Livestock Ownership by Gender and Seasonal Impact on Production: A case study in Msinga Municipality

BY

Adeyemo Adetoyese Adesoji Babajide

B. Tech Hons (Animal Production & Health)

Submitted in fulfillment of the requirement of the degree of Master of Science In Agriculture

Discipline of Animal & Poultry Science

College of Agriculture, Engineering and Science

School of Agriculture, Earth and Environmental Sciences

University of KwaZulu-Natal

Pietermaritzburg

South Africa

2015

Supervisor: Professor Nsahlai Ignatius Verla

Declaration

The investigation work present in this thesis was carried out at the University of KwaZulu-Natal, Pietermaritzburg campus and the field work were done in the Msinga Local Municipality, an administrative area in the Umzinyathi District of KwaZulu-Natal in South Africa. The research was carried out according to UKZN animal ethics policy (Reference: 122/312/Animal). The study was supervised by Professor Ignatius V. Nsahlai.

This is to declare that this thesis represents original work done by myself and have not been submitted in any previous application for a degree. All sources of information are shown in the text and listed in the reference and all assistance by others has been duly acknowledged.

Adeyemo Adetoyese Adesoji Babajide

University of KwaZulu-Natal

Pietermaritzburg Campus

Signed……

I declare that the above statement is correct.

Supervisor : Prof. Nsahlai Ignatius Verla

Signed:……..

Dedication

To God of Abraham, God Isaac and God of Isreal who ruleth in the affairs of men, my God gifts and sweet mother Mojirayo Grace Adeyemo who always be at my right hand, my mother queen late Mrs Adedotun Adedunsi Modupeola Alimi-Adeniyi (Nee-Adeyemo) who believed in and strengthen me with her courage always, my siblings Adeniran Opeyemi Jacob Adeyemo and Adetokunbo Makanjuola Adeyanju Adeyemo who have supported me emotionally, my nephews who sacrifice their precious time to leave them at the time they need me most.

Acknowledgement

I thank God for His mercy and grace throughout the time of this study, especially sound health, protection, provisions and preservation. I travelled a lot on road and by air either for data collection or conference presentation. I thank Him for Journey mercies, divine provision and protection all through the study.

I also appreciate my parent and siblings (Enrg Moses Adeyemo, Grace Mojirayo Adeyemo, Adeniran Adeyemo, Adetokunbo Adeyemo) whom God had used to be a source of provision, encouragement and emotional support. I do celebrate all my friends and lover friends who counted me worthy to come on the love platform with me despite the distance. I appreciate their concerns, care, kindness, emotional support, sweet words, phone kisses and hugs.

In patience and your constructive sources of ideas and resources, my humble supervisor Prof. Ignatius V. Nsahlai (University of KwaZulu-Natal), I say thank you, Sir. Your academic guidance, assistance and commitment throughout the study cannot be quantified.

Am extending my gratitude to staff and colleagues of the department of Animal & Poultry Science; for their contribution, and assistance in one way or the other (laboratory work and consultations).

My appreciation also goes to the Water Research Commission who admitted me into the project research team titled “Analysis of good value chain in rain-fed and irrigated agriculture to include emerging farmers in the mainstream of the economy” under Water Research commission Project Number K5/1879/4. In respect to this, some of the information in the project (chapter three) is also contained in some specific deliverable reports submitted to Water research Commission between 2013 and 2014 through the Institute of Natural

Resources (INR) in KwaZulu-Natal. I also acknowledged their financial support for this project through Institute of Natural Reseouces.

My sincere thanks also goes to Brigid Letty (Instutite of Natural Resources) who counted me worthy and incorporated into Water Research Commission project. I will not forget to thank Mrs. Briget Letty (Institute of Natural Resources), who admitted me into the Water Resource Commission Project. This project provided the funding required for the field work research projects. Thank you for your assistance in logistics and planning during my data collection, Msinag Auction programe and Farmers Day Organization. Thank you for time and effort in reviewing my manuscripts, inputs on data collection and other functions such as hiring of vehicles, telephones, and stationery. I also appreciate all project team members: co-authors (Muchara, B., McCosh Jon., Steven Arowolo), contributors (E. Wale, G. F. Ortmann, A. Obi, Z. Nxele1, P. J. Masika, M. Mudhara, A. Parry and A. Modi), reference group (Dr G. R. Backeberg, Dr A. J. Sanewe, Dr S. Mpandeli, Prof B. Grové, Prof N. Mbatha, Prof. T. E. Kleynhans, Dr S. Gqangweni, Prof. A. Jooste, Dr E. Wale, Prof. G. F. Ortmann) for their time and effort to read the writeup over and over again without tiredness.

I appreciate my team of numerators and research assistants who helped during the questionaira data collections, interpreted in famers meetings in IsiZulu, walked up and down mountains collecting feace samples of goats and cattle.

I cannot end this page without not saying a word of appreciation to all Agricultural Extention Workers from Department of Agriculture and Deparment of Rural Developemnt and Land Reforms for connecting me with Msinga farmers association and organizing the Msinga Auctions together.

May God bless you all.

General Abstract

Research was conducted at Msinga Municipality focusing on identifying limiting factors on goat and cattle husbandry and evaluating the degree to which seasonal changes could affect goats and cattle production. Msinga municipality was chosen because it has a high potential to produce indigenous goats and cattle. Because of the latter, a project titled Msinga Goats Movers was established for the commercialization of Msinga goats and an auction marketing strategy was introduced to involve communities. Three communities were chosen for this study, namely: Nxamalala, Madulaneni and Ntanyana. The research was divided into two experimental chapters.

Chapter one evaluated ownership characteristics of goats and cattle by gender and how it contributes to livestock productivity and livestock value chain. This study also looked at challenges militating against the commercialization of goats and cattle. A survey of ninety (90) farmers was conducted to record the effect of goats and cattle ownership by gender in the municipality. A focus group discussion was held based on the livestock association that exists along the irrigation scheme. Questionnaire instrument was used to capture data and analysis was done using SAS 12th Edition. Data were sorted by gender of owner, and analysed using frequency and regression procedures. Observation revealed that male ownership is directly proportional to productivity while it is inversely proportional to livestock purpose, management practices and market values.

Households headed by male had higher number of cattle than those headed by female in the ratio 3:1 while a ratio was 2:1 in the number of goats. Gender ownership ratio between male and female is almost equal (37% to 30%). Cattle were used for cultural purposes (42 %), income (22%), prestige (18%), meat (12.5%) and milk (5%) purposes. Goats serve cultural (39%), prestige (30%), income (19%), meat (11.5%) and milk (2.5%) purposes. Farmers

pointed out that their livestock numbers increased due to reproduction (40%) and buying (30%). All respondents grazed livestock on communal land without due regard for watering. There was difference in gender ownership of poultry. About 70% mortality was due to diseases, water and feed shortage which militated against increased livestock productivity, followed by pilfering, dog attack and poor management practices. There is need for profit maximizing programs that will cause a perspective shift in the culture towards livestock farming with respect to feeding management, common diseases and breeding. Also, the establishment of pests and disease control, grazing lands and water availability for agricultural purposes will greatly improve production performance.

The first part of the second experimental protocols evaluated the livestock feeding behavioural responses and weight changes as influenced by different seasons. During each season (dry season, early wet season, and late wet season) a 48 hour observation was made on 8 goats and 6 cattle. This was followed by marker (Chromium, and Ytterbium) administration. Feacal samples were collected for marker analysis. Time spent on walking, grazing, resting, standing, combats and ruminating was recorded. Results revealed that animals spent more time walking, grazing and ruminating in dry season; in early wet season animals spent more time grazing, combats and ruminating. Live weight was lost and gained in dry and early wet season, respectively.

Cattle increased social-activities in dry and early wet season compared to late wet season because of pasture defoliation and temperature changes caused by season. The time cattle spent on standing/combating, walking and ruminating/resting were significantly different in dry/early wet seasons compared to late season ($P< 0.01$). The rate of cattle rumination and resting increased with seasonal changes ($P < 0.01$). Grazing and drinking were significantly affected by seasons ($P <0.05$). Ruminants tend to adjust their grazing behaviour to either early hour of the day or late in the evening at early wet season when the temperature is above

25^0C, such that it will not affect the daily intake rate. There were significant differences observed between cattle final weight and live weight loss in dry season, with lower values recorded in the late wet season. Seasonal impacts on goats standing and combating behaviour was significantly different ($P < 0.01$). Because the heat generated through fermentation is very low compared to required body temperature, so goats engaged in more activities to sustain cold temperature in dry season. Live weight gain of goats, especially in dry season was significantly affected ($P < 0.01$).

The second part of the second experimental protocols determined the particle passage rate in goats and cattle feeding on available and varied grasses, forbes and browses on pasture throughout the three seasons. Markers (Chromium and Ytterbium) were administered and faecal samples were collected at 0, 6, 12, 18, 24, 30, 36, 42, 48, 60, 72, 84, 96, 108, 120, 132, 146, 158 and 170 hours after administration, dried at 70^oC for three days, ashed at 550^oC and analyzed using Inductively Coupled Plasma Mass Spectrometry. Dry matter digestibility and gas production were done through the in vitro digestibility method. Rumen rate of passage of a particle was slow in drought areas and dry season because decreases in intake level. Passage rate and retention times vary in different seasons based on the quality of forage available to animal. Analysis reveals that passage rate was very high in late wet compared to dry and early wet season. Perhaps, this was associated with succulent and high moisture content of forages was available this season.

In late wet season, passage rate of particle was higher. Hind gut retention time of particle was differ in late wet compare to dry and early wet season. Because regrowth of pasture in late wet season stimulates animal grazing though the intake was not satisfactory in quantity of forage expected by the animal. Rumen retention time and hind gut retention time of particle in goats are higher than cattle. The types and quality of consumed forages and their dry matter digestibility (%) were different. This can be due to different ability of consumed

forage response to seasonal effects. There was live weight loss in dry season which was extended to early wet season i.e. livestock did not recovery from live weight, until wet season. There was significant different in the in vitro gas production in between at 6 hours and 44 hours. Seasonal means at early hours of in vitro gas production (6 hours) was significantly different; dry and early wet compared to late wet season. Comparing dry and early wet to late wet seasons at 44 hours revealed different in vitro gas production. This revealed the seasonal impact on rumen activity, ruminant behaviour and forage quality.

Key words: Gender, ownership, goats, cattle, behaviour and season.

Thesis Output

Published Article

- Muchara, B., Letty, B., McCosh, Jon., Arowolo, S. Adeyemo, A. J. (2015). Investigation of small-holder food value chains: Evidence from Eastern Cape and KwaZulu-Natal Provinces. WRC Report No. 1879/1/14. www.wrc.org.za.

Inprint Articles

- Adeyemo, A. J., Odunsi, A., Nsahlai, I. V., Chimoyo, M., (2014). Recycling of Poultry. International Conference on Agriculture and Biotechnology (ICABT 2014).

- Adeyemo, A. J., Brigid, Letty, Nsahlai, I. V., (2014). Influence of Gender Ownership of Livestock on Communal Farming System. 2nd International Conference on Emerging Trends in Agriculture, Horticulture and Environmental Engineering (ICETAHE2 2014).

Conference papers

- Adeyemo, A. J., Odunsi, A., Nsahlai, I. V., Chimoyo, M., (2014). Replacement value of blood meal with hatchery waste meal in poultry diets. (47th SASAS congress 2014)

- Adeyemo, A. J., Brigid, Letty, Nsahlai, I. V., (2014). Factors affecting goats and cattle production in the communal farming system of Kwazulu-Natal. (47th SASAS Congress, 2014).

- Adeyemo, A. J., Odunsi, A., Nsahlai, I. V., Chimoyo, M., (2014). Recycling of Poultry Waste into Diets. (ICABT 2014).

- Adeyemo, A. J., Brigid, Letty, Nsahlai, I. V., (2014). Influence of Gender Ownership of Livestock on Communal Farming System. (ICETAHE2 2014).

Symposium / workshops

- Adeyemo, A. J., Brigid, Letty, Nsahlai, I. V., (2014). Goats and cattle ownership and productivity (Use Natural Resources) in and around the irrigation scheme. (SASAS KZN Branch Research Symposium, 2013).

- Adeyemo, A. J. and Nsahlai, I. V., (2014). Seasonal impacts on livestock production and mitigating factors on irrigation scheme: A case study in Msinga, Kwazulu-Natal. (2013 Post Graduate Research Day, UKZN).

- Adeyemo, A. J., Brigid, Letty, Nsahlai, I. V., (2014). Ownership by Gender and Its Influence on Goats and Cattle Production among the Isi-Zulu Tribe of South Africa. (2014 Post Graduate Research Day, UKZN).

Table of Contents

List of Tables

List of Figures

Chapter 1

INTRODUCTION

Goats and cattle have been most fortunate domesticated animal among all. Man has found a successful relationship over a century with goats and cattle. Goats specifically had been found to play more major roles contributing to mankind over 7000 years (Nassif and Amiri, 2011). Over the years, livestock has contributed tremendously and particularly to the socio-economic aspect of man (for consumption, as companionship and production) being source of income and contribute more to the primary nutritional requirements of rural livelihood.

Devendra (1999) reported that Africa and Asia have 81% out of 674 million of world goat populations. Goats are mostly reared by all livestock farmers in Africa, (Peacork, 2005). Simela et al (2008) reported over 840 million head counts in Africa, due to rapid multiplication of goats in the last three decades; in which Donkin and Ramsay (2006), discovered that 29.2% is found in Africa. Records by the Department of Agriculture and Rural Development (2005), reported that 6,495 million goats of which consist of Boer goats, Savannah goats, Angora goats, Kalahari Red goats and much more are found in South Africa.

