday temperatures for Mbhashe range from 18.3°C in July to 25°C in February. The common grasses in Mbhashe are *Themeda trianda, Cymbopogon plurinodis, Sporobolus fimbriatus, Panicum maximum, Digitaria eriantha, Eragrostis spp., Cynodon dactylon and Pennisetum clandestinum*.

4.1.2 Sampling of households and experimental goats

Prior to the identification of study sites, the level of *A. karroo* encroachment and density of shrubs of the communal grazing lands in Nkonkobe was determined by means of 100 x 2m wide belt transects (Basha *et al*., 2012) in all adjacent communal grazing lands of each of these communities. Other available browse species were also identified and recorded. In Mbhashe, the grass species composition in the open communal grazing land was also sampled by the step point method (Tracy *et al*., 2004).

A total of 80 households who own at least one growing castrate goat in each target area either *A. karroo* encroached or open grassland were chosen. The study consisted of 40 farmers from *Skolweni* and *Ncera* and 40 Farmers from *Ngubezulu* and *Bonkolo*, respectively. These households were divided into two groups based on herd size; 1–20 goats represented small herd size and more than 20 represented large herd size. After the initial recording, herds were visited every month, during which all demographic events (births, deaths, other entries and exits) that had occurred between the previous and actual day visits were recorded. At the commencement of trial, each farmer/household was provided with a booklet in which all live body weights (BW), body condition score (BCS), age, and herd composition and herd dynamic events were recorded with the help of trained research assistants. The ages of animals were also determined based on herd owner interviews and cross-checked by using information obtained by direct examination of dentition. The households were interviewed in

order to assess animal history and any form of management which will increase bias on the nutrient uptake and utilisation by goats such as supplementation and deworming.

4.1.3 Monitoring herd sizes, body condition and weights

Dynamic aspects that were monitored were births, herd composition, purchases, exchanges, sales, births, deaths and off-take, goat production potential (GPP), goat production efficiency (GPE), body weight (BW) and body condition score (BCS). Monthly questionnaires were filled in by households from July 2014 to June 2015. A total of 80 growing castrates (weaning to puberty) were selected from participating households, weighed by using Crane SHS 150 150 X 0.02kg (AE-ADAMS, United Kingdom) digital hanging scale and body condition scored. Body condition scoring was done on a scale of 1–5, with a score of 1 indicating a thin and emaciated goat, while a condition of 5 indicated an obese goat after visual appraisal and palpation on the lumbar and sternum area (Nsoso *et al*., 2003).

The goats that were used in this study were non-descript communal goat breeds which are predominantly from Xhosa lob-eared, Boer and Nguni goat genotype. Within each herd, goats were classified into four categories: does (adult female goats older than 1 year), bucks (non-castrated males older than 1 year), castrates (male castrated goats older than 1 year), and kids (female and male goats less than 1 year). The entrances recorded were births and purchases while the exits comprised of sales, slaughter, mortality, thefts and missing goats. Goats entrusted, gifts and exchanges were recorded as entrances or exits depending on whether the goats involved were exiting or joining the herd.

The months which were covered during monitoring were categorised into four seasons namely; cool-dry winter months (May to August), spring hot-dry months (September to October), summer hot-wet months (November to February) and autumn post-rainy months (March to April). Experimental animals were balanced in many factors including BCS, BW,

breed, age, physiological status and visual appraisal at the commencement of monitoring. However, selected and non-selected goats were browsing in communal browsing lands together with goats from other non-selected households. Management was considered to be extensive since all the goats were not supplemented but released to communal grazing and browsing land, their nutrition was solely dependent on rangelands then penned overnight for safety reasons at different households.

4.1.4 Goat production potential and goat production efficiency

The goat production potential (GPP) and goat production efficiency (GPE) for each community were seasonally computed, as described by Mapiye *et al*.(2009) on cattle, Mapiliyao *et al*. (2012) on sheep and Rumosa Gwaze *et al*. (2010), on goats as;

GPP = N/H

Where;

GPP = goat production potential,

N = number of mature goats and growing goats, and

H = Herd size.

The GPE was defined as the proportion of mature goats sold and/or consumed as a proportion of GPP and calculated as:

GPE = M/GPP

Where;

GPE = goat production efficiency,

M = number of mature goats slaughtered or sold

GPP = goat production potential.

4.1.5 Statistical analyses

The effects of season, communal grazing and herd size on herd entries, herd composition, exits, goat production potential (GPP), goat production efficiency (GPE), body weights (BW), proportion of kids to does, BW and BCS were determined using the repeated measures ANOVA using a general linear model (GLM) procedures of SAS (2010). Mean separation was done using the least squares PDIFF option of SAS (2010).

The statistical model used was: $Y_{ijkl} = \mu + M_i + V_j + H_k + (M \times V)_{ij} + E_{ijkl}$

Where, Y_{ijkl} = response variable (GPE, GPP, births, mortalities, entries, exits, BCS, BW);

μ = constant mean common to all observation;

M_i = effect of season;

V_j = effect of communal grazing land (Nkonkobe or Mbhashe)

H_k = effect of herd size (m = small or large herd)

(M x V)ij = interaction of the effect of communal grazing land and season

E_{ijkl} = Error common to all observations

4.2 Results

4.2.1 Herd size and composition

Table 4.7 shows the mean sizes for different classes of goat herds in all communities at the commencement of the monitoring in June 2014. The does constituted a greater proportion as compared to other goat classes in all communities. Generally there were more goats in Nkonkobe (35.3±3.07) as compared to Mbhashe (27.5±4.72). In both communities, there

were significant (P<0.05) differences on number of total goats, castrates, does and kids among large and small herds. However, there was no significant (P>0.05) difference between number of bucks in Nkonkobe among large and small herds.

The buck/doe ratio in Nkonkobe for large herds (1:13) was lower (P<0.55) than corresponding small herds (1: 5). There were no significant (P>0.05) differences on the buck to doe ratio in communities in Mbhashe among small and large herds. In Mbhashe, the kid/doe ratio for both small and large herds were not significantly different (P>0.05). In Nkonkobe community kid/doe ratio (1:3) was high (P< 0.05) in large herd than in small herds (1:7).

Table 4.6: The average goat herd size and composition of households in Nkonkobe and Mbhashe communities at the commencement of trial

Communities:		Herd composition						
		Herd Size	Does	Bucks	Castrates	kids	Kid/Doe	Buck/Doe
Nkonkobe	[i]LH	25.4[b]±2.02	13.2[b]±2.9	1.1±0.67	6.3[b]±0.48	4.8[b]±3.4 0	0.36±0.09	0.08[a]±0.006
	[ii]SH	8.9[a]±4.51	5.2[a] ±0.17	1.0±0.18	1.9[a]±1.13	0.8[a]±1.67	0.15±0.15	0.19[b]±0.012
Mbhashe	LH	21.1[b]±3.01	10.3[b]±3.37	1.3±0.11	5.7[b]±1.23	3.8[b]±2.15	0.37±0.67	0.13[b]±0.013
	SH	6.4[a]±1.73	3.5[b]±2.87	0.4±0.36	1.2[a]±0.91	1.3[b]±3.14	0.37±0.17	0.11[b]±0.008

[abc] Means within a column with different superscripts are significantly different (P<0.05).

[i]LH – Large Herd

[ii] SH – Small Herd

Figure 4.1 shows the variation of the herd sizes in communities in different seasons. There were significantly (P<0.05) more goats per household in the hot-dry season than other times of the year in all the communities. Peak herd sizes were identified in hot dry months in Nkonkobe (32.9±2.04) and (24.1±3.83) for Mbhashe large herds. Generally, the herd sizes on average peaked between September and December (hot-dry to hot-wet) and remained almost constant throughout the rest of monitoring period.

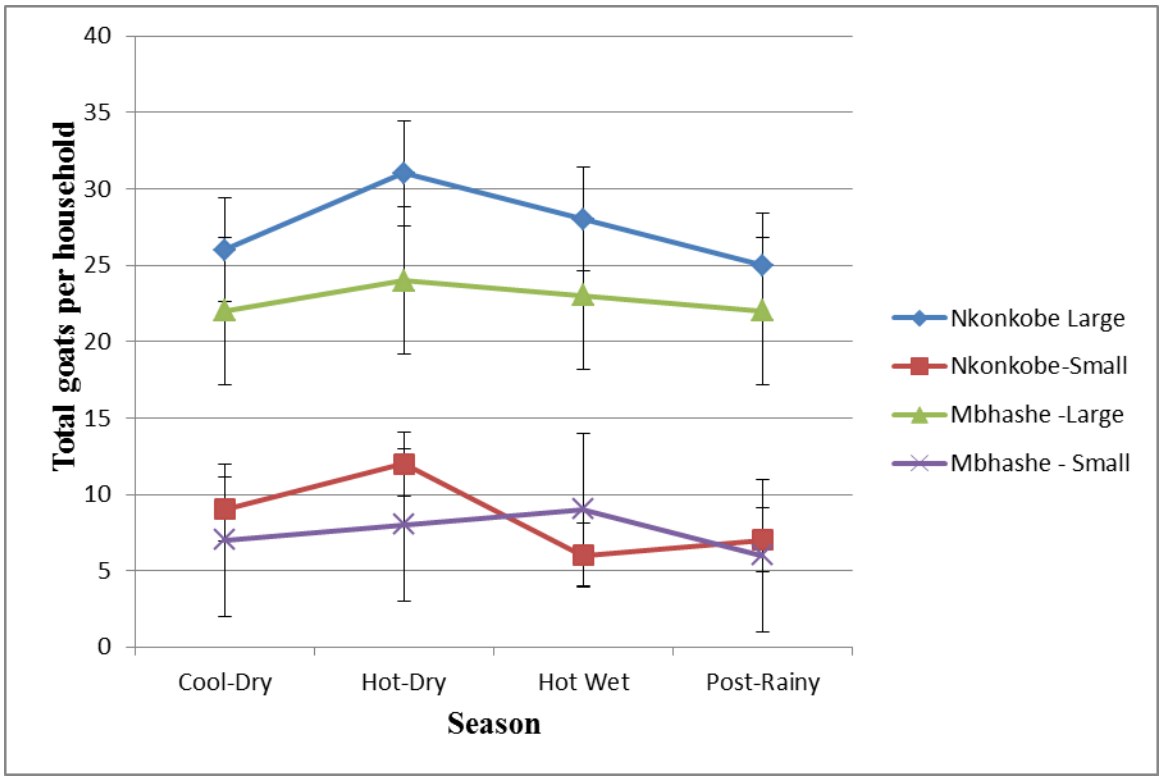


Figure 4.1: The mean herd sizes in Mbhashe and Nkonkobe communities at different times of the year (goats/household)

The number of does in Nkonkobe community households with large herds followed the trend for average herd size throughout the study period as shown in Figure 4.2. The type of communal grazing land and season interaction for the number of does per household was significant (P<0.05). The number of does was significantly higher (P<0.05) in the *A. karroo*

communal browsing lands (Nkonkobe) in the hot-dry season for households with large herd whilst in open grassland (Mbhashe) it was significantly (P<0.05) higher during the post-rainy season. Generally, numbers of does in all communities were low during the cool-dry season except for household in Mbhashe with small herds.