This prospect and continuous increase of goats and cattle suggest that there is a relationship between man (ownership) and livestock productivity. This direct interaction has a positive output on livestock. Livestock ownership contributes in different ways, such as owners purpose of rearing, ownership management practices, ownership cultural perspectives and beliefs towards livestock productivity. Livestock productivity in response to the effects of its ownership varies from animal to animal and these describe its economic value and influence to the food value chain. It varies from place to place based on different cultures.

1.1 Background

The interaction between ownership and livestock productivity has been reported in studies to have indirect and direct relationship with farmers (ownership) and livestock productivity (Okitoi et al., 2007). Effect of different seasons modifies livestock production especially ruminants because of the compartments process. Studies revealed various areas of direct relation of different seasons with ruminants; live weight change, carcass weight, intake (Thomton et al., 1985; Boudon et al., 2009), dry matter digestibility (Fox et al., 1988; Sam et al., 2003), feeding behaviour (Minson 1990; Mahrous et al., 2006), passage rate (Robles et al., 1981; Givens et al ., 2000), rate of digestion (Gasa et al., 1991), milk production (Bilik et al., 2012). Nutrition of livestock is a key component of a successful production system. Feed quality and quantity usually accounts for the single largest input cost associated with any livestock production. An understanding of livestock digestive process and basic nutrition is required by farmers (owners) for effective feeding and management practices. Ruminants have a large fluid filled digestive organ (Tom, 2010).

Roughages have been used as a collective term for a complex mixture of substances with different chemical and physical properties which exert different types of physiological effects (Mahrous et al., 2006). The use of certain analytical methods to quantify dietary fiber by nature of its indigestibility results in many other indigestible components being isolated along with the carbohydrate components of roughages (Orskov et al., 1998). These components include resistant starches and oligosaccharides along with other substances that exist within the plant cell structure and contribute to the material that passes through the digestive tract. Roughages quality and quantity are affected by seasons (Orskov et al., 1998).

Msinga Municipality is found in KwaZulu-Natal Province, South Africa. It is located in Southeast of South Africa at latitude 28^0 56' 31'' and longitudes 30^0 24' 47''. Due to the climate and weather conditions, most pastorals practice mixed farming system in all seasons.

Therefore this study focused on the differences and effect of livestock ownership on its productivity and socio-economical inputs, effect of different season on livestock body weight, feeding behaviour, quality and quantity of forages and digestibility of forages.

1.2 Problem Statement

We focused on the animal and animal products from production, marketing and utilization in respect to the food value chain. Feeding aspect of the livestock is a major factor to consider. Le Liboux and Peyroud (1991) reported that feeding has an impact on the rumen environment which automatically has either negative or positive influence on livestock's production.

Also, at what production stages do goats and cattle add value to the socio-economic life of the community? Then what are the available natural resources influencing the livestock production and the value chain of goats and cattle enterprises.

Furthermore, considering the areas with strong drought seasons, what are goats and cattle behavioural response and factors affecting livestock weight, bearing in mind the nutritional implications of quality and quantity of seasonal forages, and its impacts on digestibility?

1.3 Rationale

Adequate evaluation and study of productive value chains would bring positive change to the socio-economic life of the people and improve the health and production of livestock. The maximum productivity of natural resources towards animal production would enhance and lead to more owners wanting to sell, bringing about positive improvement to animal value chain. Understanding of seasonal effects would empower the small-scale farmers to

nutritionally manage their livestock at different seasons. Good quality roughages would be a good balanced diet for ruminants in terms of feed intake, degradation of roughages, limited gas production and its production.

1.4 Objectives

1.4.1 Main Objective:

- To determine the contribution and effects of livestock ownership and different seasons on goats and cattle productivity in Msinga Municipality of KwaZulu-Natal Province, South Africa.

1.4.2 Specific Objectives:

- To determine the socio-economic value of goats and cattle and it's opportunities to increase the positive impact.

- To determine the effect of different seasons on goats and cattle live weight change and feeding behaviour.

- To evaluate the nutritional qualities and characteristics of seasonal forages by determining the particle passage rate and dry matter digestibility using *in vitro* digestibility method.

1.5 Hypotheses

Increase in goats and cattle production will improve the socio-economic growth and food security in Msinga Municipality. Forage availability and accessibility to ruminants will greatly affect the production performance of livestock. Analysis of production chains will identify seasonal effects, forage qualities and quantities as determining factor towards livestock production. Gender of owner through different perspectives, cultural beliefs,

institutional and management practising were other undiscovered factors that affect cattle and goats commercialization in Msinga Municipality.

1.6 Research Contribution

This study would bring more knowledge to small-scale farmers that there are more benefits to be acquired from their livestock apart from cultural benefits. A sense of rearing livestock as a source of income would also be created, thereby reducing poverty level in the communal areas. It will encourage farmers to develop and accept modern practises and skills of livestock management to improve on livestock productivity. There was also more awareness of different diseases and seasons outbreaks, and the necessity to have vaccination programmes.

Moreover, farmers were exposed to management practises to support livestock health and nutrition especially during drought seasons. This exposure will reduce rate of livestock mortality especially in the dry season. In collaboration with extension workers from the Department of Agriculture and Environmental Affairs, this study facilitated establishment of grazing pastures and irrigation system. The new cultivated pasture will support communal grazing land and improve the nutritive value of forage available to livestock at various seasons.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This review study extensively focused and discussed various factors and their effects on goats and cattle production. The major factors identified were gender of owner and seasonal effects on ruminant productivity.

It discussed gender ownership as a tool that has an indirect effect on goats and cattle productivity. This aspect elaborates on gender perspectives, gender motives of rearing livestock and gender management practices and its' impacts on goats and cattle productivity. Another aspect discussed was the effect of season on ruminant production; expatiating on seasonal effects as an external factor influencing feeding behaviour (response of ruminants to quality roughages and its composition), ruminal factors influencing feeding behaviour (ruminants' internal responses that stimulate feed intake, feeding time). Furthermore, this review discussed the effect of season and roughage quality on passage rate in ruminants.

2.2 Impacts of Livestock Ownership on Productivity

Ruminants, particularly goats and cattle have proved to contribute to human livelihood over centuries (Nassif and Amiri, 2011). Mrema (1996) reported the importance of small ruminants that it had added value to the socioeconomic aspect of man; for consumption, as companionship and production, being a source of income and more to the primary nutritional requirements of rural population. Peacork (2005) reported that goats are mostly reared by all livestock farmers in Africa. They are principally reared for meat, milk, skin and wool (Mrema, 1996).

Based on the archeological verdicts, ruminant livestock, especially cattle was domesticated about 10,000 years ago. A century ago, it was recorded that there were 1200 million head of cattle in the world and it's still continuing to grow (DRDLR, 2013). South Africa with other countries has livestock industry as one of the largest enterprises in terms of financial returns. This reveals how significant and much investment the communities are putting into the livestock farming (DAEA, 2013). Researchers reported that it is doubtful whether mankind would have industrialized as rapidly as he did without livestock to provide meat, milk, hides, draught power. Also, it serves as an article for barter and an indicator of wealth (Chawatama et al., 2005).

There was a high investment into its productivity to the advantage of man because of the benefits derived from goats and cattle. It was recorded that the world population of goats and cattle as at 2003 increased by 104% and 27% respectively (IFAD, 2007b). Due to its economic and social contribution, it was reported that goats' production is on the increase in developing countries than developed countries (IFAD, 2007a; NAMC, 2005). For instance (NAMC, 2005) reported that within 1970 to 2003, goats' production decreased in the USA and increased in Africa by 53% and 97% respectively. Though this livestock relies on their ability to adapt particularly to arid conditions, low nutritive feeds and produce in harsh environments conditions and poor management practices, this has been a useful by small-scale farmers toward productivity.

In 2004, a total number of 6.850 million goats were recorded in South Africa of which KwaZulu-Natal had 13.1% (NAMC, 2005). Records by the Department of Agriculture and Development (2009), confirmed that 6,495 million goats of which consist of Boer goats, Savannah goats, Angora goats, Kalahari Red goats and much more are found in South Africa. In Addition, Agricultural Research Council (ARC, 1980) reported different indigenous breeds of cattle in South Africa, which are: Nguni breed, Afrikaners breed, Bonsmara breed,

Drakensberger and Tuli. Indigenous breeds of goats and cattle in South Africa have not been scientifically selected by breeding other than survival by nature, but there are some variation used to identify them; such as horn, coat type, colour, ear length and size (Donkin and Ramsay, 2006). While speckled goats, Loskop South indigenous goats, KwaZulu-Natal goats, Nguni and Delfizijl goats were classified as indigenous goats of South Africa (Ramsay and Donkin, 2000). The KwaZulu-Natal goats have the following genetic features reported by (DAEA, 2013); (a) Have ability to survive harsh temperature even to the extremes. (b) High adaptation to long time of droughts. (c) They are extremely hardy. (d) High resistance to diseases and parasites. (e) Have never received adequate management practices and special care than being milked (by some cultures) and kraaled at evening.

2.2.1 Livestock ownership by gender

Gender is a biological condition, not a social construction (Reddy, 2005; Oladele and Monkhei, 2008). Most time it is used in respect to sex in social departmental studies and academic field of cultural studies. To investigate the roles, household tasks, restrictions, prospect and inducement of people involved in agriculture, gender has shown to be an important socioeconomic factor (Poats, 1991; FAO, 1998; Oladele and Monkhei, 2008). Agriculture, especially livestock farming has proven to be an indispensable sector towards developing and improving rural livelihoods. Because it is not limited like other agricultural sector and does not strengthen gender inequality among ownership in the societies. For instance (a) both genders have access to livestock and are involved in the production unlike cropping or irrigated plots which is allocated by households not by gender in most rural societies; (b) livestock gives equal right of ownership to gender in irrespective of age. This allows gender ownership to exercise their rights without any external community or government authority. On the other hand, local authorities, traditional councils and government policies have been limiting factors to gender inequality through the land tenure

system in most rural communities; (c) seasonal impact of livestock production can only have hazard effect but cannot stop it compare to other aspect of agriculture. Its activities and products (eggs, milk, meat, etc.) are produced meeting human needs throughout the year; (d) it tends to gain more attention of women bringing about gender ownership balances in most rural communities because of the life entity of livestock.

Social, cultural and economic factors have been major influencing keys to ownership by gender distribution in many societies; Kenya (Mullin, 1995); Zimbabwe (Chawatama et al., 2005); South Africa (NAMC, 2005); Rome (FAO, 1998); Southeast Africa (Horaki et al, 2009); Botswana (Nsoso et al., 2005) and Ethiopia (Yisehak, 2008). Also, reported that large ruminants are owned by men while small ruminants and monogastric animals are mostly owned by women (IFAD, 2007b). Women and children took more percentage of ownership in western Kenya than men in poultry (Okitoi et al., 2007). In Tanzania reported by FAO (1998), men claim total ownership of livestock while in Pakistan women only have access to animal brought as part of her dowry. Cattle, sheep, goats and equine are owned by men while poultry is owned by women in Ethiopia (Yisehak, 2008) and in the Kgatleng District of Botswana (Nsoso et al., 2005). Ownership by gender differences has also brought about division of labour in livestock production, especially in households where it is their major source of income. Men focuses on the rearing, management and control while women are responsible for feed gathering, care providers, birth attendants, processing and marketing. (IFAD, 2007b; Lo Bianco and Andrea, 2007). Mullin (1995) estimated 46% of agricultural labour and 70% of food production are done by women.

2.2.2 Impact of livestock ownership by gender in South African agricultural household

Out of the total surface area available in South Africa, only 11% and 54% were classified as arable and grazing land respectively (DARD, 2005). About of the 2.9 million households in South Africa, KwaZulu-Natal had the highest agricultural households with 24.9% (Census

Agriculture Households, 2013). Livestock farming has been outstandingly proved to contribute tremendously to the overall economic growth in KwaZulu-Natal Province, where 66.5% of the total households in KwaZulu-Natal are involved in agriculture (Census Agriculture Households, 2013). Out of this percentage household's livestock farming households only, crop farming households only and mixed farming households only are 41.9%, 30.3% and 24.6% respectively (DAEA, 2013). These have impacted the communities positively, socially, economically, financially, cultural and religious impacts such as provision of employment, boosting the social-economic activities, adding value in cultural ceremonies and as sources of income.

Though, there are still unreported study (practices) and non-farm activities of rural households which are detrimental to agriculture (particularly livestock farming). Potential of which still remains a major contributing factor to rural livelihood for the poor. Therefore, the Agricultural sector is an important industry in the economy of KwaZulu-Natal as large populations of households relies on livestock farming as means of survival. Within the province, the distribution of livestock across the province as reported by the (DARD, 2005) were cattle only (11.3%), sheep only (0.4%), goats only (6.6%), pigs only (0.3%), poultry only (45.9%) and the total animal combination (35%). These are areas where livestock are communally reared (Census 2011 Agricultural households, 2013).

Majority of indigenous goats in Msinga municipality are reared on scattered communal lands throughout the municipality because of the topography of the land (DARD, 2005). As a result, livestock farming systems take place on subsistence level where the homestead produce meat and milk from their backyards, mostly for ceremonies and cultural purposes. Due to the small scale livestock farming system practiced in the municipality, the goats and cattle partially form part of the formal supply chain and as such generate minimal income and no employment. From data presented by NAMC (2005) and DARD (2009), livestock farming

is on the decrease in terms of production especially goats. This is within a very short period of time (4 years) which calls for immediate intervention to look into definite problems with solution to this act.

Gender equality has been embraced in the municipality, but to some certain extent because of the cultural beliefs and practices (DRDLR, 2013). Women only take responsibilities at work and decision making at household level only while men herd the cattle and join in public meetings relate to livestock farming as reported in Botswana but vice versa in South Africa, (IFAD, 2007b). Only men are responsible for decision making, such as which animal to sell, at what price, animal selection, disease diagnosis and treatment. On the contrary, women make such decisions when the husband is late. In-balances of gender role caused by culture and society have underestimate women value of the input (IFAD 2007a; Oladele et al., 2008). This is a paternalistic bias and has resulted in gender-blindness in many communities in Africa (Niarmir, 1994). Also, this study focused on identifying critical problems facing livestock gender ownership towards commercialization with recommended solutions along the production chain.

2.3 Seasonal Impacts on Ruminants Feeding Behaviour

Ruminants' productivity is influenced by many factors. The two main important factors are what and how much time they spent to eat (grazing/browsing time). Ruminants are highly selective, depending on the forage whether it is palatable or partially unpalatable. Therefore, ruminants consume a wide variety of feeds though they prefer some feeds more than others. Some other feeding habits of ruminants are that they usually feed in green pastures or cereal grains. Also the rate at which they consume feed differs; some with relatively slowly and without apparent interest while some with apparent relish. Ruminants have the sensation to identify both pleasant and unpleasant feed either prior to or during grazing/browsing. This determines the amount of time such ruminant will spend grazing or browsing on that

particular feed item. For example, they consistently consume a feed that causes metabolic upsets (1) thermo-ammoniated straws which causes “hysteria” and (2) molasses which causes “molasses toxicity” (Oladapo et al., 2009).

Ruminants are individualistic in nature, during feed selection where possible the feeding time of different feeds differs among ruminants. Marcio et al (2012) reported that ruminants feeding on dry pasture vary their feeding time of supplement considerably to an appreciable level of amount eaten. Flock of sheep grazing on dry pasture was observed, 50% was reported to consume molasses block while 75% of herd of cattle feeding on dry pasture readily access molasses (Dzakuma et al., 2004; Tahir et al., 2008). Considering various factors, as season appears to be one of the external factors that affect ruminant production and also affect pasture forages that ruminants feeds on. The following sub-topics below discuss extensively how season influences forage quality and quantity; how forage affected by season influences ruminant feeding behavior (grazing/browsing time) and physiological response of ruminants to different seasons in respect to their productivity.

2.3.1 Factors affecting forage composition

Despite various reports from several researchers from different parts of the world, it has been noted that everyone has different values of the same forage (NAMC, 2005). This can be traced to the influence of environmental factors to different geological zones to which seasons are a major factor. Also, the nutrient composition of forages differs from place to place, but this is very important, even in formulating our feed diets (Guicharnaud et al., 2010).

Indirectly, deficiency of some elements of the animal is traceable to lack of such elements or nutrients in the diet. Therefore, the nutrient composition of each dietary ingredient needs to be checked. For ruminants, nutrient composition of forages is very important to productivity.

Therefore in this aspect; we shall look into problems that cause variation in nutrient composition of forage. Nutrient variations which occur naturally in the composition of plants are of economic importance in the livestock industry.

Differences in nutrient composition of forage can either be inherited characteristics or those caused by species variation. An environmental influence which is different from place to place is another factor that causes variations in forage quality. Below discussed are prominent factors and extent of which they affect forage composition.

2.3.1.1 Soil nutrient composition

According to Du Toit et al. (1940), South Africa soil is low in phosphorus. Redfearn and Hailin (2002) attributed the low phosphorous content of grasses grown in a part of the Republic of South Africa to low availability of phosphorus in the soil. Ball (2001) and Bossio (1997) found the same relationship to hold in the case of vegetation grown on a phosphorus deficient soil in southern Norway. Bilik et al. (2012) observed that fertile soils tend to increase the percentages of protein, crude fiber and ash in alfalfa. Tiemann et al. (2009) reported that forage grown on an infertile soil contained only one-third as much phosphorus as did similar hays grown on a fertile soil. Havlin et al. (1999) found that that soil measurements are low in nitrogen, lime, potash and phosphorus, produced grasses the ash of which contained smaller percentages of lime phosphorus and potash (Table 2:1).

Table 2:1: Percentage composition of ash on different soil fertility

	Total in	**Composition of Ash**		
	Dry matter (%)	P_2O_3 (%)	Lime (%)	Potash (%)
Average of 8 grasses from poor soils	9.83	0.98	3.08	
Average of 3 grasses from fertile soils	9.93	2.76	9.11	
Average of 17 poor soils		0.047	0.168	0.087
Average of 17 fertile soils		0.184	0.465	0.143

(Havlin et al., 1999)

2.3.1.2 Application of fertilizer element

MacDonald et al. (1997) reported that season has an indirect effect on soil type which influences the nitrogen content of crop when harvested and crop residues in spring. Bilik et al. (2012) reported that after applying various phosphorus fertilizers to wheat that there was a greater influence on the phosphorus content of the straw than of the grain. Also Bossio et al. (1997) found that phosphorus content increase in alfalfa through application of its fertilizer.

Mucheru-Muna et al. (2007) established that the amount of nutrient available to forage is influenced by season and this determine the forage composition at maturity or harvest time. Zayed et al. (2013) found that the phosphorus content of mixed grasses could be increased from 0.11% to 0.24% by application of phosphate fertilizers. (MacDonald et al., 1997; Yiu-Kwok Chan et al, 2013) observed with pot cultures of wheat, oats and barley at the Rhode Island station that the amount of phosphorus added to the culture usually approximated the amount in the harvested plants. The straw varied more widely in percentage of phosphorus, depending more directly upon the amounts supplied during the growing season (Havlin et al., 1999). This confirmed (Mucheru-Muna et al., 2007) that season affects soil conditions such as porosity, airspace and texture which brings about availability of nutrients in the growing season. Guicharnaud et al. (2010) found similar results concerning the use of nitrogen and potash by the corn plant.

The protein content of corn and stover were greater when nitrogen carriers were applied in the early wet season (Sakata et al., 2014). Havlin et al. (1999) found that applications of phosphate carriers to a deficient South African soil improved the feeding qualities of the grasses due to an increase in the phosphorus content of this forage.

2.3.1.3 Seasonal rainfall or water supply

Water is majorly one of the essential elements needed by the plant for its nutrients. It is essential to the life of the plant because it access its food in liquid forms. The amount of

water available for use in the soil during the growing season also influences the amount of soluble plant food derived from the soil and stored within the plant (Sakata et al, 2014). It was noticed in certain parts of Germany that years of drought were accompanied by a mineral deficiency disease of livestock, caused by the lack of certain mineral elements in the forage grown under these conditions (Krauss and Pell, 2003). The same occurrence has been observed in many parts of the world, and reported by such men as Sinyangwe (1995) of Zambia; Els et al. (1999) of Namibia; Govender et al. (2006) of South Africa, Ley et al. (2004) of the United States of America, Ching-Sen Chen et al. (2013) of China and Jeremy (2011) of Germany. Du Toit et al. (1940) noted that the phosphorus content of meadow fescue and clover was directly affected by the amount of irrigation water applied during the wet season. Mucheru-Muna et al. (2007) noticed that there is undoubtedly an increase in the percentage of ash as the quantity of irrigation water is increased. In cereal grains, protein decreased in percentage as the irrigation water was increased (Krauss et al., 2007). The percentage of protein in the straw also decreased slightly, as well as in the forage crops, alfalfa, timothy, brome, orchard and Italian rye grasses. The ether extract content varied irregularly. In cereal grains the crude fiber remained practically constant, while in the straw crude fiber increased with the amount of irrigation water (Mucheru-Muna et al., 2007). Among the other forage crops the same tendency was noted. Root crops varied little in content of crude fiber.

2.3.1.4 Stage of development of the plant at the time of harvest

Many studies have been made on the corn plant and others which show that in general the dry matter and crude fiber content of the plants increases with advancing maturity (Menteca and Smith, 1994). Perhaps the largest number of these investigations has been conducted on the corn plant. Oladapo et al. (2009) reported that the production of quality hay (corn leafs) for dry season feeding of ruminants is better harvested at 12 weeks stage growth. Havlin et al.

(1999) made studies of the chemical changes occurring during the growth of maize and found that the dry matter, ether extract and nitrogen-free extracts increase with the age of the plant. While the crude protein and ash decrease in percentage during the same period (Krauss et al., 2007). In the stalk and leaves the percentage during the same period of growth is high, but when the grain is taken into consideration, the percentage of crude fiber in the total plant decreases from the tassel stage to maturity (Table 2.2), (Menteca and Smith, 1994).

Table 2:2: Average Composition of Dent and Flint Corn at Different Stages of Maturity

	Dry matter %	Ash %	Crude protein %	Esther extract %	Crude fiber Ear %	Stover %	Fodder %	N-F-F %
Tassel	13.48	8.53	11.65	1.68	-	-	27.66	50.48
Milk	1847	6.49	8.95	1.57	18.86	28.04	26.08	56.91
Dough	25.02	5.51	8.22	2.20	11.83	29.77	22.52	61.55
Clazed	32.72	5.38	8.33	2.67	9.57	33.53	21.42	62.20
Ripe	43.01	5.00	8.19	2.94	8.59	34.37	20.29	63.58

(Menteca and Smith, 1994)

Mohamed (2011) observed that the protein, ether extract and ash decrease in timothy grass (*Phleum pratense)* with growth, while the nitrogen-free extract increases. Little variation in the content of crude fiber was noted after the heads were formed. With Sudan grass (*Sorghum × drummondii),* Ball et al. (2001) found a decrease in the percentages of crude protein, ether extract and ash, while an increase was noted in the percentage of nitrogen-free extract, crude fiber and total dry matter, with maturity (Mohamed, 2011). Seasonal nitrogen application was reported to boost fruits and leaf nitrogen concentrations on young ‘keisie’ canning peach trees on a sandy infertile soil in the Western Cape Province, South Africa (Wooldridge, 2006).

2.3.1.5 Leaching caused by rain and dew

Havlin et al. (1999) noted that there is no tendency of nutrient loss in the humid than in the dry season. A single rainfall of 1.76 inches washed out a large amount of the soluble food compounds from a cutting of alfalfa hay (Givens et al., 2000). The protein content was

decreased one-third, while the nitrogen-free extract decreased by five percent in amount. Due to the losses of soluble matter, the crude fiber was nearly one-third higher in the remaining leached sample.

About three-fourths of the phosphorous could be dissolved out of alfalfa hay with water (Redfearn and Hailin, 2002). Wooldridge (2006) sprinkled sample of forage with distilled water and found that the water removed rather large amounts of soluble mineral matter from the plants. Heavy rains in October (Indiana) made a marked reduction in the potassium content of corn stalks and ears (Klopfenstein et al., 2001). Losses due to exposure to the weather for 35 days, with corn amounted to 21.5% of the total dry matter, 31.3% of the potash (KIO). 15.6% of the phosphoric acid (P_2O_3), and 25.9% of the nitrogen. Losses were greater from the leaves than from the ears (Havlin et al., 1999).

2.4 Ruminant's Behavioural Response to Seasonal Roughages

The voluntary feeding time on different feedstuffs and the amount of digesta in the reticulo-rumen are interdependent (Coleman and Moore, 2003). When sheep were offered several roughages such as hay and dried grass, there was evidence that they ate to a constant fill (Grant and Albright, 2001). The importance of plant cell wall as the primary restrictive determinant of feeding time has been demonstrated (Krause et al., 2003). However, rumen capacity did not limit the feeding time of silage when compared to companion hays (Dziba et al., 2003; Dumout and Gordon, 2003). This indicates that the feeding time rate is otherwise influenced by some other factors either initiated by the animal or not by the animal.

It is generally assumed that feeding time and digestibility of forages are directly related. While they are somewhat interrelated, feeding rate and digestibility of forages is separate measures of quality (Taweel, 2004). Feeding time is dependent upon the structural volume measured by the cell wall content, while digestibility is dependent on the chemical content

and its availability (Decruyenaere, 2009). This is particularly noted if one compares the difference in feeding time on grasses and legumes.

A major constraint to rate of feeding in ruminant feedstuffs is the indigestible dry matter (Boudon et al., 2009; Oladapo et al., 2009; Myer and Elzo, 2010; Fereira et al., 2012; Awad and Elhadi, 2012). The relationship between available nutrients and voluntary feeding time in ruminants is biphasic (Forbes, 1995). There is a positive correlation between the content of available energy and the amount of food eaten with poor and medium quality roughages and a negative correlation with high-quality roughages and cereal-based diets (Bezabiha et al., 2012; Manzano et al., 2012; Bilik et al., 2012). Apart from all others discussed environmental characteristics, dietary choices and roughage nutrient influence ruminants to eat (Baumount et al., 2000). The ruminant feeding environment (stocking density and feed availability), is also a contributing factor in feeding behavior through animal comfort and feed competition ratio (Grant et al., 2001). Baumont (2000) reported that dominance and feed competition ratio have a direct impact on feeding behaviour, therefore the proper stocking rate will reduce negative impact.