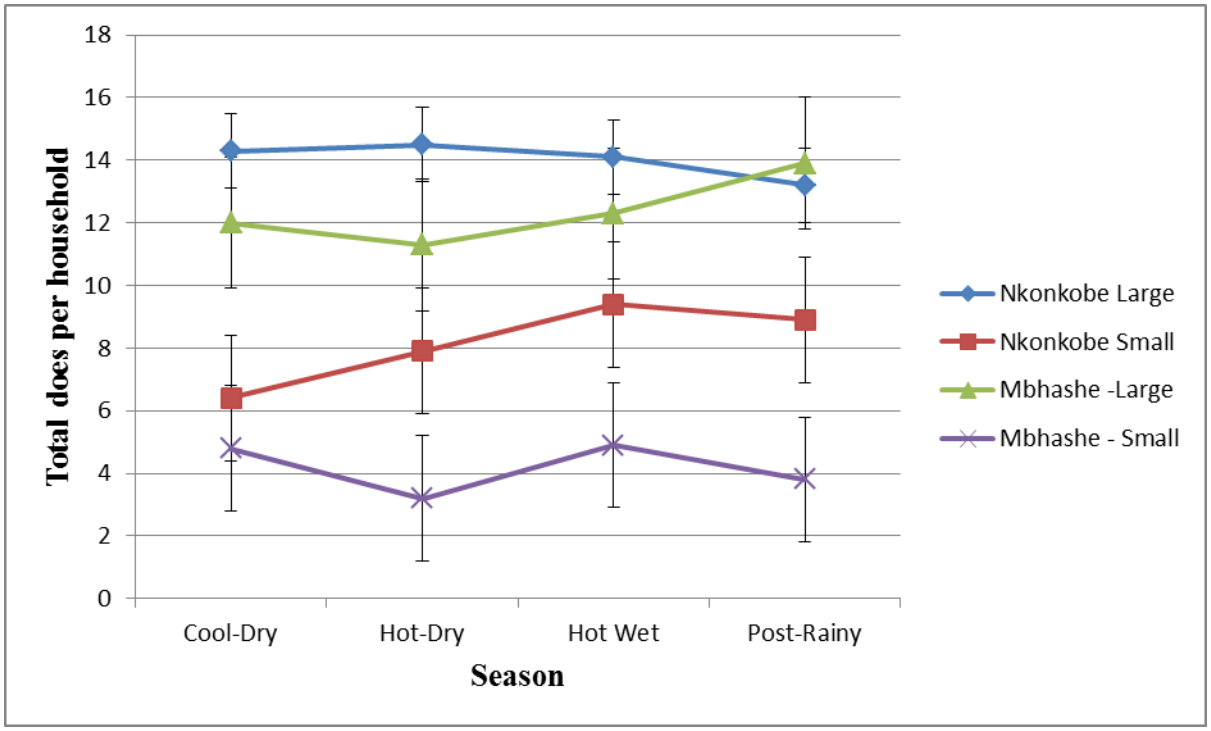


Figure 4.2: The mean number of does per household in Mbhashe and Nkonkobe communities at different times of the year

There was a significant (P<0.05) difference between type of communal grazing land and season on kid numbers throughout the study period. The number of kids was highest in the Nkonkobe during the post-rainy season and lowest in the cool-dry season as compared to the Mbhashe as shown in Figure 4.3. Generally, the average number of kids in household with large herds was significantly (P<0.05) higher than small herds in both communities.

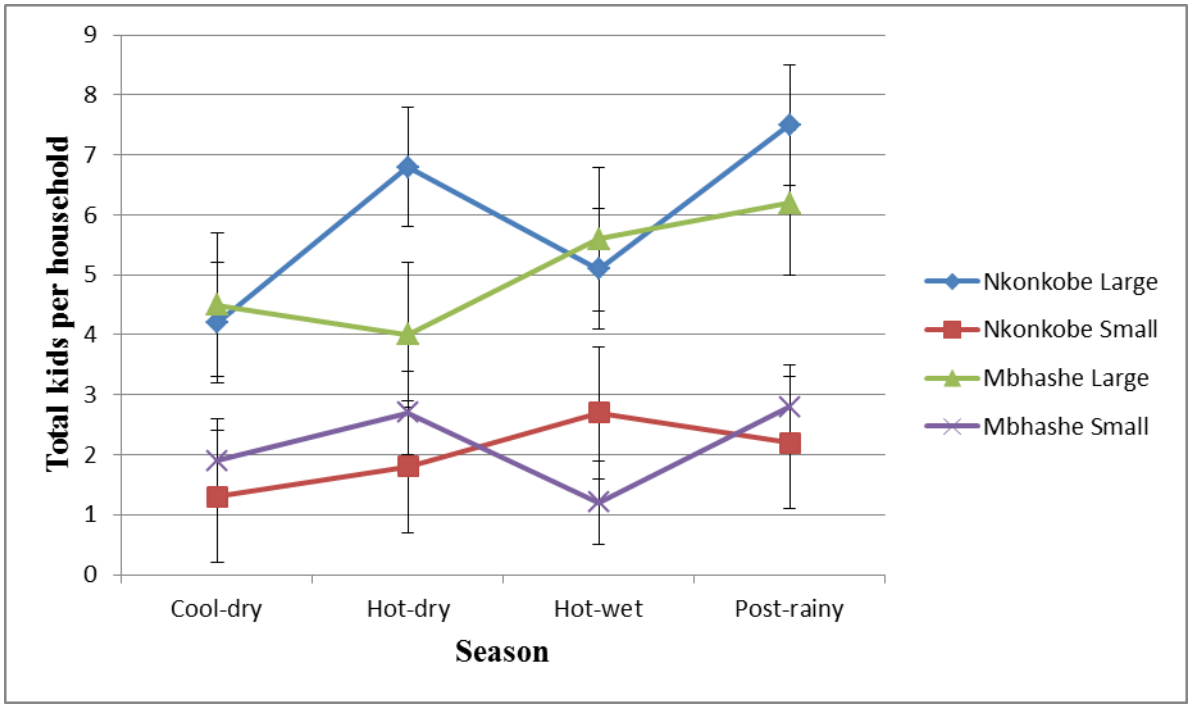


Figure 4.3: The mean number of kids per household in Mbhashe and Nkonkobe communities at different times of the year

The mean number of castrates per household with large herds in both communities were significantly ($P<0.05$) different. The number of castrated goats in households with large herd was significantly ($P<0.05$) higher in the *A. karroo* dominated grazing land (Nkonkobe) in the hot-dry season, whilst in Mbhashe there were significantly ($P< 0.05$) higher during the hot-wet season than other times of the year. Generally, numbers of castrates were low during the cool-dry season as shown in Figure 4.4.

4.2.2 Body weights and condition scores

The body weights (BW) were significantly ($P<0.05$) different during the hot-wet and post-rainy period (November–May) in both communities and in all classes of herd sizes as shown in Figure 4.5. The BW of goats of households with small herds in Mbhashe were low throughout the study period.

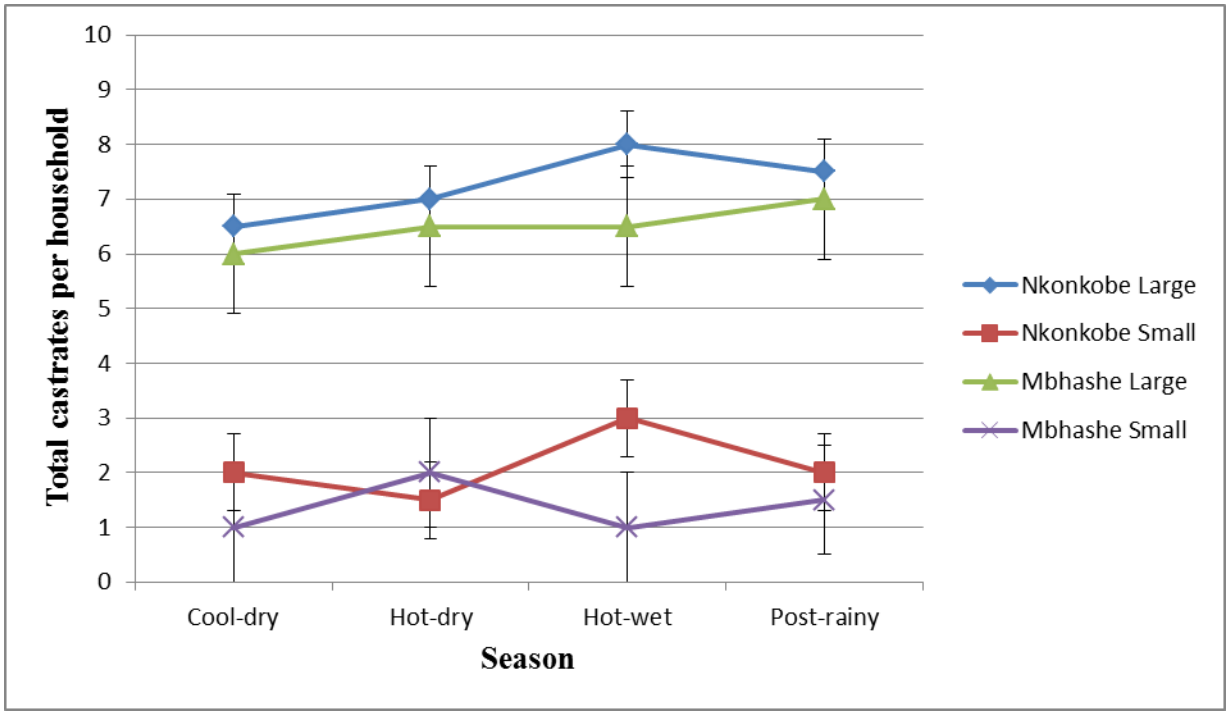


Figure 4.4 The mean number of castrates per household in Mbhashe and Nkonkobe communities at different times of the year

However, in both communities goats maintained their weight over the study period although there was an initial increase in weight after the post-rainy season. The goats in Nkonkobe from households with small herd had highest weights than in Mbhashe during hot-dry season. Peak weights of goats from households with large and small herd in Mbhashe were recorded in the post-rainy period (23.6 ± 0.22 kg) and (16.9±0.85 kg), respectively.