2.5 Physiological Factors Affecting Feeding Time

Among all other factors illustrated in studies, factors affecting ruminant productivity can majorly be subdivided into three, namely plant factors, animal factors and environmental factors. Below are some study reviews of plants and animal factors (Givens et al, 2000). See Table 2.3.

Table 2:3: Different physiological factors affecting roughage quality

	High Intake	Low Intake	References
Plant factors			
Fibre Content Forage class	Low fibre C-3 grass (temperature), Legume	High fibre C-4 grass (tropical)	Van Soest (1965) Reid et al. (1998) Wilson and Kennedy (1996)
DM content	Hugh DM silages	Low DM silages	Peoples and Gordon (1989), Teller et al, (1993) Romney et al, (1997) Hodgson et al (1991) Penning et al (1991)
Sward structure	High plant density Optimum sward Height for animal Species grazed	Low plant density Sward height too low for animal species grazed	Hodgson et al (1991) Penning et al (1991) Cushnahan et al (1998)
Conservation	Good fermentation of silage	Poor fermentation of silage	Forbes (1995)
Animal Factors			
Physiological Status	Growing Animal Lactating animal	late pregnancy mature unproductive animals	Conrad et al. (1964) Campling (1966)
Size	Large animal	Small animal Forage characteristics limit bite mass and	Ingvartsen et al (1992) Illius and Allen (1994) Illius (1998).
Intake rate	Forage characteristics optimum bite mass and minimize mastication	increase mastication	Newman et al. (1994)
Previous experience	**Supplement Licks**	**Presence of alkaloids, condensed tannins, glucosinolates**	**Provenza et al (1990) Duncan and Milne (1993) Thompson and Stuedemann (1993)**

(Givens et al, 2000)

2.5.1 Animal sex

Another factor is sex of the ruminant animal. Sex seems to have limited effects on feeding time rate (Agricultural Research Council, 1980; National Research Council, 1987, Myer and Elzo, 2010; Dzakuma et al., 2004; Rodriquez, 2008). Feeding time, chewing rate and frequency decreased based on sex (Zhongqiu, 2013). Intake differences attributable to sex may be evident at certain times. Ingvartsen et al. (1992) reported that in body weights less

than 250 kg, heifers had a greater intake capacity than steers or bulls. At a given body weight, heifers are proportionally more mature (fatter) than steers (Bruininx et al., 2001). Reddy (2005) in their equation for predicting dry matter intake use a frame-equivalent weight adjustment instead of a direct adjustment for sex.

2.5.2 Animal age

The age of an animal when it is placed on feed can affect feeding behavior (Dziba et al., 2013). Zhongqiu (2013) reported that in the spring, more time is spent on rumination than summer because ruminants tend to maximize nutrient intake, energy and cover up for loss of feeding time during spring. Older animals (e.g. Yearlings' vs calves) typically consume more feed per unit body weight than younger ones (Coleman and Moore, 2003). Presumably, the greater ratio of age to body weight (age relative to proportion of mature body composition) for yearling cattle prompts greater feed intake. This effect has been likened to increased feeding time by cattle experiencing compensatory growth (National Research Council, 1987). Assuming that cattle started to feed at heavier BW are generally older cattle, age-related effects on rate of feeding are partly responsible for the positive relationship between the initial weight on feed and dry matter intake. Reddy (2005) suggested a 10% increase in predicting dry matter intake by cattle started on feed as yearlings compared with cattle started on feed as calves.

Before, more accurate predictions of feeding behavior are possible, designed studies are needed in which independent effects of age and body weight or body composition on feed time can be quantified. Dado and Allen, (1995) found that daily dry matter intake increased 0.20 kg for each 50 kg above 277 kg of initial weight when placed on a high-energy diet, and it decreased by this same amount of initial weights less than 277 kg. Similar trends were obtained by (Roddriquez et al., 2008; Morris and Du Toit, 1998; Menteca and Smith, (1994). Growing cattle started on feed as yearlings consume an average of 10% more than calves

with similar weights and frame sizes. Abdalla (1986) found that compensating cattle whose rate of growth had been retarded to about half of that at which maximum daily protein gain could be expected consumed an average of 10% more DM/W 0.75 when fed *ad libitum*. The yearling effect on feeding time may be the same as that obtained during compensatory growth. As the cattle age, lesser weight indicates a previous period of retarded growth. Zhongqiu (2013) confirmed that age is directly proportional to feeding time, chewing rate and rumination. Abdalla (1986) found that rumen size rapidly increases following retarded growth; the impetus for compensatory growth appeared to be increased demand for nutrients, with an increase in appetite as well as increased efficiency of utilization of nutrients.

2.5.3 Body composition and size

Body composition determines the rate of body metabolism. Percentage of body fat seems to affect feed intake (National Research Council, 1987). As animals mature, adipose tissue may, in some way, have a feedback role in controlling feed intake. Grant and Albright, (2001) reported that dairy cattle had the greatest dry matter intake with feeding time and ruminating during the first five weeks of lactation. Regardless of the mechanism, the percentage of body fat is often considered in equations to predict feed intake by beef cattle. Fox et al. (1988) suggested that dry matter intake decreases by 2.7% per 1% increase in body fat over the range of 21.3% to 31.5% body fat. As a result of the relationship between feed intake and body fat, careful monitoring of feed intake can be a useful management tool to determine when cattle have reached an appropriate slaughter condition. Gastrointestinal size is related to the 1.0 power of body weight, while energy intake is related to weight raised to the 0.75 power (Havlin et al., 1999). This implies a more rapid turnover of rumen contents at lighter weights. Rodriquez et al., (2008) found that the best fit of intake data with body weight when examined resulted in powers of 0.5 to 0.8. Dado and Allen (1995) found intake to be related to the 0.47 power of body weight. This relationship varied with the time on a high-energy

ration (Bruininx et al., 2001). Tahir et al (2008) concluded that intake of beef cattle was 95 g/W 0.75Kg, with a 95% confidence interval of 88 to 102 (where W is body weight).

2.6 Environmental Factors affecting Feeding Behaviour

2.6.1 Temperature and weather

Considerable research has been conducted to evaluate effects of ambient temperature on feeding behaviour and digestive function, the topic has been reviewed extensively (Kennedy et al., 1986; Minton, 1986; Young et al., 1989; Tarr, 2007). The temperature has shown to affect the feeding behaviour as ruminants retire from feeding to seek shade and cool areas (Tucker et al., 2007; Atrian et al., 2012). In experimental situations, feeding time rate has shown to increase as the temperature decreases below the thermo-neutral zone. Cattle try by all means to avoid direct sunlight and prefer more a shady place to unshaded place with a cooling system (Anderson et al., 2012). With cold stress, ruminal motility and digesta passage increase before changes in feeding rate increase occur, prompting to conclude that the digestive tract response may be essential for accommodating greater feed intake (Fereira et al., 2012). As noted by Tarr (2007), however, this general response to temperature change can vary in thermal susceptibility of the animal to acclimate and diet. Behavioural responses to thermal stress (e.g. decreased grazing time) are restricted by some experimental conditions that could intensify the effects of thermal stress on feeding rate. For example, acute cold stress decreased forage intake by as much as 47% in grazing cattle (Bezabiha et al., 2012). However, for thermally adapted grazing cows (Beverlin et al., 1989) reported only small changes in forage intake with temperature deviations of 8° C to –16° C.

Feeding time declined in cattle of European origin, *Bostaurus*, above environmental temperatures of 20^0 C to 25°C (Marcio et al., 2012). Continuous heat stress may reduce the feeding rate until cattle reach negative energy balance, and they may cease eating when climatic temperatures above 40°C are maintained. Thermal stress is most severe in dairy

cows at the early stage of production (Anderson et al., 2012). These effects are enhanced directly by relative humidity. Cold temperatures result in increased feed time, and directly proportional to energy balance, which is affected by tissue, insulation, including fatness and pelage (Atrian et al., 2012). Thyroid function and maintenance requirements usually increase from normal at 10°C to 1.5 times maintenance at -20° C (National Research Council, 1981).

In addition to dietary dilution with indigestible material and hot climate, there are numerous other constraints on feeding behaviour. Ruminants have, in comparison to carnivores, dietary regimens that induce large thermogenic effects (Baumont et al., 2000). Most of this arises from ruminal fermentation as the heat of fermentation. Hypothalamic temperature increases with feeding activity, whether or not energy is consumed. It is not likely, then, that hypothalamic temperature plays a role in controlling feed intake.

2.6.2 Forage availability for grazing cattle

The two major factors influencing feeding time by grazing cattle are quantity and quality of available forage (Baumont et al., 2000). Cattle body homeostatic regulation and forage quality have been found to contribute to short-term feeding behaviour and long-term depends on body reserve and nutritional requirements (Faverdin et al., 1995). In pastures or ranges with abundant available forage, animals can selectively graze large mouthfuls of the most nutritious plant parts, usually leaves. As the quantity declines, the amount of intake per grazing bite declines.

In addition, as the grazing pressure increases and/or the plants mature, the animal is forced to consume plant parts with a slower rate and extent of digestion. The data by (Rayburn, 1986) indicated that intake of cattle and sheep is maximum at forage availability of about 2,250 kg/ha, or 40 g of organic matter (OM)/kg of live weight (LW), and then rapidly declines to 60% of maximum by 450 kg/ha or 20 g of OM/kg of LW. Forage density per unit area in the

winter season has been often very low quality, especially in the tropics (Manteca et al., 1994). Therefore, grazers tend to increase the feeding time rate and walk long distances in an attempt to attain the rumen fill. This feeding behaviour is affected by environmental daily temperature.

2.6.3 Dietary factor affecting feeding behaviour

2.6.3.1 Water content of diet

The water content of the diet is a potential factor to increase dry matter intake as it decreases (Tahir et al, 2008). An increased amount of water proportional brings increases in the ambient temperature (Nardone et al., 2010). Thus, restricting water reduces dry matter intake (Awad and Elhadi 2012), and any factor that affects water consumption could reduce intake. Voluntary free water intake plus the water in the feeds consumed is approximately equal to the water requirements of cattle (National Research Council, 1984). Thus, dietary water concentration per season would not be expected to influence dry matter intake until total expected water intake per unit of dry matter is exceeded. Rumen contents contain about 85% water; thus water added to the rumen has little effect on dry matter intake since it is rapidly absorbed and excreted (Helena and Jens, 2010). For lactating cows, 0.87 kg of water must be added to the expected daily intake for each kg of milk produced. Forced water intake above these levels could reduce intake. In milk-fed calf intake is reduced 32% as dry matter content of milk falls from 15% to 5% (Agricultural Research Council, 1980). The diet moisture that stimulates diets bulkiness is inversely proportional to the capacity of the reticulo-rumen (Tahir et al., 2008).

2.6.3.2 Degree of fermentation

It has been shown that a desirable fermentation during ensiling does not reduce dry matter intake in cattle (Le Liboux and Peyroud, 1991; ARC, 1980). However, when silage is unusually wet or dry, undesirable fermentation may occur. In silages with greater than 65%

DM, the potential for moulding increases, this could reduce the feeding rate (Delfino and Mathison, 1991). In silages with less than 30% DM, a pH of higher than 4.4 may be indicative of proteolytic fermentation and the development of amines and excessive butyric acid, which may reduce the feeding rate (Helena and Jens, 2010).

2.6.3.3 Feed processing

Reducing particle size and collapsing of the cell structure by finely grinding and pelleting fibrous feeds reduces rumination time and increases the rate of passage and thus feeding rate (Gasa et al., 1991), by up to 50% (Okine and Mathison, 1991). When acetate: propionate ratio decreases which improved utilization of digestible energy, digestibility also decreases up to 3% to 8% per increase in maintenance. Feeding time is improved most with processing where roughage is the major constituent, and the impact increases with increasing concentrations of plant cell wall and with alkali, ammoniation, or other treatments that increase the potential for cell wall digestion (Ball et al., 2001). Increasing the rate of passage of indigestible material can improve intake of forages high in cell wall content by up to 50%. Generally, as the feeding rate decreases with processed grains fed, digestibility decreases.

2.6.3.4 Forage management

Forages that are high in digestibility and easily consumed in large amounts are an essential dietary component for many high producing dairy cattle (Baumont et al., 2000). The high feeding rate of forage diets by high producing ruminants is thought to be limited by the bulky nature of forage fiber. It has been reported that large ruminants have a partial ruminal capacity for fiber and they will maintain a relentless level of fiber fill by consuming an amount of forages (Le Liboux Peyroud, 1991). However, researchers noted that the dynamics of digestion and intrinsic aspects of cell walls affect space occupying characteristics of fields and their effect on feeding rate (Fereira et al., 2012; Bezabiha et al., 2012; Oladapo et al., 2009; LIamas-Lamas et al., 1990).

High level of grains inclusion in diets, depresses digestibility when feeding rate is high. (Boval et al., 2007; Tafaj et al., 2005; Nsahlai et al., 2003). Digestibility of starch and the cell walls of concentrates may be affected to a greater extent than the cell walls of forages because of their high digestibility and rapid rate of passage. Therefore, when formulating forage diets for high producing cows, estimates of diet digestibility should be considered.

Digestibility is affected by rate of feeding (Gasa et al., 1991; McCollum et al., 1992; Schofield et al., 1994; Dado, 1995), forage: concentrate ratio (Mahrous et al., 2006; Knonoff et al., 2003), and forage maturity (DAllen, 1996; Dove, 1996). At high intake, the depression in digestibility of fibrous portions of the diet generally is greater than the depression of more readily fermentable diet constituents (Mantysaari et al., 2006).