There was a significant difference on the effect of common grazing and browsing land and season on body condition scores (BCS) of the selected castrates as shown on Figure 4.6. Generally goats in Nkonkobe had higher ($P<0.05$) body condition scores than those in Mbhashe throughout the study period. In all communities, goats had high BCS in the post-rainy season. In Nkonkobe, *A. karroo* encroached area, goats had higher body condition scores compared to those in Mbhashe during cool-dry season.

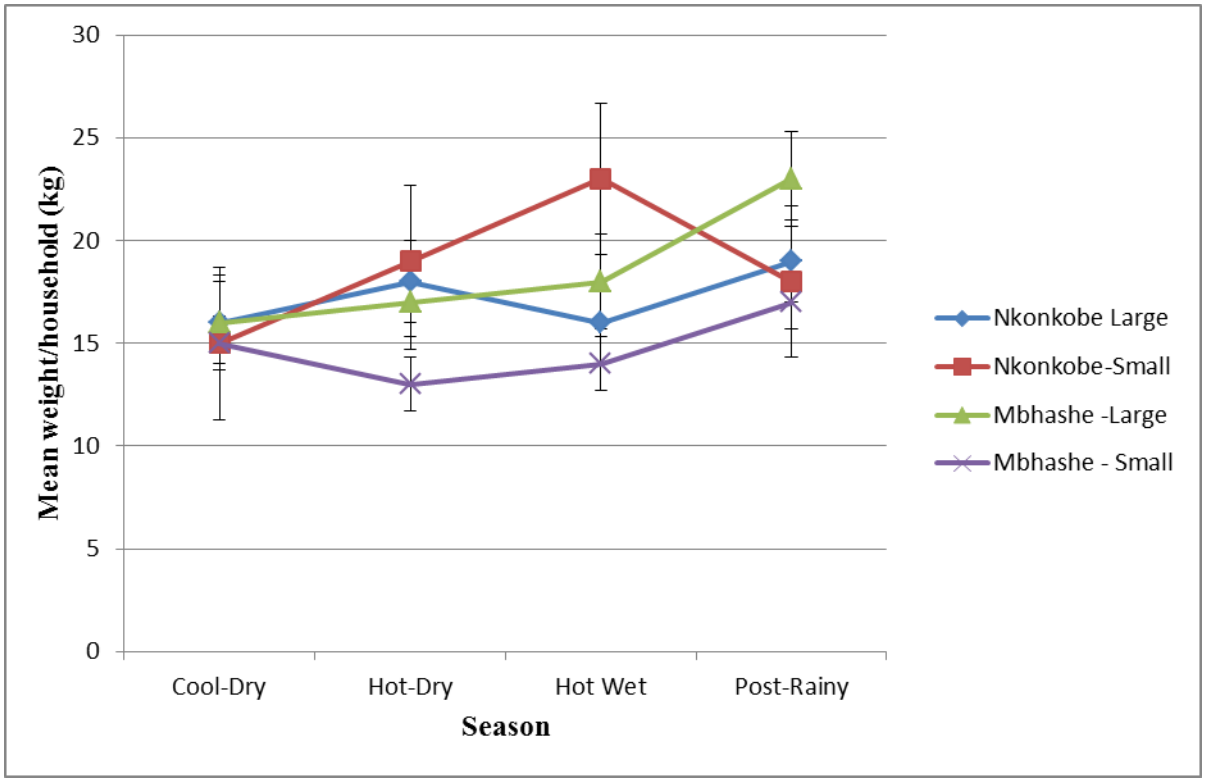


Figure 4.5: The mean body weights of selected castrates per household in Mbhashe and Nkonkobe communities at different times of the year

Across the two communities, during the hot-wet months the body condition scores were similar. The goats in Nkonkobe from households with large herds realized a decline in BCSs in the hot-wet period (3.9 ± 0.5) whereas in Mbhashe realized a decline in BCSs in the cool-dry months (3.3 ± 1.0).

4.2.3 Goat exits and entries

During the study period, there were no goats which were missing, entrusted and gifted in or out of the herd in all communities. Sales and slaughters were significantly ($P < 0.05$) higher in households with large herds in both communities than in smaller herds. There was a significant ($P<0.05$) difference between season and herd size on total number of goats slaughtered and/or sold. In all communities, most goats were sold and/or slaughtered in hot-wet season (November to February) 0.21±0.162 and 0.06±0.146 goats/household for large

and small herds, respectively in Nkonkobe and (0.17±0.306 goats/household) and (0.06±0.276 goats/household) for large and small herds, respectively in comparison with other seasons as shown in Figure 4.7

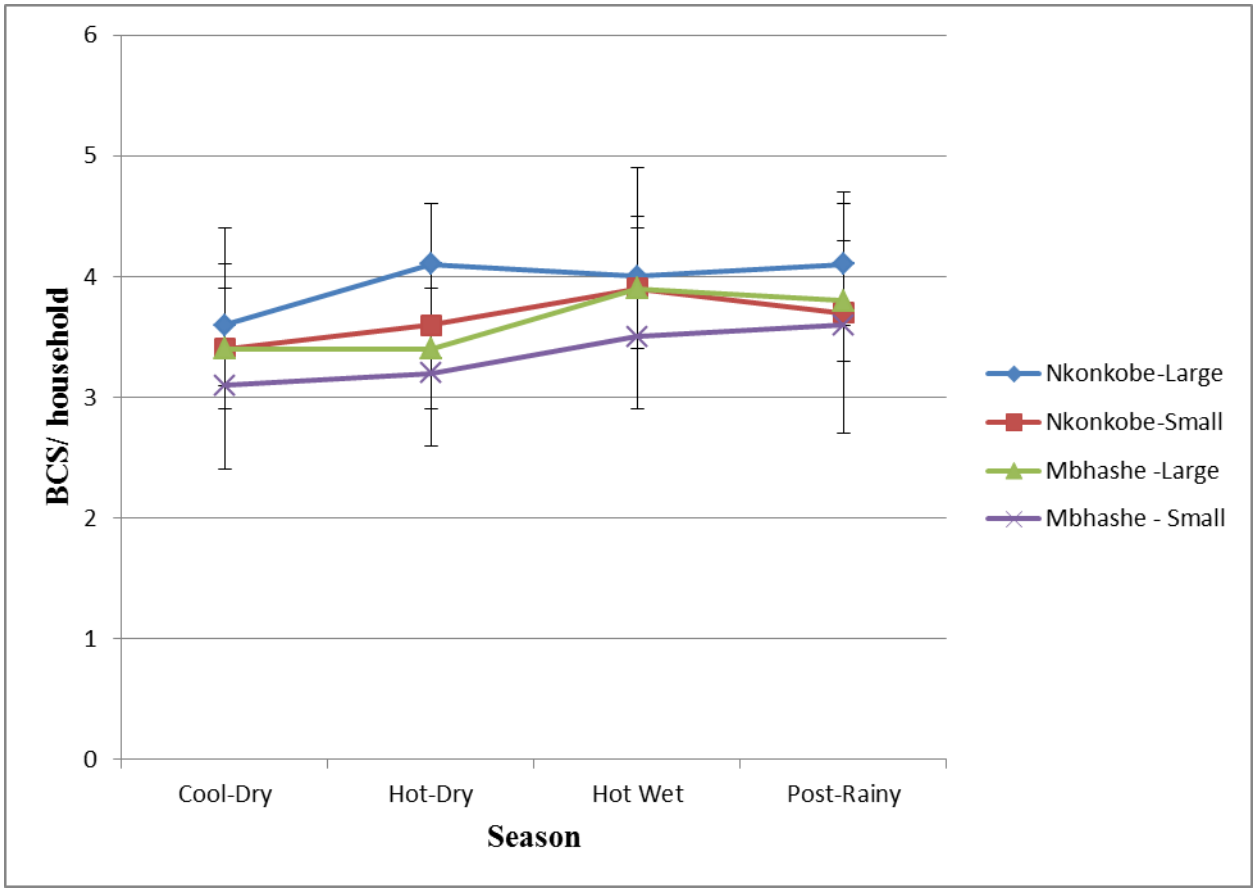


Figure 4.6: The mean BCS of selected castrates per household in Mbhashe and Nkonkobe communities at different times of the year

Adult goat mortality in Mbhashe was at its peak in cool-dry season (0.39 ± 2.76 goats/household) followed by hot-wet (0.26 ± 3.51 goats/household). Generally, in all communities, kid mortality was significantly ($P<0.05$) higher than adult mortality except in Mbhashe during the hot-wet season when they similar. The kid mortality was significantly ($P<0.05$) higher during cool-dry in Mbhashe community as shown on Figure 4.8.

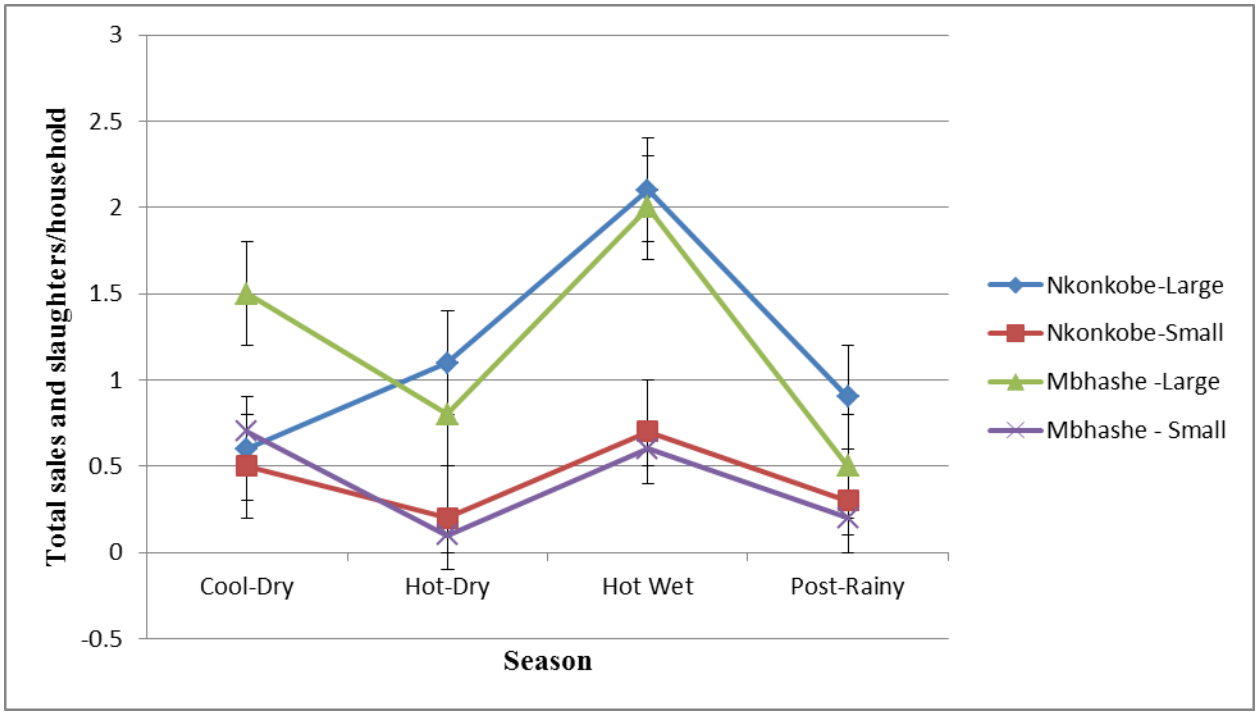


Figure 4.7: The mean total sales and slaughter of goats per household in Mbhashe and Nkonkobe communities at different times of the year

Season and communal grazing land did not affect the total number of goats that joined the herd through purchases and exchanges and/or as gifts. Purchases composed of 2.7% of all goats entries recorded during study period. In the large herds, births were significantly ($P<0.05$) higher in hot-dry seasons (4.75±0.313), compared to other seasons with the same trend in small herds as shown in Figure 4.9

Total entries of goats during the study period followed the trend for birth of castrates as shown in Figure 4.1.0. There was no significant difference ($P>0.05$) between season and community on total number of goats that entered the herd. Most goats entered the herd in hot-wet (1.23±0.135 goats/household) and (1.06±0.127 goats/household) for Mbhashe and Nkonkobe. During the post-rainy the total entries were 0.18±0.124 goats/household and 0.43±0.144 goats/household for Mbhashe and Nkonkobe, respectively in comparison with other times of the year.