With grazing cattle, quantity of forage available can affect the feeding rate. Orr et al. (2001) reported that feeding rate was maximized when forage availability was approximately 2,250 kg dry matter/ha or a forage allowance of 40 g organic matter/kg body weight. The feeding rate decreased rapidly to 60% of maximum when forage allowance was 20 g organic matter/kg body weight 450 kg (National Research Council, 1987). Minson (1990) noted that bite size decreased with forage mass of less than 2,000 kg dry matter/ha; this decrease was only partially compensated for by increased grazing time, resulting in a decreased forage intake.

The break point at which feeding rate was decreased with decreasing forage allowance seemed to lie between 30 g and 50 g dry matter/ kg body weight. Relationships may vary with forage type and sward structure. McCollum et al. (1992) evaluated the effect of forage availability on cattle grazing annual winter wheat pasture and noted that high feeding rate of digestible organic matter was predicted at 124,700 g dry matter/ha (approximately 300 g dry matter/kg BW). Selective grazing of growing forage may increase in pastures with both growing and senescent material. Cattle prefer senescent forage when growing forage is

available (Minson, 1990). Therefore, the effects of forage availability on feeding rate should be considered in light of pasture composition and the potential for selective grazing.

2.7 Ruminal Factor Influencing Feeding Behaviour

The reticulo-rumen represents the first chamber in the alimentary tract of ruminant animal and its capacity sets a limit on the amount that animal can eat (Forbes, 1995). Anything that causes sufficient distension of the reticulo-rumen or any other compartment of the digestive tract triggers the mechano-receptors, which transmit a message to central nervous system resulting in the cessation of feeding time. According to Decruyenaere et al. (2009), diet composition and physical form have a significant effect on reticulo-rumen fill and passage rate. Bezabiha et al., (2012) discussed whether the rumen fill effect of diet on the reticulo-rumen was more important for the short term regulation of feeding rate than the weights of diet. Most theories of feeding rate regulation include the idea that ingestion of feed causes changes in the body which are monitored by the central nervous system. It also regulates the time when feeding should stop (Forbes, 1995).

Qualities of forages (legume/grass) are usually characterized by slower ruminal digestion, longer retention times, delayed clearance from the ruminal compartments and a slow rate of passage, creating dietary fill of the reticulo-rumen. The part of the alimentary tract that is the most important in the regulation of feeding rate by physical fill is the reticulo-rumen (Allen, 2000). Klopfenstein et al. (2001) stated that receptors in the epithelial lining of the rumen, that they are concentrated in the anterior dorsal portion of the rumen and reticulum (cited by Forbes, 1995). Excitation of these receptors caused by rumen fill causes a message to be sent to the satiety centres of the central nervous system to cease intake (Allen, 2000). Enlargement in the rumen is determined by both the weight and volume of the digesta (Rossini et al., 2012.

Increase in feeding rate is directly proportional to ruminal digestibility and the rate of passage from the rumen, and inversely proportional to the fill effect of diets (Van Soest, 1994; Forbes,

1995; Allen, 2000). Grass forages with a high ruminal rate of digestion have been associated with increased voluntary feeding rate, since the faster rate of digestion results in the reticulo-rumen emptying more quickly. Although ruminal digestion of neutral detergent fiber (NDF) and organic matter (OM) in whole crop silages is lower than in the grass silages, the total DM intake is higher. This sensation supports the fact that whole crop silages exhibit the faster rates of passage. Van Soest (1994) suggested that the additional intake of feed becomes possible once the reticulo-rumen is cleared.

2.7.1 Physical capacity of the rumen (rumen volume)

Forbes (1995) reported that the capacity of the digestive tract (rumen) is affected by the rate and extent of degradation. Tahir et al. (2008) stated that there is a parallel relationship between the physical capacity of the rumen and feeding rate. An absorption rate of digestible materials of the feed components and the passage rate of both digestible and non-digestible feed components, determines the amount of the feed eaten by ruminants.

On the other hand, deficient nutrient in the rumen or lack of essential amino acids in the animal also influence feed intake. Rossini et al. (2012) reported that bypass protein supplements in diet increase feed intake. Dado and Allen (1995) stated that feeding rate and weight of the empty reticulo-rumen were significantly different in ruminants. In contrast, the relationship between feeding rate and body composition for fatty animals were found to be non-significant (Forbes, 1995). This is because excess fats around the reticulo-rumen reduce its capacity (Fox et al., 1988).

Pregnant heifers reduced feed intake after 14 weeks of pregnancy (Grant and Albright, 2001) while Anderson et al. (2012) reported that there were increases in feed rate towards late pregnancy stage (0.2% per week to 9.4% per week). Cows in late pregnancy ate less hay than non-pregnant cows and feeding rate has been seen to decrease during the last month of

pregnancy (Luo et al., 2004). There is a significant difference was observed between the reduction in dry matter intake in the last six weeks of pregnancy and the birth weight of the calf (Allen, 2000). These revisions suggested that the decrease in feeding rate is due to less available space in the rumen of pregnant animals.

2.7.2 Water content of feeds

There is a decrease in the DMI of silages as the water content increases. Zhigang and Robert (1996) reported that for every increase in water intake of ruminant, there is decrease in dry matter intakes especially rumen of non-lactating and non-pregnant mature cows. Water-filled balloons were assumed to behave just like water in stems and leaves causing the inert fill. High moisture content feeds in the rumen produces water filling effects in the rumen (Orskov et al., 1998). This is because the high moisture content material around the cell wall behaves like water-filled balloons, producing the sense of rumen fill. The high moisture content of forages increases the bulkiness of diets and is negatively related to the capacity of the reticulo-rumen.

2.7.3 Reticulo-rumen motility (rate of passage)

An increase in the rate of flow of flow of digesta from the rumen is also influenced by increase in ruminant motility (Faverdin et al., 1995). These lead to decrease in distension and increase in dry matter intake (Forbes, 1995). When there is an increase in the motility of the reticulo-rumen, it creates more contractions that enhance rumination causing ingested particle reduction and increase in passage rate. This process helps eventually to increase the feeding rate. Forbes (1995) reported that high concentrations of the volatile fatty acids (VFA) reduce reticulo-rumen motility. This described the effect of volatile fatty acid concentrations on ruminal PH. Increased in the concentrations of the volatile fatty acids, the more it influence

the rumination which hastens the particle reduction and ultimately slowing down the rate of passage (Schwartzkopf-Genswein et al., 2003).

2.7.4 Feeding behaviour associated with high neutral detergent fiber diet

Ruminant behavoiur (feeding, chewing, walking and ruminating behaviors) have increased forage intake through high demand for high inclusion level of forage in the diets (Boudon et al., 2009). Generally, cows spend more time chewing and ruminating per unit of dry matter (DM) when diets have high forage content compared to concentrate or pellet diets. Dado and Allen (1995) reported that some changes in feeding and chewing behavior because ruminant demand forage diet as inter-meal to maintain the maximum rumen fill level. Boudon et al. (2009) observed that ruminant spent more time chewing per unit of dry matter (DM) and there were more and longer bouts of rumination.

2.7.5 Reticulo-rumen distension

Distension of the reticulo-rumen could be a strong constraint on feeding rate in ruminant animals. Even on the highly digestible sward, neutral detergent fiber content of ingested herbage largely exceeds 25% DM, the limit above which NDF content has a negative impact on intake via distension of the reticulo-rumen (Allen, 2000). Additionally, rumen fill plays a major role in feeding rate regulation, i.e. as it increases, digestibility decreases (Dove, 1996). It has also been reported (Taweel et al., 2004) that the reticulo-rumen of ruminants can contain large amounts of digesta at the end of the day. This suggests that the ruminant animal has reached the extreme ruminal capacity. Constraint as a result of reticulo-rumen distension has led to other constraints such as the amount of energy absorbed during digestion; remain to be demonstrated in the context of ruminant animal grazing highly digestible swards. Studies have shown that rumen fill clearly impact the feeding behaviour of grazing beef heifers or dairy cows (Chilibroste et al., 1998).

2.8 Utilization of Feeding Times

The feeding of small amounts of concentrate feeds can increase the feeding times by ruminant livestock in some feeding systems. Studies on feeding behaviour of ruminants can be used to establish the relationship between behaviour and intake rate and to verify the potential of knowledge about the feeding behaviour to improve animal performance (Mendes et al., 2010). Improvement in ruminants feeding rate can also be motivated by the provision of quality roughage (degradable protein) to promote rumen fermentation, resulting in increased fibre digestion, intake rate of roughages, reduced waste from unconsumed and undigested feeds, and increased animal productivity and efficiency. Zanine et al. (2007) reported by Marcio et al. (2012) observed that ingestive behaviour of ruminants is an important tool for the elaboration of management protocols, which may facilitate and increase the productivity when properly designed and executed.

Feeding management has also proven to affect animal behaviour. At higher levels of feeding with better quality roughages (with cereals or high-sugar concentrates) substitution effects occur so that fibre digestion and feeding rates may be reduced by increasing concentrate feeding. Feeding management practices affect degradability and its quality (Carlotto et al, 2010). Therefore, ruminants tend to adjust their behaviour in order to meet their nutrient demands. The utilization and productivity of ruminants depend on many factors, but the most important two that are usually considered are what and how much they eat. Consideration of the time spend eating is directly proportional to how much they eat, there is a relationship between forage (what ruminant eats), quality/quantity (how much eaten) and feeding time (time spend eating).

2.9 Conclusion

Ruminants are highly productive animal with multiphase complexities in regard to their feeding behaviour, intake and digestibility, which in turn contribute to their productivity.

Various factors as the case maybe, affect goats and cattle feeding behaviour and could either be positive or negative to the animals. But in most cases, ruminants have direct response to the internal or external factors, in order to maximize any of the effects of those factors. Livestock is faced with problems caused by change in season and environmental conditions. These effects, over a period of time, have influenced the animals to develop a generic corresponding effect in order to sustain and adapt to the changes.

.

Chapter 3

OWNERSHIP BY GENDER AND ITS INFLUENCE ON GOATS AND CATTLE PRODUCTION IN A COMMUNAL FARMING SYSTEM IN MSINGA MUNICIPALITY

Abstract

The study aimed at evaluating goats and cattle ownership and its impacts on productivity in the communal farming system. Also discovering challenges militating against its commercialization. In each of three communities, thirty (30) homesteads were selected based on their willingness to participate and possession of goats and cattle. Hence, a total of 90 homesteads was used across the municipality for questionnaire interview. The questionnaire data were sorted by gender owners and analyzed by frequency procedure and geometric linear regression model of SAS. A focus group discussion was held based on the livestock association that exists along the irrigation scheme to evaluate the cultural view, communal management practices, and identify available marketing opportunities of goats and cattle. Homestead headed by males had higher possession of cattle than those headed by female in the ratio 2.5 while a ratio was 1.9 in the possession of goats. Ownership of goats and cattle across the Msinga municipality comprises between 30% for female and 37% for male ownerships. This indicated that men are in more procession of livestock within the communities then women. The use of cattle for cultural purposes (42.34 %) was more important compared with income (22.18%), prestige (18.15%) meat (12.50%) and milk (4.84%) purposes. Goats serve cultural (38.91%), prestige (29.94%) income (19.20%), meat (11.5%) and milk (2.5%) purposes. Farmers pointed out that livestock numbers increased due to reproduction (40%) and buying (30%). All respondents grazed livestock on communal land without due regard for watering. About 70% mortality was due to diseases, water and feed shortage which have militated against increased livestock production, followed by pilfering, dog attack and poor management practices. There is need for profit maximizing programmes that would encourage a perspective shift in the culture towards livestock farming with respect to routine management in feeding, common diseases and breeding. Also the establishment of pests and diseases control grazing lands and water availability for agricultural purposes will greatly enhance production performance.

Key words: owners, gender, goats and cattle

3.1 Introduction

Agriculture, among all other sectors has proven to have a closer relationship with natural resources. Its productivity and impacts were significant to mankind for over the centuries. Livestock farming has contributed tremendously to the well-being of man (its influence on livelihood and social status; Valdivia, 2001). The agricultural sector has efficient techniques that manage natural resources without any demerits (Yisehak, 2008). This sector also happened to be one of the slow moving modernized sectors in developing countries. There are very few partnership and corporate organizations in the agricultural sector because factor of production is costly (such as inability to acquire land, low land nutritional value, high cost of mechanization and lack of capital, etc.), (Donkin and Ramsay, 2006). Therefore, many farmers prefer to operate individually. This gives rise to many small scale farmers than commercial ones in developing countries (Sebei et al., 2004). Statistically, small scale farmers had been found to contribute largely to the agricultural industry, especially in developing countries (Yisehak, 2008). Also, it was reported that local production has contributed a larger quota (63%) to the total livestock population in South Africa (Census 2011 Agricultural Households, 2013; Ramsay et al., 2000). More researches have been conducted to improve, increase production efficiency and solve some challenges facing small-scale farmers (Lo Bianco and Andrea, 2007; Sebei et al., 2004). As indicated by other researchers, there are other problematic factors for rural farmers and it is limiting livestock production in communities (Rushton and Ngongi, 1998).