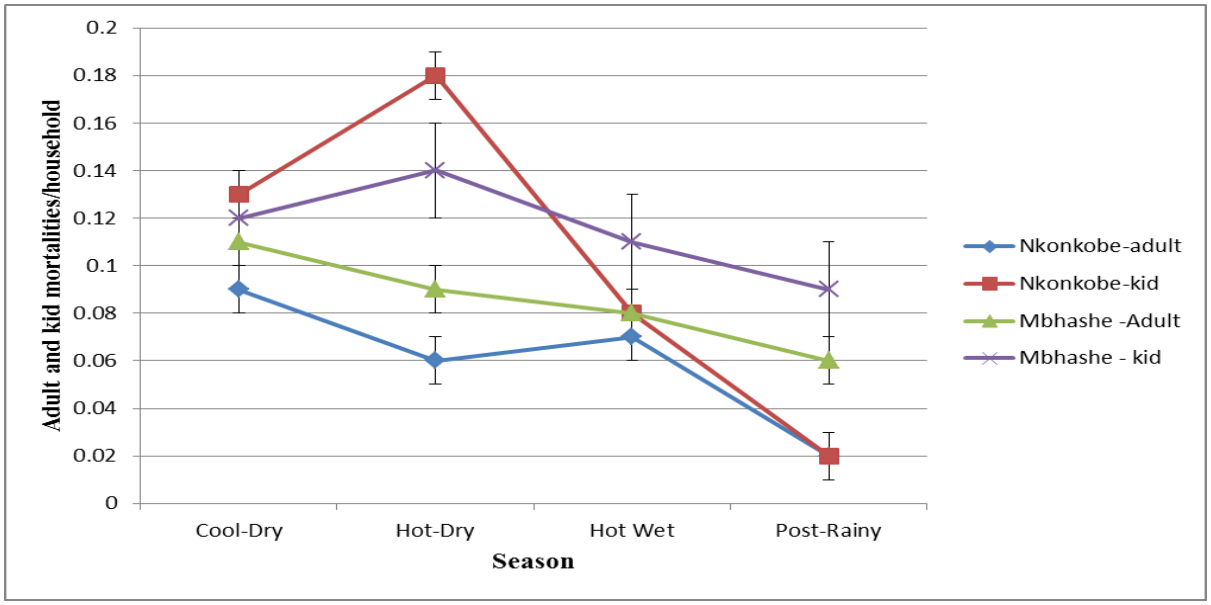


Figure 4.8: The mean adult goat and kid mortality goats per household in Mbhashe and Nkonkobe communities at different times of the year

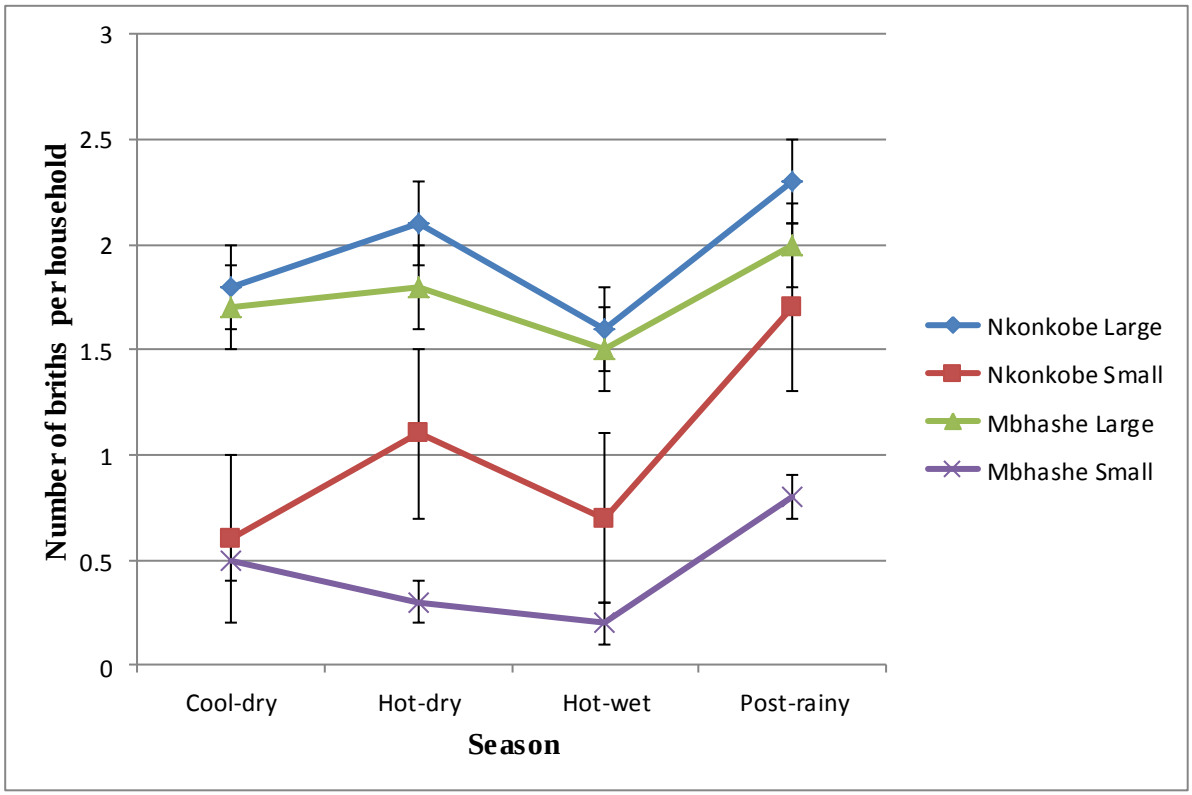


Figure: 4.9 The mean number of entries as births per household in Mbhashe and Nkonkobe communities at different times of the year

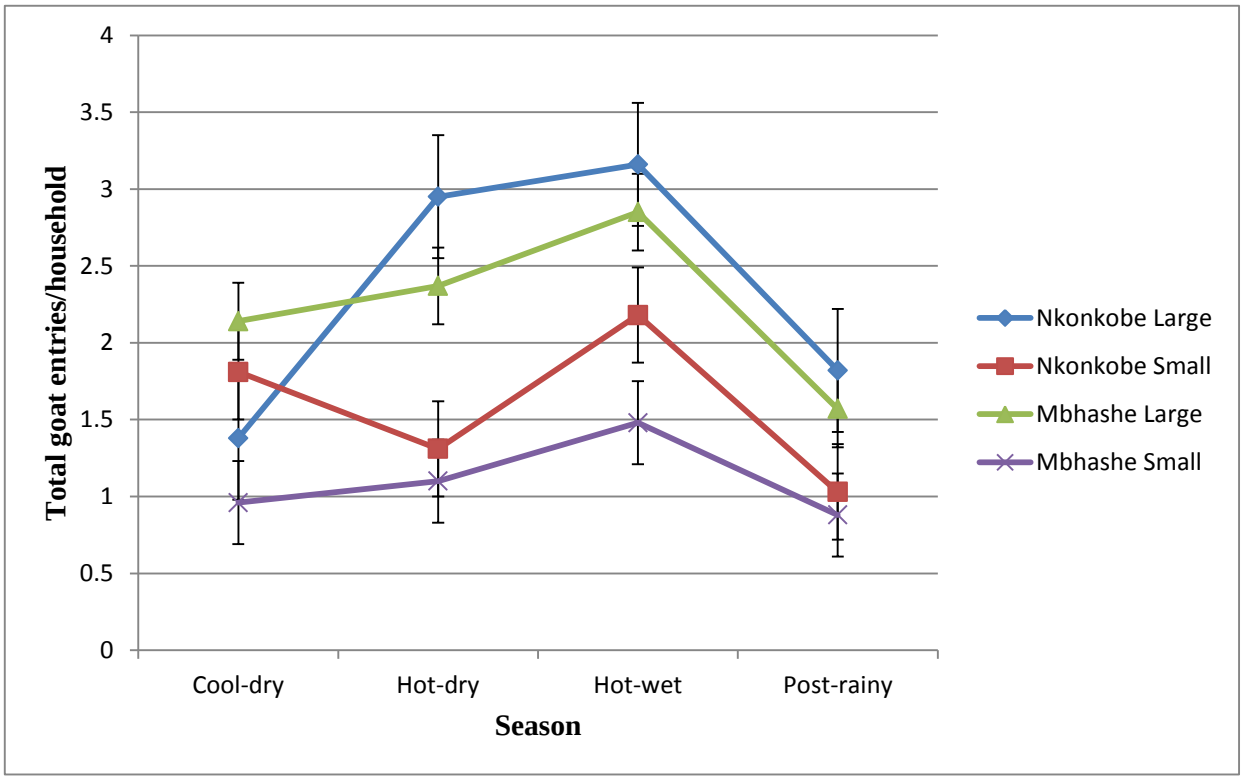


Figure 4.10: The mean number of goat entries per household in Mbhashe and Nkonkobe communities at different times of the year

4.2.3 Goat, production potential and efficiency

The goat production potential (GPP) was significantly ($P<0.05$) higher in large herds than in small herds in both communities. However, there were no significant ($P>0.05$) across the seasons is all communities. The GPP declined in Mbhashe community for both large and small herds from cool-dry to hot wet season, it initially increased for small herds during the cool-dry season as shown in Figure 4.1.1. Nevertheless, in both communities a general decline in GPP was observed throughout the study period.

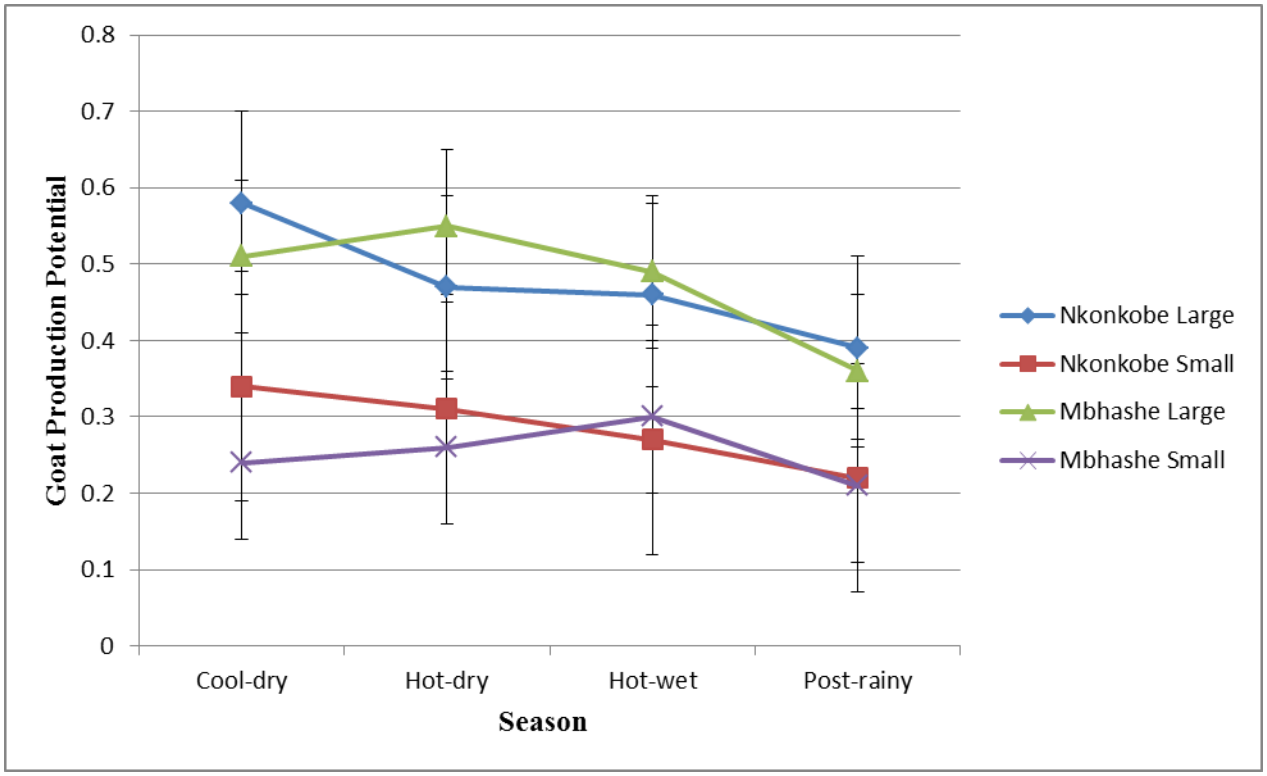


Figure 4.11: The mean Goat Production Potential (GPP) per household in Mbhashe and Nkonkobe communities at different times of the year

The goat production efficiency (GPE) of all communities was decreasing from cool-dry season to the post-rainy season during the study period. There were no significant ($P>0.05$) on the GPE across the seasons. However, in Nkonkobe community, GPE was higher than Mbhashe throughout the year as shown in Figure 4.1.2.

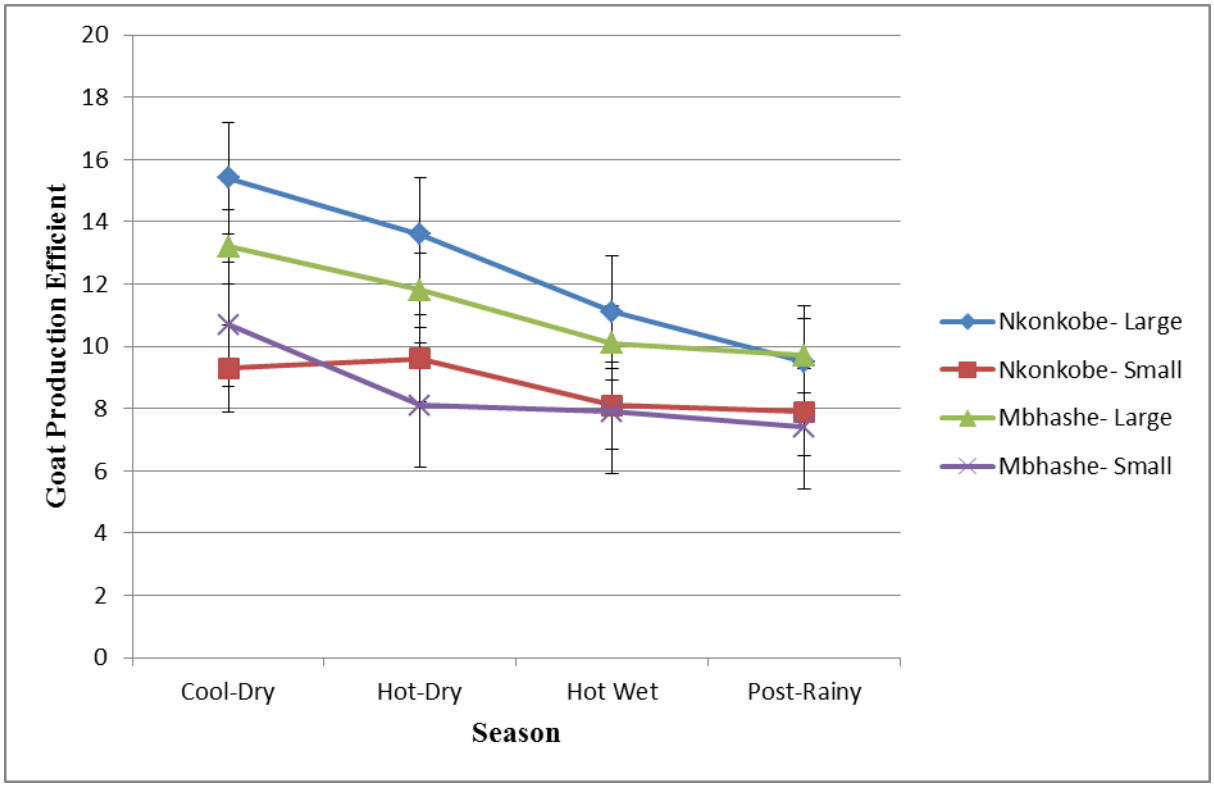


Figure 4.12: The mean Goat Production Efficiency (GPE) per household in Mbhashe and Nkonkobe communities at different times of the year

Throughout of the study, most entries as births were observed in small herds in both communities as shown in Table 4.9. However, in Nkonkobe large herds, entries as purchases were higher than the entries as births. In both communities, exists from the herd were mainly caused by sales and slaughters other than mortality. The births were significantly ($P<0.05$) higher in large herds in both communities. There were no significant ($P>0.05$) differences on mortality in both communities. However, the GPP and GPE for households with large herds in both communities were higher than those owning small herds.

Table 4.7: The summary of GPP, GPE, entries, and exits in goat herds per household in Mbhashe and Nkonkobe communities throughout the study period

Characteristic:				
	Nkonkobe		Mbhashe	
Entries	[i]SH	[ii]LH	SH	LH
Births	$2.95^{a}\pm0.178$	$8.02^{b}\pm0.148$	$1.88^{a}\pm0.194$	$6.86^{ab}\pm0.112$
Purchases	$0.62^{a}\pm0.11$	$4.39^{b}\pm0.024$	$0.48^{a}\pm0.045$	$6.71^{b}\pm0.084$
Exits				
Sales/slaughter	$4.18^{a}\pm0.02$	$11.8^{b}\pm0.008$	$2.15^{a}\pm0.022$	$6.11^{ab}\pm0.094$
Mortality	0.05 ± 0.044	0.003 ± 0.061	0.09 ± 0.051	0.05 ± 0.013
[iii]GPP	$0.910^{a}\pm0.059$	$0.810^{a}\pm0.076$	$0.73^{a}\pm0.083$	$0.797^{a}\pm0.034$
[iv]GPE	$4.593^{ab}\pm0.030$	$14.56^{b}\pm0.049$	$2.95^{a}\pm0.181$	$7.666^{a}\pm0.102$

[abc] Means within a row with different superscripts are significantly different ($P<0.05$)

[i] SH – Small Herd
[ii] LH – Large Herd
[iii] GPP - Goat Production Potential
[iv]GPE - Goat Production Efficiency

4.3 Discussion

4.3.1 Herd size and composition

In general, herd sizes among households in all communities shadowed seasonal patterns in feed and rainfall availability. In communal areas such as in the Eastern Cape Province, extensive management of animals is either directly or indirectly linked to the seasonal conditions (Angassa and Oba, 2007; Kgosikoma, 2006). Consequently, these seasonal variations are a key factor of production. Factors such as soil type, climate, altitude, rainfall pattern, soil fertility and other agro-ecological factors can lead to different woody plant population and composition which will in turn have direct or indirect effect on herd size and composition dynamics of goats in different times of the year.

In this study, it was observed that households who reside close to *A. karroo* encroached areas such as the Nkonkobe community owned many goats as compared to those in open grassland in Mbhashe community. This can be attributed to the available of feed in the form of browse which in turn will improve the nutritional status of these goats especially during the cool-dry and hot-dry seasons leading to better growth and reproductive performances. In the current study it was also observed that adult females often comprised slightly above half of the herd size and these findings agrees with Chikagwa-Malunga and Banda (2006), Dossa *et al*. (2007) and Rumosa Gwaze *et al*. (2010), who accredited this to the fact that farmers retained breeding females while they sell and/or slaughter castrates.

Ahmadu and Lovelace (2002) also reported that high proportion of breeding does can boost growth of overall herd size through improved births if there are no other factors limiting reproduction. Bucks and castrate constituted about 30% of both herd sizes which is different to findings of Ahmadu and Lovelace (2002) in Zambia who reported 20% for all male goats kept under traditional management. Average buck/doe ratio of 1:25 to 30 which was observed

in the current study is in agreement with that reported by Wilson and Durkin (1988) and Rumosa Gwaze *et al*. (2010). However, high buck/doe ratios did not correspond with high kid/doe ratios as observed by Rumosa Gwaze *et al*. (2010). This suggests that availability of bucks in communal systems does not necessarily translate to improved reproductive capacity of does. Reasons could be fertility and distribution of those bucks in a traditional set up in order to increase mating chances of bucks in communal grazing lands. In addition, low kid/doe ratio could be attributed to low plane of nutrition especially during the dry season. Therefore it is advisable for resource-limited small scale communal farmers without bucks to either borrow the buck or mingle their goats those with reproductively sound bucks in communal grazing land.