Factors such as ownership by gender, inherited poor management practices, cultural belief systems about certain animals and environmental farming systems have been unidentified (IFAD, 2007a). Some rural farmers still hold the belief that livestock farming is not a source of income and this becomes a major barrier to commercialization of goats and cattle particularly in the agricultural industry (Ramsay and Donkin, 2000). However, for the

commercialization agenda of governments to be successful, especially in developing countries, small-hoders farmers must start to see livestock farming as a source of income (animals as saleable commodity). They must be convinced that standard of living can be improved through livestock farming, apart from other cultural benefits derived.

Cattle production in South Africa increased by 37,000 heads between the years 2004 and 2011. About 80% of the total heads are for beef cattle production and the remaining 20% are for dairy cattle production (DAFF, 2012). There are high differences between the commercial producers and communal subsistence producers of cattle based on skills and available facilities. The proportion of cattle ownership by producers is 60% commercial producers to 40% communal subsistence producers (DAFF, 2012). The rate of cattle importation decreases as compared between 2004 (16 million Kg) and 2011 (10 million Kg), (DAFF, 2012). South Africa annually imports approximately 250,000 live goats from Namibia, which are marketed in KwaZulu-Natal Province (NAMC, 2005). This implies that there is more demand for goats than the supply and that the goats are gaining more market value every year. This is a wakeup call for communal farmers to strive to increase production of which they have the potentials. Furthermore, this shortage in the livestock supply chain is a wrong perception of communal farmers (Sebei et al., 2004). For example, some perceived that goat meat is inferior to other domestic meats because younger goats in South Africa are slaughtered for ritual purposes and older ones (inferior animals) are sold in the commercial market (NAMC, 2005). A study that was conducted in the Eastern Cape Province, South Africa revealed that livestock played specific roles in the socioeconomic life of owners (farmers) which is not necessarily related to generation of financial income (Ramsay and Donkin., 2000).

Therefore, this study aimed at (1) evaluation of goats and cattle ownership by gender and its productivity, (2) establish impacts on the socioeconomic and cultural aspects at the Msinga

Municipality and (3) determine small-holders farmers' cultural views and perspectives with their effects on goats and cattle commercialization.

3.2 Materials and Methods

3.2.1 Study Site

The study was conducted at Msinga Municipality, KwaZulu-Natal Province, Southeastern part of South Africa. The study site is located on the geographical coordinates 28.7461° S, 30.4525° E (Census 2011 Agricultural Households, 2013; TrueNoth Mappings). Department Agriculture and Environmental Affairs (2013) reported that 11% of the total surface area of South Africa were classified as arable, whereas 54% was classified as grazing land. KwaZulu-Natal province is listed as the second largest agricultural producing province in South Africa, in terms of agricultural households in livestock production (Census Agricultural Households, 2013). Also, KwaZulu-Natal had 28.2% of its provincial population of households involved in agriculture while 41.9% out of this population are involved in livestock production (Census Agricultural Households, 2013).

The Msinga Municipality is dominated by IsiZulu ethnic group of people, situated in central KwaZulu-Natal Province (Statistics South Africa, 2012). The Msinga Municipality has a rainfall varying between 550 to 2000 mm per annum over a landscape ranging up to altitude 3500 m above the sea level. Its temperature varies from the hot subtropical areas of north-eastern KwaZulu-Natal to the western parts where winter frost is a regular occurrence and snow is experienced from time to time (Census 2011 Agricultural Households, 2013). It has a total landscape of 2,501 km^2 (Figure 3.1; Statistics South Africa, 2012).

Figure 3:1: Geographical picture of Msinga Municipality showing research site (True North Maps, PMB).

3.2.2 Selection of livestock farmers

Through visits to the communities during the feasibility study and supports by the extension and veterinary workers' meetings were organized with local authorities such as chiefs, farmers and livestock associations. This helped to gain access and get researchers familiar with them. Then, a list of farmers keeping livestock (having goats or cattle or both) from each community was compiled for follow-up. In the process, the aim and purpose of the research project were disseminated to create interest and develop interpersonal relationship with farmers. A total of ninety (90) small-scale livestock farmers were selected based on their willingness to participate. These farmers engaged in mixed system of farming. The crop production system is divided into two: Irrigation and garden farming system. Each household has allocated a portion of irrigated plot which is part of the community irrigation scheme. The garden plot is the individual cultivated land around the settlement.

3.2.3 Communities selection

The platform created above gave us access to household rearing goats and cattle in the municipality. The scheme was sub-divided into three major groups, following the trend of the irrigation scheme. Livestock farmers were divided into three major groups based on their geographical location. Starting from the beginning of the scheme, across the middle and at the end of the scheme; taking into consideration the dip-tanks they associated, three communities were selected. These communities were Ntanyana, Madulaneni and Nxamalala.

3.2.4 Research procedure

Survey

A survey was conducted to explore the existing chains and potential value for goats and cattle towards the gross socioeconomic value in Msinga, and its opportunities for increasing the impact. Data were collected through personal interviews of selected livestock farmers using pre-tested questionnaires and by direct observation of livestock management practices,

feeding systems and feed samples. The questionnaire was translated in the local language (IsiZulu) for proper understanding of the concept (English version Appendix 1 & IsiZulu version appendix 2). The questionnaire was administered to ninety (90) households selected for the interview. A total of 30 households was selected in each of the three communities. Interviews were conducted by the research team where direct monitoring was done by the researcher.

Focused group discussion

The aim of the discussion was to evaluate the cultural view, communal management practices, and identify available marketing opportunities of goats and cattle. Focus group discussion was organized within each community using their local livestock association groups. These local groups were formed within the community and they hold weekly meetings. The local groups are in charge of dipping-tanks within the communities and ensure equal access to all livestock farmers. Data collected through focus group discussion helped to verify data obtained through questionnaire interviews. It helped to identify the communal livestock management practices and community views about livestock. It also created an opportunity to discuss livestock health issues such as diseases in the area, malnutrition (feeding management), purpose for keeping livestock and usage of irrigation scheme for livestock production (Appendix 3).

Individual interviews

Some stakeholders who had been visiting the Municipality towards commercialization of goats (establishment and growth of Msinga Goat Movers project) were also interviewed. Stakeholders such as Department of Agriculture and Environmental Affairs (DAEA), Department Rural Development and Land Reform (DRDLR), Msinga farmers Association, Livestock Agents & Auctioneers (AAM), Interested Breeders and Local community farmers.

This interview contributes to validate the livestock production prospects and its impacts on socioeconomic activities in the Msinga Municipality (Appendix 4).

3.3 Statistical Analysis

Data (livestock increase 12 months of data collection, farmers' sources of income, sources of livestock increase, livestock purposes, management practices, health routine and marketing of livestock by gender) were analyzed by frequency procedure of SAS (2013). Livestock population was analyzed by general linear model procedure. Frequency procedure and regression procedure were used to determine the annual livestock populations (SAS, 2013). The statistical model was as follows:

$$Y_{ij} = \mu + G_i + e_{ij}$$

Where: Y_{ij} = dependent variable (livestock numbers over 12 months); μ = overall mean; G_i = Effect of gender owners and e_{ij} = residue error

3.4 Results and Discussion

3.4.1 Descriptive statistic on livestock production as influenced by gender of owners

Majority of homesteads (84%) has goats compared to cattle (69%), sheep (23%) and poultry (3%). Population of goats in possession by homesteads was higher compared to other livestock (cattle, poultry and sheep) (Table 3.1). The gender ratio (male to female) of owners was 2.5, while the ratio of animal population owned by these genders was 4.6 (Table 3.1).

There was decrease in goats' population among female owners over 12 months (1.4) while it increases among the male owners (5.6) (Table 3.2). The disparity in the population of goats owned is very wide compared to the gender of owners. This is due to some biased gender factors which had favoured the men such as (a) Cultural position of men. Men are regarded as heads of households and have final decision on livestock. (b) Men are more traditionally inclined and are not easily deviated from cultural beliefs and practices. Men in these

communities appreciate goat because it is widely accepted animal for cultural ceremonies like ancestral worship, minor part[1] of the *lobola* and special family and community occasions (Focus Group Discussion). Goats are used to pay sexual harassment penalty and minor community fine (DARD, 2013). These agreed with the findings of the focus group discussion. (c) The average population of goats per men ownership was 27 goats per ownership. It was discovered from the focus group discussion that men tend to keep goats as prestige in the municipality.

The average population of goats per female owners is 22; this is because few goat owned by females was possessed at old age (i.e. eldest in the family) or when their husbands are late. Therefore, before female owners reach the disadvantage stage (either old age or widowhood) which gives them an edge and the right of ownership in the household, government can encourage women livestock owners through projects/policies and programmes. This cultural trait in IsiZulu is similar to Xhosa culture of South Africa, where livestock ownership (cattle) is concentrated entirely in the male hands (Hebinck and Smith, 2012).

Culture in South Africa is similar to that of Southern Tanzania as reported by Tesha (1998), that woman cannot claim ownership of cattle and goats. In the case of a married woman who had an ownership contract of cattle and goats, the animals still belong to the man, even after divorce. More opportunity was given to women in Zimbabwe, where women have control over milking, processing and marketing of milk but cannot influence other decisions such as breeding, feeding and slaughtering (Chawatana et al., 2005). Women are only allowed to own poultry and small ruminants in Botswana (Oladele et al., 2008). This conformed with the reported by Food and Agricultural Organization (FAO, 1998) that poultry keeping is largely the responsibility of women in Africa. It also agreed with the findings of Rushton and

[1] Goats are considered as a poor man's cow, that is why goats are used to replaced cattle in traditional lobola ceremonies at Msinga.

Ngongi, (1998) that projects to improve poultry productions were often observed as a way to reach poor rural women. This painted a picture that cultural behaviour in Africa has shifted poultry farming to women.

Nuer Society of Sudan does not permit women to own cattle and goats at all as part of their cultural practices, but they have the responsibility for grazing these animals (Dieckmann, 1994). However, this practice is contrary to the animal husbandry system in Pakis where women have the full ownership control over livestock brought as part of their dowry (Dohmen, 1992).

Also in Malawi, where women are head of households, they have total influence on the livestock they processes (Fachamps and Gabre, 2001). Studies showed that livestock ownership between genders is becoming an equity in Africa countries; Zimbabwe and Mozambique (Chawatana et al., 2005), Botswana (Oladele and Monkhei, 2008), Namibia (Duvel et al., 2000), Malawi (Fafchamps and Gabre, 2001), Nigeria (Olojede and Njoku 2007), Kenya (Okitoi et al., 2007), Uganda (Oluka et al., 2005).

The ratio of gender of the owner (male: female) for cattle is 2.9 households, but the ratio of the population of cattle owned is 3.6 respective (Table 3.1). The average populations of cattle per male owner and per female owner were 13 and 7, respectively. Females do not like keeping cattle because of attention demanded on cattle management, such as herding (DRDLR, 2013). Another factor responsible for this range of differences is the head of a household who is usually a man except when he had passed on. There was an increase in cattle population among the female owners (2.4) while it decreases among the male owners (0.6) (Table 3.2). This was because male use theirs for cultural and ceremonial purposes than female.

In stipulations of the population of livestock across communities, goats had the highest population, followed by cattle while poultry and sheep were smallest populations sampled. The highest population of goats is because goats are slaughtered for more cultural functions by Nguni people. So many households tend to rear more goats and cattle than any other animal. Cattle were the second highest in the livestock population because it's another livestock, mostly use for cultural functions. Cattle are used for *lobola* package during "marriage negotiation" in preparation for the cultural wedding. Male owners have more goat and cattle than female owners because females are financially constrained to own cattle "thus goats are poor men's cow" (Table 3.1). Due to the environmental and nutritional stress of livestock during the dry season, small-holder farmers in the study area found it easier to manage goats than cattle. Goats are owned by many because (1) they are more affordable than cattle, (2) they can survive harsh environmental conditions, (3) they are a mixed feeder, especially during dry seasons when grasses loses nutrients, they switches to browsing.

Table 3:1: Distribution of livestock ownership among sampled population across the communities

Livestock		**Gender of Owners**		**Animal Population Owned by**	
	Communities	**Male**	**Female**	**Male**	**female**
Goats	Madulaneni	16	9	273	200
	Ntanyana	21	3	411	12
	Nxamalala	17	10	793	108
	Total	54	22	1477	320
	Ratios(male:female)	2.5		4.6	
Cattle	Madulaneni	8	10	73	46
	Ntanyana	25	3	277	7
	Nxamalala	7	8	173	89
	Total	40	21	523	142
	Ratios(male:female)	1.9		3.6	

Table 3:2: Mean of livestock numbers for different genders in Msinga over the period of two years

	Year (N)	Gender		*RSME*	P value
		Female	Male		
Goats	2012 (n)	11.7±11.85 (23)	20.6±58.25 (43)	47.7960	0.4044
	2013 (N)	10.3 ±13.05 (22)	25.0 ±64.47 (54)	52.8919	0.2132
Cattle	2012 (n)	4.6 ±8.87 (20)	8.9 ±11.16 (29)	10.4351	0.0676
	2013 (N)	6.0 ±12.57 (21)	7.5 ±-13.73 (41)	13.3453	0.6037

3.4.2 Socioeconomic benefits

Most of the population sampled were rearing livestock for prestige (Focus Group Discussion). The cultural understanding and set up in the community gives regards and honour livestock farmers based on the number of livestock, especially goats and cattle possessed by individual farmers. This agreed with the findings made by Census agricultural household (2013) reporting that 41.9% of agricultural household in KwaZulu-Natal are livestock farmers and 24.6% of agricultural households practice mixed farming.

Apart from the cultural benefit, there are also economic benefits. Many livestock farmers have an economic gain from livestock production. This is by individuals selling livestock to friends and butchers. Most times this is done when such individual farmer are in financial need. Furthermore, Focus Group Discussion revealed that goats play an important role that is respected in the communities to the extent that it must not be slaughtered until the head of the household gives contrary instructions. Livestock (cattle) is also used as lobola to each other (Focus group Discussion). *Lobola* is a cultural bride's gift from the groom's family packed together with bride price paid to bride's family.

Livestock plays a major role to such an extent that bride's price is not complete without the cattle gift. The most important recognized socioeconomic benefit of goats is the usage in ancestral worship (Focus Group Discussion) which is an inherited cultural practice and belief among IsiZulu ethnic group of South Africa. This practice had been sustained alongside with this cultural practice; farmers keep or sell hide of goats and cattle. The hide is used as a pelt for sitting or designed as cultural dress of IsiZulu people. This justified the impact of livestock to mankind apart from companionship, income, hide and skin (Nassif and Amiri, 2011). It promotes inter-social relationship and serve as a means of legal local bills in communities. It is also in agreement with livestock impacts in Botswana reported by Mrema (1996) that it is an important household asset in providing security, cash, food, cultural and social identity, draught power, skin, hide and medium of exchange. World Bank (2008) also reported that livestock production is a very important socioeconomic activity. Therefore, cattle and goats have not lost their socioeconomic benefits in the IsiZulu culture.

3.4.3 Productivity of livestock

Goat productivity and uses as influenced by gender

The distribution of small ruminants in South Africa is not even and numbers tend to be higher in dry areas (Ramsay and Donkin, 2000). Flock sizes, especially are larger in dry than in humid areas (Felix and Fair, 2009). Goats are reared among the IsiZulu tribe mainly for four major benefits, namely: meat, milk, skin and wool in this order of importance (Coetzee, 1998). The majority of small ruminants is owned by individuals or families in community areas. A majority of farmers practice mixed farming which includes large variations of annual crops (maize, vegetables) and livestock (swine, poultry small and large ruminants) (Ruston, 1998).

Annual crops like maize, vegetables (spinach, cucumber) and livestock like poultry, swine, small and large ruminant animals (Focus Group Discussion). All respondents (Small-holder

farmers) engaged in free range systems of farming and graze on communal lands. Due to high rates of tick infestation, farmers through their groups and associations established dip-tanks within the community as a means of control.

The system of livestock husbandry at Msinga is casual and cultural, and is not an organized activity because of the following reasons:

- More ($P < 0.0001$) male than female owners use modern medicine to cure goats (Table 3.3). Among the population sampled, 4% and 10% of female and male owner respectively, uses traditional medicine and engages in dipping practices. The percentages of male and female owners using modern medicine were 57% and 19%, respectively (Table 3.3). Vaccination programme for livestock is poor and the cultural medicinal routine treatment is not even better. It was discovered during the focus group discussion that a majority of farmers cannot identify or prevent in advance against infections that come with changes in season in these communities; thereby exposing livestock to seasonal diseases. Farmers only call for veterinary treatment when a disease outbreak has struck the kraal. As a result of delayed treatment, there is a high rate of mortality across seasons. Male owners have more financial funds for modern treatment than female owners.
- About 32% male and 9% female owners buy feed and feed crop residues (Table 3.3). There is a high proportion of male than female headed households use dry land crop production (Chi square 4.7744, $P < 0.05$, Table 3.3). Questionnaire results indicated that farmers had little or no supplementary feed offered to livestock. Animals only depend on feed found on communal grazing lands, which are totally dried and insufficient during winter grazing (sweet veld). Other standing forages are sour veld grasses (low nutrient grasses); therefore animals struggled in search of quality forage in dry season. For

example, data showed that livestock are not allowed to graze on irrigated farming plots, but are allowed on homestead gardens of individual farmers.

- Almost 46.67% of male owners' and 24.44% of female owners practice irrigated farming, but only 8.89% (both genders) fed crop residues from the farm (Table 3.3) to livestock. Nearly 23% and 7% of male and female owners dip livestock and have homestead gardens (Table 3.3). Farmers do not allow livestock to graze on irrigating farming plots and very few release livestock to graze on homestead gardens (after harvesting). Therefore, livestock are only allowed access to maize-stover when it was planted in home gardens.

  No good flock management is practiced for a frivolous reason that some farmers only rear for social purposes (34.21%, Appendix 6). Focus Group Discussion recorded that farmers practiced similar livestock farming system which has become a cultural norm in the area. It is a system whereby farmers have limited contribution (input and almost no feed) to the production. The only consistent management routine in goat rearing is the administration of modern medicine. Farmers find it easy to spray, drench, rub and inject goats.

- It was observed that farmers have poor housing and tethering of livestock (Appendix 7). A rural livestock farming system by both genders are the same but its affects livestock productivity because of inadequate facilities. This observation agreed with the study reported by (IFAD, 2007a) that small ruminant production in traditional systems throughout tropical Africa is fair. Small ruminants are generally recognized for their importance and contribution to mankind, especially in the tropics (Oladele and Monkhei, 2008). However, Africans who keep small ruminant stock rear it for irrational reasons for meeting particular needs and specific objectives of owners (FAO, 1998).

Table 3:3: Variation in goats' management routine as affected by gender

Management routine	Female (%)		Male (%)		Chi-Square	P Value
	No	Yes	No	Yes		
Dry land crop production	32.22	2.22	48.89	16.67	4.7744	*
Homestead garden	31.11	3.33	62.22	3.33	0.657	NS
Irrigation farming	10.00	24.44	18.89	46.67	0.0005	NS
Goats (traditional medicine)	30.00	4.44	55.56	10.00	0.0909	NS
Goats (modern medicine)	15.56	18.89	8.89	56.67	10.989	**
Goats (dipping)	30.00	4.44	46.67	18.89	2.8757	NS
Goats (buying fed)	26.67	7.78	41.11	24.44	2.0128	NS
Goats (crop residues)	32.22	2.22	58.89	6.67	0.3469	NS

**Significant differences (P <0.001), *Significant difference (P < 0.05).

It's also revealed in table 3.4 below, how the gender of owners across the communities affects interest in livestock and how it met specific purposes across communities.

Table 3:4: Uses of livestock (goats) as affected by gender of owners

		Female (%)		Male (%)		Chi-Square	P Value
		No	Yes	No	Yes		
Goat Purposes	Goats income	21.11	13.33	20.00	45.56	7.9537	**
	Goats meat	15.56	18.89	33.33	32.22	0.263	NS
	Goats milk	32.22	2.22	63.33	2.22	0.4486	NS
	Goats cultural purposes	17.78	16.67	27.78	37.78	0.6996	NS
	Goats prestige	18.89	15.56	44.44	21.11	1.4694	NS
Goats Increase	Goats buying	33.33	1.11	61.11	4.44	0.4892	NS
	Goats reproduction	25.56	8.89	27.78	37.78	8.2677	**
	Goats gifts	32.22	2.22	58.89	6.67	0.3469	NS

**Significant difference (P < 0.001)

Goats are a major source of income among other goat purposes across these communities with fewer females than males benefiting (Chi-Square 7.9537, P <0.001, Table 3.4). Male owner (45.56%) recognized goat production to this effect, compared to female ownership (13.33%). Other uses of goats are as follows: goats' cultural purposes (54.45%), goats meat (51.11%), goats' prestige (36.67%), and goats' milk (4.44%) (Table 3.4). Msinga farmers reared goats for social and cultural purposes than economic interest. Less than 4.44% of the

population surveyed indicated that they milk goats, but not regularly. Whenever this milking is done, is for the head of the family only.

There are quite a few differences in the use of goat. For instance, female perspective goes for meat, prestige and cultural purposes (18.90%, 16.67% and 15.56%, respectively), while male perspectives go for income, meat and cultural (45.56%, 32.22% and 33.78%), respectively (Table 3.4). Cultural purpose is common and higher in male owners than female. It is a pointer to the fact that cultural purposes prevail above all other benefits to these owners. This agreed with the study made by Wilson (2012); Scoones (2009); Felix and Fair, (2009) that African farmers have specific reasons or purposes for rearing livestock.

Changes in the number of goats

Questionnaire results showed that 57.14% of the total households had increased goat number due to reproduction, gifts and buying while 45.94% of households had decreased in goat number over 12 months. These changes are due to cultural purposes, meat and as source of income. Reproduction is a major factor of increase across all sampled communities at Msinga communities which was higher for male (37.78%) than female (8.89%) (Table 3.4, Chi- square 8.2677, $P < 0.001$).

A small proportion of male and female bought and received gifts from other three communities. Goats from males reproduced more than from females because males cultivate different management practices which contributed positively to an increase in livestock production. This is because the male has more financial capability than female to manage livestock farming. These findings contrasted with the findings by FAO (1998) that women are not meant to rear ruminants except poultry. Most of these factors of production can be improved because they are under the influence of environmental and ecological factors (Felix and Fair, 2009).

Available data suggested that production will continue to increase because the local breeds have high reproductive efficiency, except in the presence of some constraints like nutrition, health and management. Also, the increase litter size and short parturition interval tended to boost production and increase efficiency. Good breeding selection, coupled with efficient production can be easily achieved in small ruminants because they have a faster population turnover rate. (Valdivia, 2001; NAMC, 2005; Lo Bianco and Andrea, 2007).

Distribution by gender

Goat distribution showed that a greater number of owners had fewer numbers of goats. Owner numbers are higher in male (20) than female two (2) numbers with the same number of goats. As the number of owners increases, the number of owners decreases. This confirms the finding during focus group discussions, that owners rear goat for specific cultural purposes and when the purpose is achieved the owners has no goats any more in possession. Therefore, goats farming are not a continuous farming practice in IsiZulu culture.

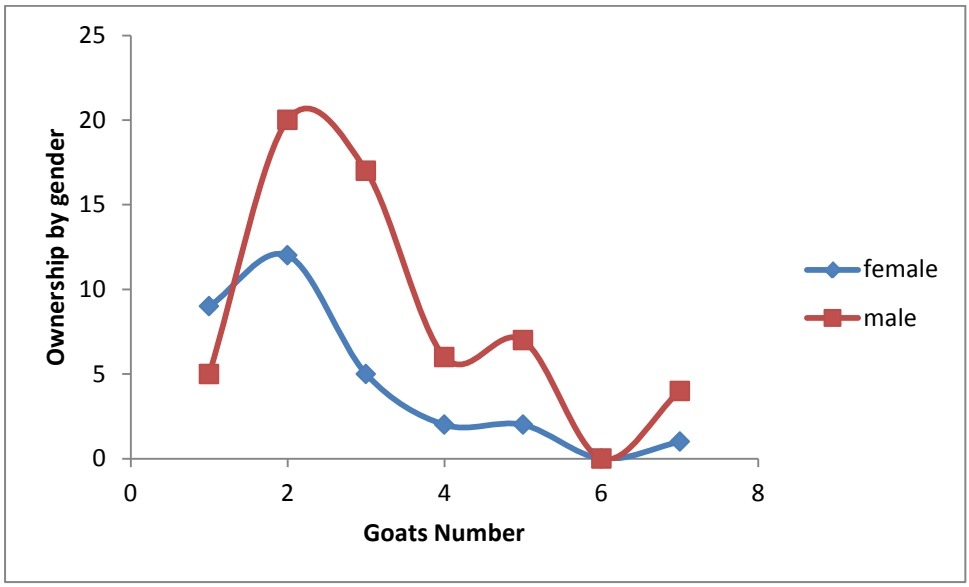


Figure 3:2: Relationship between goat number (x) and number of owners by gender (y) of population of livestock farmers sampled: female owners (n = 31) and male owners (n = 59)

Cattle productivity and use as influenced by gender

Only a small proportion of female (2.22%) and a reasonable proportion of male (25.56%) owners buy feed to supplement cattle feeding during the winter season (Chi square 10.72, $P < 0.001$, Table 3.5), while 2.22% and 10.0% of female and male owners' gives crop residues. About 70% and 3.33% of owners treat their cattle with modern and traditional medicine respectively, while 70% take their cattle for dipping. Focus Group Discussion indicated that the farmers do not have management practices of buying grass (Lucerne hay) to support cattle nutritionally.

Only 25.56% of male owners buy feed perhaps because of their financial capability. Financial handicap of owners was also a factor affecting modern medicinal treatment of cattle. Dipping treatment is free and the reagent use is provided by the Department of Agriculture and Environmental Affairs, many owners prefer dipping to traditional medicine.

Improvement in cattle feeding through supplementation with additional feed source will contribute greatly to cattle production. Observations during forage sampling at different seasons showed that cattle struggle to graze on communal pasture during dry and early wet season because communal grazing lands are fully mature. It was noted during the focus group discussion, that Msinga farmers treat cattle as a livestock that do not need much attention and adequate management routine. Msinga farmers believed that cattle have the ability to serve as draught animals and it is also a major factor in the opening up of arable areas, especially in places with heavy soils (Newman et al., 1994).

Similar proportions of male and female used cattle for meat (total 32.22%), cultural purposes (total 30.0%), rear cattle for income (total 45.55%) and cultural prestige (total 21.11%), and keep cattle for income (total 43.55%). Large families during festive period do slaughter cattle for meat purposes as indicated from the focus group discussion and for cultural ceremonies. Apart of cattle being a source of income, the skin is culturally used for mats, decoration and

clothing among the IsiZulu tribe. Another attribute of cattle farming in Msinga communities is that number of cattle herd is a form of prestige within the community. This has drawn the interest of many owners into the farming system. Cattle are rarely milked (1.32%, Appendix 6).