The predomination of births as main constituency of total entries on herds agrees with the results reported for cattle by Ezanno (2005). The low herd sizes during cool-dry season in open grassland communities can be attributed to mortality and sales triggered by reduced feed since CP in cool-dry season can be as low as 2% in the grasses in sweet rangelands (Lesoli, 2008). Low goat entries during cool dry and hot-wet seasons mainly in open grassland community can be attributed to the fact that during those months, forage quantity and quality are low (Peacock *et al*., 2005) and coincide with periods of reduced kidding. Supplementation of goats with high quality forages such as *A. karroo* leaf meal during these seasons can increase number of births as well as likelihood of survival of kids born.

4.3.2 Body weights and condition scores

The growth and reproductive performances of goats in Nkonkobe community were significantly higher as compared to goats in Mbhashe. This ability to retain productivity is due to nutritional balance in the diet of the animal (Ngambu *et al*., 2013). *Acacia karroo* is known for its high nutritive value (Marume *et al*., 2012; Ngambu *et al*., 2013; Ngongoni *et al*., 2007). The goats owned by communal farmers who reside in *A. karroo* encroached areas

improved due to adequate amounts of protein in the browse species (Ngongoni *et al*., 2007). Findings in the current study in agreement with studies done by Mellink and Martin (2001), Mapiye *et al*.(2009) and Mapiliyao *et al*. (2012), who reported that a curve-linear relationship exist between feed supply and animal performance in the arid and semi-arid areas.

Goats in *A. karroo* dominated communal grazing lands such as Nkonkobe community compensate feed shortage from post-rainy to hot-dry season. According to Barnes *et al*. (1996) *A. karroo* tree usually have some leaves on branches at all times of the year, even during periods of drought. During this period in open grassland such as Mbhashe community, common grass species such as *Themeda trianda, Cymbopogon plurinodis* (Danckwerts *et al*., 1985) are dormant, and then grows with emergence of new shoots in hot-dry season, and the establishment of plants the following hot-wet season. For this reason goats on these rangelands are likely not going to perform to expectation especially if the highly nutritious browse species are either unavailable or available but in low quantities (Mapiye *et al*., 2009; Mapiliyao *et al*., 2012; Rumosa Gwaze *et al*., 2009c).

According to Mapiliyao *et al*. (2012), body weight and body condition score is traditionally used to assess nutritional status of animals. Among growing goats which were selected and monitored in all communities, those in *A. karroo* encroached areas had an ADG and BCS higher as compared to those in open grassland probably due to availability of browse species specifically *A. karroo* tree which remain relatively nutritious and palatable throughout the year (Nyamukanza and Scogings 2008). Goats in Mbhashe began to lose BCS in post-rainy season possibly due to decreasing quality of grazing after flowering in the post-rainy season. The Mbhashe veld type is known as the sour veld which declines in nutritional quality post-rainy season.

The high BCS observed in goats in *A. karroo* relative to open grassland could be attributed to the differences in availability and quality of feed during the times of stress. The variation in the growth rate among goats in communities could be due to other factors which were not controlled which also concurs with previous studies that compared performance of sheep (Mukasa-Mugerwa *et al*., 2000; Mapiliyao *et al.*, 2012), goats (Rumosa Gwaze *et al*., 2009a) and cattle (Mapiye *et al*., 2009). According to Ebangi *et al*. (1996), the higher weight gain in male animals relative to females could be due to hormonal difference in their endocrinological and physiological functions.

Many external parasites such as ticks and internal parasites are more active during the hot-wet season. The slight decline in BCS and ADG in Mbhashe communitiy during hot-wet season could have been caused by diseases such as anaplasmosis and cowdriosis in view of the fact that these are the main diseases affecting goats in the Eastern Cape (Masika and Mafu 2004; Rumosa Gwaze *et al*. 2009a). Kahiya *et al*. (2003) investigated the effects of *A. nilotica* and *A. karoo* diets on experimentally infected goats using *Haemonchus contortus*. It was concluded that worm burdens were significantly reduced in the faecal egg counts of goats fed with *A. karroo*.

Growth and health of goats is usually negatively affected by coccidiosis which is associated with higher worm loads in the hot-wet and post-rainy seasons than cool-dry and hot-dry seasons (Rumosa Gwaze *et al*. 2009b). The reasons for increase in ADG and reduced kid mortality in communal grazing lands which are encroached by *A. karroo* tree such as Nkonkobe community during hot-wet months could be due to the antihelminthic properties of condensed tannins found in *A. karroo* leaf browsed by goats.

Nyamukanza and Scogings (2008) observed that goats fed *A. karroo* coppices had higher ADG compared to those fed commercial pellets consequently attributed that it was due to the

high CP content of *A. karroo* leaves. In the sweet rangelands, which are characterized by natural browse such as *A. karroo* with CP content of approximately 20%, there is not much variation in the protein content of feed across the seasons (Peacock *et al*., 2005). Goats are able to tolerate the phenolic compounds in *A. karroo* tree does and utilize the available nutrients (Nyamukanza and Scogings, 2008).

4.3.3 Goat exits and entries

High births which were experienced during hot-dry season especially in Nkonkobe could be the reason for higher kid mortality experienced at same time due to susceptibility of newly born kids to vagaries of weather (Rumosa Gwaze *et al*., 2010). The higher kid mortality in small herds than in large herd might be due to owners of small herds either lacking money for medication, good housing and possibly inbreeding due to lack of knowledge and capital to purchase new breeding stock (Homann *et al*., 2007). There was no investigation on actual causes of these kid mortalities. The high mortality observed in the hot-wet months can be attributed to warm and moist conditions, which promote vector survival and multiplication (Marufu *et al*., 2010).

The observation that communal farmers with small goat herd sizes in all communities had higher mortality, confirms that high mortality rates severely restrict resource-limited farmers from obtaining higher benefits from goats. Capital mobilisation for programs such as Nguni cattle project is needed to assist these farmers who cannot build up their herds (Rumosa Gwaze *et al*., 2009a; Mapiliyao *et al*., 2012) to sustainable herd sizes. Slaughter and sale of goats mainly occurred during hot-wet season which coincide with festive and ceremonial months of the year (November to February) reaffirming the importance of goats in ceremonies and festival, especially rite of passage for boys. This was also reported by Masika and Mafu (2004) and Rumosa Gwaze *et al*. (2009a).

According to Rumosa Gwaze *et al*. (2010), when there is an urgent need for cash such as school fees and uniforms in January, the communal farmers sell their goats. This also confirms the role of goats in resource-limited communal farmers as a source of income. In all communities, slaughter and sale of goats during the post-rainy season coincided with Easter celebrations. These finding concur with Coetzee *et al*. (2005), Montshwe, (2005), Delali *et al*. (2006), who reported a similar trend for cattle and Mapiliyao *et al*. (2012), for sheep.

4.3.4 Goat production potential and efficiency

In all communities, the GPE was very low as compared to the GPP. However, the GPE was different for the two communities indicating that a higher number of mature and growing goats were being sold by farmers in Nkonkobe relative to Mbhashe. The GPE was perhaps depressed by the effects of sales, slaughter, births and mortality on goat herd size dynamics. The observation that season, herd size and communal grazing land did not affect GPE possibly suggests that the latter is not a good indicator of goat productivity in a communal set-up (Mapiye *et al*., 2009).

The highest GPE value recorded in the cool-dry season in Mbhashe could imply high sales and slaughter that occurred in that season. The observed higher total exits and GPE in the Mbhashe compared to Nkonkobe might mean that farmers in the Mbhashe slaughtered and/or sold more goats relative to their herd sizes to reduce the risk of mortality through starvation.

Under communal low-input production systems in rural areas, young animals are rarely purchased, sold or slaughtered because they are highly susceptible to extreme weather, draughts, diseases and parasites (Chiduwa *et al*., 2008; Mapiye *et al*., 2009). The low GPE could be due to other significant functions of communal goats such as manure and milk which are not incorporated in the current GPE formulae. In a multipurpose livelihood system set up such as Eastern Cape rural areas, absence of other goat functions in the current GPE

formula potentially results in significant underestimation of their contribution to livelihoods (Delali *et al*., 2006).

4.4 Conclusion

Goats which browsed *A. karroo* largely performed better in both growth and reproduction in relative to those which grazed in open grassland especially during the cool-dry season. In view of the fact that *A. karroo* tree is highly abundant, extremely adaptable to several environmental conditions and preferred by goats across seasons, it is advisable to resource-limited communal farmers to harvest and supplement their goats with *A. karroo*. However, low GPE values reported especially for Nkonkobe did not signify that goats are unimportant but that the farmers were keeping goats for other purposes other than slaughtering and selling. It is important that appropriate interventions be recommended to farmers to increase efficiency of goat production with follow-ups to assess the impact of the interventions.

4.5 References

Acocks, J.P.H. 1975**.** Veld types of South Africa. *Memoirs of the Botanical survey of South Africa*. 2nd Edition. South Africa, 40: 1–128

Ahmadu, B. and **Lovelace, C.E.A**. 2002. Production characteristics of local Zambian goats

Anderson, S. 2003. Animal genetic resources and sustainable livelihoods. *Ecological Economics* 45 (3): 31–339

Angassa, A. and **Oba, G**. 2007. Relating long-term rainfall variability to cattle population dynamics in communal rangelands and a government ranch in southern Ethiopia. *Agricultural Systems*, 94: 715–725

Antonelli, A.C., Mori, C.S., Soares, P.C., Kitamara, S.S. and **Ortalani, E.L.** 2004. Experimental ammonia poisoning in cattle fed extruded or prilled urea: clinical findings. *Brazilian Journal of Veterinary Research and Animal Science*, 41: 67–74

Bakare, A.G. and Chimonyo, M. 2011. Seasonal variation in time spent foraging by indigenous goat genotypes in a semi-arid rangeland in South Africa. *Livestock Science*, 135 (2-3): 251–256

Barnes, R.D., Filer, D.L. and **Milton S.J.** 1996. *Acacia karroo*: monograph and annotated bibliography. *Tropical Forestry Papers No. 32. Oxford Forestry Institute*, UK: Oxford University Press: United Kingdom

Basha, N.A.D., Scogings, P.F., Dziba, L.E. and Nsahlai, I.V. 2012**.** Diet selection of Nguni goats in relation to season, chemistry and physical properties of browse in sub-humid subtropical savanna. *Small Ruminant Research*, 102(2–3): 163-171

Chiduwa, G., Chimonyo, M., Halimani, T.E., Chisambara, S.R. and **Dzama, K**. 2008. Herd dynamics and contribution of indigenous pigs to the livelihoods of rural farmers in a semi-arid area of Zimbabwe. *Tropical Animal Health and Production*, 37: 333–344

Chikagwa-Malunga, S.K. and **Banda, J.W**. 2006. Productivity and survival ability of goats in smallholder crop/livestock farming systems in Malawi. *Livestock Research for Rural Development*, 18(7): 37-49

Coetzee, L., Montshwe, B.D. and **Jooste, A.** 2005. The marketing of Livestock on communal lands in the Eastern Cape Province: constraints, challenges and implications for the extension services. *South African Journal of Agricultural Extension*, 34 (1): 81–103

Danckwerts, I. E., Aucamp, A.I. and **Barnard, H.I.** 1985. Forage Production of some Grass Species in False Thornveld of the Eastern Cape. *Journal of Grassland Society of Southern Africa*, 2 (4): 31-34

Delali, B.K., Dovie, D.B.K., Charli, M., Shackleton, C.M. and **Witkowski**, **E.T.F**. 2006. Valuation of communal area livestock benefits, rural livelihoods and related policy issues. *Land Use Policy*, 23: 260–271.

Ebangi, L., Nwakalor, L.N., Mbah, D.A. and **Abbah, D**. 1996. Factors affecting the birth weight and the neonatal mortality of Massa and Fulbe sheep breeds in a hot and dry environment. *Cameroon. Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux* 49: 39–353

Ellery, W.N., Scholes, R.J. and **Scholes, M.C**. 1995. The distribution of sweetveld in South Africa's grassland biome in relation to environmental factors. *African Journal of Range and Forage Science*, 12: 38–45

Ezanno, P. 2005. Dynamics of a tropical cattle herd in a variable environment: a modelling approach in order to identify the target period and animals on which concentrating management efforts to improve productivity. *Ecological Modelling*, 188 (2–4): 470–482

Gebregiorgis, F., Negesse, T. and **Nurfeta, A**. 2011. Feed intake and utilization in sheep fed graded levels of dried moringa (Moringa stenopetala) leaf as a supplement to Rhodes grass hay. *Tropical Animal Health and Production*, 12: 112-123.

Homann, S., Van Rooyen, A., Moyo, T. and **Nengomasha**, Z. 2007. Goat production and marketing: Baseline information for semiarid Zimbabwe. Bulawayo. *Zimbabwe: International Crops Research Institute for the semi-arid tropics*, 84: 312-26

Kahiya, C., Mukaratirwa, S. and **Thamsborg, S.M**. 2003. Effects of *Acacia nilotica* and *Acacia karroo* diets on Haemonchus contortus infection in goats. *Veterinary Parasitology*, 115(3): 265-74

Kgosikoma, O.E. 2006. Effects of climate variability on livestock population dynamics and community drought management in Kgalagadi, Botswana. *MSc thesis, Department of International Environment and Development Studies,* Norwegian University of Life Sciences, Norway: 11–56.

Lesoli, M.S. 2008. *Vegetation and Soil Status and Human Perceptions on the Condition of Communal Rangelands of the Eastern Cape, South Africa*. MSc Thesis, University of Fort Hare, South Africa

Mapiliyao L., Pepe, D., Marume, U. and **Muchenje, V.** 2012. Flock dynamics, body condition and weight variation in sheep in two ecologically different resource-poor communal farming systems. *Small Ruminant Reseach*, (104): 45– 54

Mapiye, C., Chimonyo, M. and **Dzama, K.** 2009. Seasonal dynamics, production potential and efficiency of cattle in the sweet and sour communal rangelands in South Africa. *Journal of Arid Environment*, 73: 529–536

Marufu, M.C., Chimonyo, M., Dzama, K. and **Mapiye, C.** 2010. Sero-prevalence of tick-borne diseases in communal cattle reared on sweet and sour rangelands in semi-arid area of South Africa. *The Veterinary Journal*, 184: 71–76

Marume, U., Chimonyo, M. and **Dzama, K**. 2012. Influence of dietary supplementation with Acacia karroo on experimental haemonchosis in indigenous Xhosa lop-eared goats of South Africa. *Livestock Science*, 144: 132–139

Masika P.J. and Mafu **J.V**. 2004. Aspects of goat farming in the communal farming systems of the central Eastern Cape, South Africa. *Small Ruminant Research*, 52 (1-2): 161-164

Masika P.J., Mafu, J.V., Goqwana M.W., Mbuti, C. and **Raats, J.G.** 1998. A comparison of goat growth performance in a communal and commercial farming system in the Central Eastern Cape Province, South Africa. Paper presented at the *Research and Training Strategies for Goat Production Systems in South Africa,* Kings Lodge, Hogsback Eastern Cape, South Africa: 22-26 November 1998

Mellink, E. and **Martin, P.S.** 2001. Mortality of cattle on a desert range: pale-obiological implications. *Journal of Arid Environment*, 49: 671–675

Mendieta-Araica, B., Sporndly, R., Reyes-Sanchez, N. and **Sporndly, E**. 2011. Moringa (Moringa oleifera) leaf meal as a source of protein in locally produced concentrates for dairy cows fed low protein diets in tropical areas. *Livestock Science*, 137: 10–17

Montshwe, B.D. 2005. *Factors Affecting participation in mainstream cattle markets by small scale cattle farmers in South Africa*. M.Sc. Thesis, Department of Agricultural Economics, University of Free State, South Africa: 1–20

Moyo , B., Masika, P.J. and **Muchenje, V**. 2013. Effect of supplementing crossbred Xhosa lob-eared goat castrates with Morenga Oleifera leaves on growth performance, carcass and non-carcass characteristics. *Tropical Animal Health and Production*, 11: 970-978

Mukasa-Mugerwa, E., Lahlou-Kassi, A., Anindo, D., Rege, J.E.O., Tembely, S., Markos, T. and **Baker, R.L**. 2000. Between and within breed variation in lamb survival and the risk factors associated with major causes of mortality in Indigenous Horro and Menz sheep in Ethiopia. *Small Ruminant Research*, 37: 1–12

Mupangwa J.F. 1996. Pasture seed production of promising grasses and legumes at Domboshawa, Zimbabwe, **Ndikumana J.** and **de Leeuw**, **L**. Sustainable Feed Production and Utilization of Smallholder Livestock Enterprises in Sub-Saharan Africa. *Proceedings of the Second African Feed Resources Network (AFRNET), Harare, Zimbabwe, 6–10 December 1993.* African Feed Resources Network Nairobi, Kenya: 201

Ndemanisho, E.E., Kimoro, B.N., Mtengeti, E.J. and **Muhikambele, V.R.M.** 2006. The Potential of *Albizia lebbek* as a supplementary feed for goats in Tanzania. *Agroforestry System*, 16: 85-91

Ngambu, S., Muchenje, V. and **Marume, U**. 2013. Colour and Cooking Losses of Meat from Indigenous Xhosa Lob-eared Goats. *Asian-Australian Journal of Animal Science*, 1: 128-132

Ngongoni, N.T., Mapiye, C., Mwale, M. and **Mupeta, B**. 2007. Effect of supplementing a high-protein ram press sunflower cake concentrate on smallholder milk production in Zimbabwe. *Tropical Animal Health and Production*, 39: 297–307

Nsoso, S.J., Aganga, A.A., Moganetsi B.P. and **Tshwenyane** S.O. 2003. Body weight, body condition score and heart girth in indigenous Tswana goats during the dry and wet seasons in southeast Botswana. *Livestock Research for Rural Development*, 4: 15-29

Nyamukanza, C.C. and **Scogings, P.F.** 2008. Sprout selection and performance of goats fed *Acacia karroo* coppices in the False Thornveld of the Eastern Cape. *South African Journal of Animal Science*, 2: 38-46

Oni, A.O., Arigbede, O.M., Oni, O.O., Onwuka, C.F.I., Anele, U.Y., Oduguwa, B.O. and **Yusuf, K.O**. 2010. Effects of feeding levels of dried cassava leaves (Manihot esculenta, Crantz) based concentrates with Panicum maximum basal on the performance of growing West African Dwarf goats. *Livestock Science*, 129: 24–30

Palmer, A.R. and **Ainslie, A.** 2006. Using rain-use efficiency to explore livestock production trends in rangelands. *African Journal of Range and Forage Science*, 24(1): 43–50

Peacock, C., Devendra, C., Ahuya, C., Roets, M., Hossain, M. and **Osafo, E**. 2005. Livestock and Wealth Creation: Improving the Husbandry of Animals Kept by Resource–Poor People in Developing Countries. In: **Kitalyi, O.E., Jayasuriya, A., Smith, T.N**. Edition. *Nottingham University Press*, Nottingham, United Kingdom: 361–385

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K**. 2009a. Variation in the functions of village goats in Zimbabwe and South Africa. *Tropical Animal Health and Production*, 41: 1383–1391

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K**. 2009b. Prevalence and loads of gastrointestinal parasites of goats in the communal areas of the Eastern Cape Province of South Africa. *Small Ruminant Research,* 84: 132–134

Rumosa Gwaze, F., Chimonyo, M. and **Dzama, K**. 2010. Estimation of goat production potential and efficiency in the resource-poor communal areas of the Eastern Cape Province of South Africa. *Tropical Animal Health and Production,* 42: 1235–1242

Rumosa-Gwaze, F., Chimonyo, M and **Dzama, K**. 2009c. Communal goat production in Southern Africa. *Tropical Animal Health and Production*, 41: 1157–1168

Safari, J., Mushi, D.E., Mtenga, L.A., Kifaro, G.C. and **Eik, L.O.** 2009. Effects of concentrate supplementation on carcass and meat quality attributes of feedlot finished Small East African goats. *Livestock Science*, 125: 266‑274

Sanon, H.O., Kabore-Zoungrana, C. and **Ledin, I**. 2008. Growth and carcass characteristics of male Sahelian goats fed leaves or pods of *Pterocarpus lucens* or *Acacia Senegal*. *Livestock Science*, 117: 192–202

Scogings, P.F. and **Mopipi, K**. 2008. Effects of water, grass and N on responses of *Acacia karroo* seedlings to early wet season simulated browsing: Aboveground growth and biomass allocation. *Journal of Arid Environments*, 72: 509–522

Simela, L. and **Merkel**, **R.** 2008. The contribution of chevon from Africa to global meat production. *Meat Science*, 80: 101–109

Statistical Analysis Software (SAS) STAT® 9.22 User's Guide. 2010. SAS Institute Inc;Cary, NC, USA

Tracy, B.F., Renne, J.I., Gerrish, J. and **Sanderson, M.A**. 2004. Effects of plant diversity on invasion of weed species in experimental pasture communities. *Basic and Applied Ecology*, 5: 543—550

Webb, E.C. and **Mamabolo, M.J**. 2005. Production and Reproduction characteristics of southern African Indigenous Goats in Communal Farming Systems. *South African Journal of Animal Science*, 18: 34-47

Wilson, R.T. and **Durkin, J.W**. 1988. Small ruminant production in central Mali: reproductive performance in traditionally managed goats and sheep. *Livestock Production Science*, 19: 523–529

Xhomfulana, V., Mapiye, C., Chimonyo, M. and **Marufu, M.C.** 2009. Supplements containing *Acacia karroo* foliage reduce nematode burdens in Nguni and crossbred cattle. *Animal Production Science*, 49(8): 646–653

Yayneshet, T., Eik, L.O. and **Moe, S.R**. 2008. Feeding Acacia Etbaica and Dichrostachys cinerea fruits to smallholder goats in Northern Ethiopia improves their performance during the dry season. *Livestock Science*, 119: 31–41

Chapter 5: General discussion, conclusion and recommendations

5.0 General discussion

In rural areas of Eastern Cape Province, communal goat production is one of the most valuable livestock sector. However, there are several constrains limiting the productivity of these goats such as health, nutrition, kid mortality, gastro-intestinal worms and climate. In most cases, the livelihoods of resource-limited communal farmers usually depend on these goats. Due to lack of adequate resources, the production system for these communal farmers are undermined by several factors especially lack of nutritionally adequate forage during the dry season.

It has been reported that *A. karroo* tree is the dominant invading species in the False Thornveld of Eastern Cape and it is an ecological threat (Nyamukanza and Scogings, 2008). In addition, several researchers have reported that *A. karroo* leaves improve meat quality (Kaitho, 1997; Mapiye *et al*., 2010; Ngambu *et al*., 2013) and reduce nematode burden in goats (Kaitho, 1997; Kahiya *et al*., 2003; Xhomfulana *et al*., 2009). In Eastern Cape, *A. karroo* trees have been reported to be a valuable source of forage for herbivores, particularly during dry periods (Aganga *et al*., 2000; Dube *et al*., 2001; Tefera *et al*., 2008). However, there is no substantial research on effect of *A. karroo* trees on *in situ* communal goat performance in the False Thornveld of Eastern Cape.

In Chapter 3, the study monitored different goat herd sizes browsing in *A. karroo* encroached communal grazing lands versus those grazing in open grasslands. It was observed that communal farmers in *A. karroo* encroached areas had significantly more goats than those in open grasslands. This can be supported by results tabled which indicate that those farmers in open grassland were selling and/or slaughtering their goats during the cool-dry period as compared to those in *A. karroo* encroached areas. The BCS and ADG of goats in *A. karroo* encroached areas were considerably higher than those in open grassland especially during the

hot-dry and cool-dry seasons. The results provide evidence that goats residing in *A. karroo* encroached areas perform better than those in open grasslands. This is mainly because goats are more of browsers than grazers. The high CP observed in *A. karroo* leaves especially during the hot-wet season improve the nutrition of communal goats. This consequently increase improve the reproductive and growth performance of these goats. The anthelmintic properties of *A. karroo* leave reduce the nematode burden. This may in turn improve BCS, ADG as well as reduce kid mortalities and incidences of intestinal diseases such as colibacillosis in goats. Generally, communal farmers with large herd had higher GPE compared to those with small herds mainly because of the communal farmers with larger herds had a greater number of goats to dispose than those with few goats.

In the False Thornveld of Eastern Cape, *A. karroo* density continuously increases to approximately 900 trees/ha, which can yield up to 1000 kg/ha/annum of leaf material. Resource-limited farmers can harvest *A. karroo* leaf meal to supplement their goats. Since *A. karroo* tree is adapted and widely distributed in dry areas, easily propagated from seed (Scogings and Mopipi, 2008), has high growth rates and coppicing ability (Barnes *et al*., 1996), it is possible to get sufficient and continuous supply of leaf meal for sustainable communal goat production in Eastern Cape.

Many researchers reported the use of *A. karroo* leaf meal as a protein supplement in their experiments. However, there are few studies if any on the variation of nutrient contents in *A. karroo* browse trees in False Thornveld of Eastern Cape. In Chapter 4, it was observed that *A. karroo* contained above 110 CP g/kg of DM per kg across all seasons of the year. This maintain low to medium goat production. The observed CP levels across the seasons were within the 110 to 160 g/kg DM which are optimum for goat production (NRC, 2000; Gleghorn *et al*., 2004).

The levels of ADF, NDF, total lipids, condensed tannins and phenolic substances in *A. karroo* browse trees across all seasons of the year observed in the current study are consistent with what has been reported in other studies (Kahiya *et al*., 2003; Xhomfulana *et al*., 2009; Mapiye *et al*., 2010). The levels of condensed tannins across all seasons were higher than reported for other Acacia species such as *A. tortilis and A. nilotica* (Aganga *et al*., 2000; Abdulrazak *et al*., 2000; Tefera *et al*., 2008). However, goats can be able to utilize *A. karroo* leaves due to their saliva which contain proline-rich protein.

In Chapter 4 of the current study, it was also observed that the contents of mineral elements in *A. karroo* browse trees are considerably high during the cool-dry period. The concentration of Ca, P and Mg in *A. karroo* browse trees is comparatively throughout the season than recommended levels for beef cattle (NRC, 2000). The *A. karroo* browse trees also contain significant amount of trace minerals which are essential for livestock production. Iron was the most abundant trace mineral than other trace minerals. However, the variation of these minerals in *A. karroo* can be attributed to, soil, climate, season, stage of growth and browsing pressure.

5.1 Conclusion

In the current study, it was observed that *A. karroo* tree has potential to improve the nutrition of communal goats. The goat herds which browse *A. karroo* browse tree in the communal browsing areas performed better in herd growth, births and mortalities than those in open grasslands. *Acacia karroo* relatively maintained its nutritional status throughout the year. Except for the content of condensed tannins, nutritional content of *A. karroo* tree are within the recommended ranges for productivity many livestock species. Given that *A. karroo* trees are highly abundant in the False Thornveld of Eastern Cape, resource-limited communal farmers can harvest *A. karroo* leaves during the hot-wet season when the nutritional value for *A. karroo* leaves is high.

5.2 Recommendations

In this study, since goats browsing *A. karroo* encroached communal grazing lands performed better than open grassland, therefore, it is recommended that communal farmers residing in *A. karroo* encroached areas increase their goat herd sizes. During the hot-wet season, the level of CP will be higher and the CT lower, therefore; it is advisable for resource-limited communal goat producers to harvest the *A. karroo* leaves during summer in order to supplement their goats during the cool-dry season. Repeated chemical analyses for *A. karroo* leaves are recommended before *A. karroo* can be safely used by feed manufacturers.

5.3 References

Abdulrazak, S.A., Nyangaga, J. and **Fujihara, T**. 2001. Relative palatability to sheep of browse species, there *in sacco* degradability and *in vitro* gas production characteristics. *Asian-Australasian Journal of Animal Sciences*, 1: 1580-1584

Aganga, A.A., Adogla-Bessa, T., Omphile, U.J. and **Tshireletso, K**. 2000. Significance of browses in the nutrition of Tswana goats. *Archivos de Zootecnia*, 49: 469–480

Barnes, R.D., Filer, D.L. and **Milton S.J.** 1996. *Acacia karroo*: monograph and annotated bibliography. *Tropical Forestry Papers No. 32. Oxford Forestry Institute*, UK: Oxford University Press, USA.

Dube, J.S., Reed, J.D. and **Ndlovu, L.R**. 2001. Proanthocyanidins and related phenolics in Acacia leaves of Southern Africa. *Animal Feed Science and Technology*, 91: 59–67

Gleghorn, J.F., Elam, N.A., Galyean, M.L., Duff, G.C., Cole, N.A. and **Rivera, J.D**. 2004. Effects of crude protein concentration and degradability on performance, carcass characteristics, and serum urea nitrogen concentrations in finishing beef steers. *Journal of Animal Science*, 82: 2705-2717

Kahiya, C., Mukaratirwa, S. and **Thamsborg, S.M**. 2003. Effects of *Acacia nilotica* and *Acacia karroo* diets on *Haemonchus contortus* infection in goats. *Veterinary Parasitology*, 115(3): 265-74

Kaitho R.J. 1997. *Nutritive value of browses as protein supplement(s) to poor quality roughage*. PhD Thesis, Department of Animal Nutrition, Wageningen Agricultural University, Wageningen , Netherlands.

Mapiye, C., Chimonyo, M., Marufu, M.C. and **Dzama, K**. 2010. Utility of *Acacia karroo* for beef production in Southern African smallholder farming systems: A review. *Animal Feed Science and Technology*, 164 (3-4):135–146

National Research Council (NRC), 2000. *Nutrient Requirements of Beef Cattle*. 7th revised Edition, National Academy Press, Washington, DC, USA

Ngambu, S., Muchenje, V. and **Marume**, **U.** 2013. Effect of *Acacia karroo* Supplementation on Growth, Ultimate pH, Colour and Cooking Losses of Meat from Indigenous Xhosa Lop-eared Goats. .*Asian-Australasian Journal of Animal Science*, 26(1): 128–133

Ngwa, A.T., Nsahlai, I.V. and **Bonsi, M.L.K.** 2002. The rumen digestion of dry matter, nitrogen and cell wall constituents of the pods of *Leucaena leucocephala* and some Acacia species. *Journal of the Science of Food and Agriculture*, 82: 98–106

Nyamukanza, C.C. and **Scogings, P.F.** 2008. Sprout selection and performance of goats fed *Acacia karroo* coppices in the False Thornveld of the Eastern Cape. S*outh African Journal of Animal Science*, 2: 38- 46

Scogings, P.F., and **Mopipi, K**. 2008. Effects of water, grass and N on responses of Acacia karroo seedlings to early wet season stimulated browsing: leaf N, fibre and tannin concentrations. *Journal of Arid Environments*, 72: 1666–1674

Tefera, S., Mlambo, V., Dlamini, B.J., Dlamini, A.M., Koralagama, K.D.N. and **Mould, F.L.** 2008. Chemical composition and *in vitro* ruminal fermentation of common tree forages in the semi-arid rangelands of Swaziland. *Animal Feed Science and Technology*, 42: 99–110

Xhomfulana, V., Mapiye, C., Chimonyo, M., and **Marufu, M. C.** 2009. Supplements containing *Acacia karroo* foliage reduce nematode burdens in Nguni and crossbred cattle. *Animal Production Science*, 49 (8): 646–653