Changes in cattle numbers

About 31.11% of household increased in cattle number due to reproduction, (11.11%) received cattle as gifts, and (6.66%) buys cattle. Increase in cattle number is at dilemma (Table 3.5) because farmers are not concerned about production but prestige within these communities. Multiplication of cattle only comes through reproduction; *lobola* and gifts contributing very well small increases. Cattle gift is a factor because only cattle are part of the *lobola* during cultural marriage negotiation between families. Due to poor livestock management skills, lack of supplementary feeds, poor health and breeding programmes, mortality and poor calving rate are very high. This agreed with Donkin and Ramsay (2006) reports that rural farmers are less financially capable to operate a livestock farming adequately.

Table 3:5: Management and uses of livestock as affected by gender of owners

Cattle		Female (%)		Male (%)			
		No	Yes	No	Yes	Chi-Square	P Value
Health routine	Cattle (traditional medicine)	33.33	1.11	63.33	2.22	0.0017	NS
	Cattle (Modern medicine)	11.11	23.33	18.89	46.67	0.1148	NS
	Cattle (dipping)	11.11	23.33	18.89	46.67	0.1148	NS
	Cattle (buying fed)	32.22	2.22	40.00	25.56	10.7200	**
	Cattle (crop residues)	32.22	2.22	55.56	10.00	1.4678	NS
Cattle Purposes	Cattle income	21.11	13.33	33.33	32.22	0.8935	NS
	Cattle meat	20.00	14.44	47.78	17.78	2.0429	NS
	Cattle milk	32.22	2.22	63.33	2.22	0.4486	NS
	Cattle cultural purposes	20.00	14.44	50.00	15.56	3.2078	NS
	Cattle Prestige	22.22	12.22	55.67	8.89	5.8655	*
Cattle increases	Cattle buying	32.22	2.22	61.11	4.44	0.0035	NS
	Cattle reproduction	27.78	6.67	41.11	24.44	3.0495	NS
	Cattle gifts	32.22	2.22	56.67	8.89	1.0395	NS

*Significant difference ($P < 0.05$)

The reason why farmers advanced for rearing are to keep the grass down on marginal areas, aesthetic and cultural reasons. Focus group discussion revealed that households have animals or believe that cattle must be presented for ceremonial reasons. Cattle farming has greatly influenced the socioeconomic aspect of the communities at Msinga communities. As stated by Valdivia (2001) cattle production contributed socially, culturally and financially to the development of Msinga farmers.

Distribution by gender

The distribution of cattle showed that many owners (male =30, female = 11) have a few cattle (1). But as the number of cattle increase, the number of cattle owners decreases. This distribution is skewed. There was a sharp fall in the number of male owners as cattle increase. Though, fewer than male owners, female owners increased as cattle number increases

slightly, but fall (0) immediately. Focus group discussion revealed that in IsiZulu culture, women are not allowed to herd cattle they hired herdsmen, which are cost implicative and most male owners have the financial strength to pay for herding or herd cattle themselves.

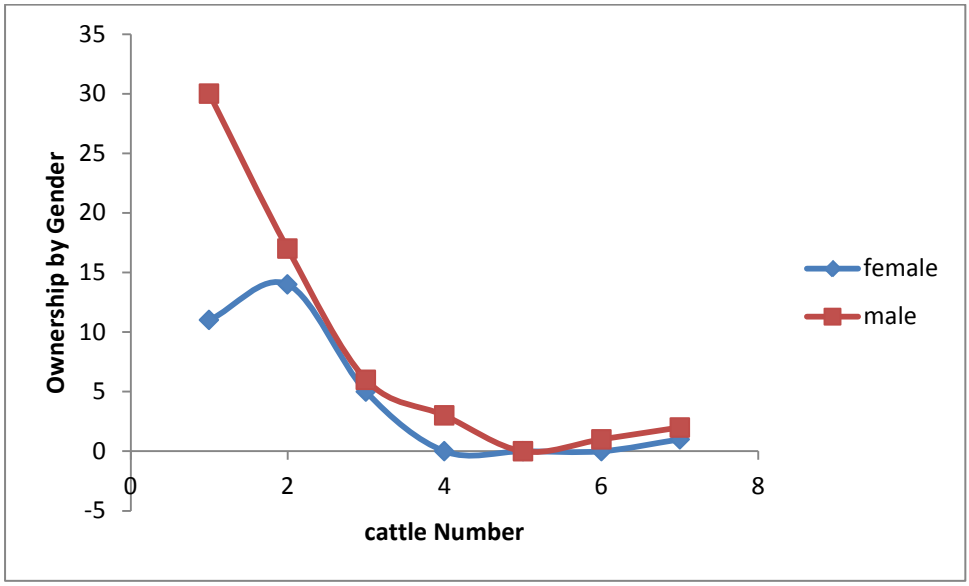


Figure 3:3: Distribution of cattle by gender: female owners (n = 31) and male owners (n = 59)

3.4.4 Health management

More male than female headed household vaccinated (Chi-square=12.422; P<0.01) goats and treated against goats disease (Chi-square=7.6131; P < 0.01). Similar proportion of female and males (P>0.05) had previous training (total 17.77%), provided drinking facility (total 33.33%), additional feed (total 69.89%), provided cattle with vaccination (total 61.11%), and treated against cattle diseases (32.33%; Table 3.7). In Table 3.6, 68.89% and 61.11% of the homesteads sampled indicated that they give self-medication to goats and cattle, respectively.

Survey results showed that 66.67% of farmers experienced re-occurring goat diseases and 25.56% of farmers experienced re-occurring cattle diseases across these communities. Close to 70.0% and 32.33% of farmers vaccinate goats and cattle (Table 3.6). As part of the health management routine such as identification and vaccination against infectious diseases in the kraal or environment is the duty of the farmer. Livestock should not be left unmanaged. Focus Group Discussion noted that farmers do not have a vaccination program for livestock.

Information and knowledge about livestock farming was acquired as a result of interpersonal relationship and cultural behaviour developed over time (DAEA, 2013).

Data showed that there is higher percentage of male owners who engaged in health management than female because they administer injections and takes cattle for dipping. Diagnosis of diseases in the area is characterized and influenced by environmental factors and poor management practices. Some medications usually used by farmers are Sulfazine16%, Vecoxan, Oxytetracyline (such as Hi-TET 200 LA, or Terramycin), Ivomec and cooking oil. Farmers explained that they were not familiar with symptoms of most diseases. It was noted during the focus group discussion that they used their initiative when they observe any symptoms, changes or unusual behaviour amidst livestock, before calling for veterinary intervention which usually come too late.

Data indicated that worm infection; pneumonia, foot rot, diarrhea and ticks & lice infections had been the most re-occurring diseases across these communities which were due to dirty water, unfavourable weather conditions, unsanitary kraaling facilities and lack of preventative measures (Focus Group Discussion).

Table 3:6: Variation of training, feeding and health routine practices as influenced by gender

Health routine	**Female (%)**		**Male (%)**		**Chi-Square**	**P Value**
	No	**Yes**	**No**	**Yes**		
Training livestock	30.00	4.44	52.22	13.33	0.7687	NS
Animal drink	17.78	16.67	22.22	43.33	2.6572	NS
Additional feed	25.56	8.89	41.11	24.44	1.2056	NS
Goat vaccination	18.89	15.56	12.22	53.33	12.422	**
Goat disease	16.67	17.78	13.33	52.22	7.6131	**
Cattle vaccination	13.33	21.11	25.56	40.00	0.0006	NS
Cattle disease	27.78	6.67	40.00	25.56	3.585	NS

**Significant difference (P <0.001), *Significant difference (P < 0.05)

3.5 Conclusion

Gender ownership had a great influence on goats and cattle productivity in Msinga Municipality. Gender differences based on the cultural views, purposes and norms are affecting the commercialization of goats and cattle. The input of ownership by gender also made a difference in livestock productivity. Financial constraints and labour required for livestock management routines is also a barrier towards production. By way of commendation, from all observations and surveys, a change of perspective will bring a positive change to livestock production in Msinga community. Empowerment programmes towards maximum profit of livestock production, especially as source of income will change the socioeconomic and developments in the Municipality. This will encourage farmers to improve management practices, adequate health programmes and good breeding selection. Secondly, proper establishment and management of cultivated pastures specific for livestock and water availability will greatly influence the production performance of livestock. Thirdly, livestock farmers should be educated in forage conservation methods such as silage, hay and other management practices. Since most farmers are practicing mixed farming, it is easier to prepare and store hay from crop residue. Fourthly, training to observe symptoms of common diseases and how to prevent should be created amongst farmers.

Chapter 4

SIGNIFICANT EFFECT OF SEASON ON RUMINANT FEEDING BEHAVIOUR AND BODY WEIGHT CHANGES

Abstract

This study was done to evaluate seasonal responses of ruminant based on roughage qualities, feeding behaviour, in vitro digestibility, gas production of fed forages and live body weight changes. Data from this study were captured over three seasonal periods (dry, early wet and late wet seasons). Observation were made for 48 hrs to determine feeding behaviour of cattle and goats at different seasons. Live weight changes were recorded at the start and end of each season. Selected livestock (three cattle and four goats) were dossed with a marker to determine the particle passage rate through the rumen and hind gut, and feacal samples were collected over seven days. *In vitro* digestibility was done to determine the dry matter digestibility and gas production of consumed forages. Sum of 66 cattle and 132 goats were sampled for live weight change, heart girth and length with calibrated weight tape measurement over three seasons. Data showed that there were seasonal ($P<0.05$) effects on the length of time cattle and goats spent grazing, ruminating, walking and standing in dry to early wet and to late wet seasons. Live weight changes differed ($P<0.05$) in dry and early wet compared to late wet seasons. Particle passage rate through the rumen and hind gut, digestion and retention times were different across seasons. Animal and season interaction affected ($P<0.001$) particle passage rate through the rumen and hindgut. *In vitro* gas production at 6 hrs and 44 hrs were different to 20 hrs. therefore quality forage should be taking in consideration, espercially during harsh seasons for maximum livestock productivity.

Key words: forages, behaviour, weight, rumen and digestibility

4.1 Introduction

Up to date research has been indicating that among all other factors that influences ruminant productivity is the feeding behaviour factor (Marcio et al., 2010). Ruminant responses (internally or externally) to many factors which contribute to their productivity. These factors can either be environmental, management, health, social interactions or feed, for example pastures (Helena et al., 2010); intake rate (Naomi, 2007; Allen, 1996; Fereira et al., 2012); management (Grant et al., 2001; Schwartzkopf-Genswein et al., 2003); season (Manzano et al., 2012), forage (Decruyenaere et al., 2009; Baumont et al., 2000) and concentrates (Rossini et al., 2012). Environmental factors are characterized by seasonal changes and temperature fluctuations, both of which can affect production. Feeding behaviour and weight changes have been identified as media by which ruminant respond to environmental changes (Sibbald et al., 2000).

Getting cattle through different seasons has been a major problem, especially in dry season (Brian et al., 2007) without compromising performance; livestock needs to maintain body condition throughout seasons. This is mostly affected by the fluctuation in cost of feeding and ruminant behaviour response to feeding. Feeding behaviour consists of long and short term activities (Schwartzkopf-Genswein et al., 2003). These involve eating, chewing, ruminating and drinking over a 24 hours period. Either ruminant animals prefer specific roughage or speed more feeding time on a particular roughage diet, both are major determining factors to tolerability and utilization of roughage diet (Tucker et al., 2007).

Baumont et al. (2000) established a significant difference between the motivation to eat and feed factors that influences feeding behavior. Researchers suggested that rumen fill plays a major factor in the feeding rate of roughages, through the physical load of the fore-stomachs (Rossini et al., 2012; Manzono et al., 2012; Bezabiha et al., 2012); Fereira et al., 2012; Myer

and Elzo, 2010). Determining factors to acceptability, feeding rate and utilization of roughage diets by ruminants is influenced by physiological need (productivity) and quality of roughage (Tucker et al., 2007).

Achieving a better understanding of the constraints involved in low feeding rate of ruminants will help improve the prediction of daily intake variation and build new criteria for assessing roughage quality. Variability in feeding rate among ruminant animal introduces an assortment of complex biological problems. Many of these have not been effectively demarcated for ruminants; nevertheless, imminent and measurements made in the past two decades have resulted in several functional predictive equations, with specificity for the physiological function mimicked through models (Nsahlai et al., 2007).

Energy for lactation influenced feeding rate than for maintenance (Ball et al., 2001; Luo et al., 2004). Other changes arise from weight gain or loss, gestation, activity, and climate (Nardone, 2006). However, knowledge of these bounds of the homoeothermic status of cattle and physical constraints on feed intake were useful methods for developing a prediction equation of feed rate (Allen, 2000; Guicharnaud et al., 2010).

Forbes (1995) suggested that fiber mass initiate decrease of feeding time when the cell wall content of the diet is 60% or more on a dry matter basis. This fiber initiates a decrease in the length of time animals spends feeding. When inert bulky materials (Faverdin et al., 1995) or dry hay (Schwartzkopf-Genswein et al., 2003; Boudon et al., 2009) were placed into the rumen, the feeding rate was decreased, but not as much as expected. Dove (1996) indicated that the amount of high fiber diets that ruminants can consume varies with the proportion of structural carbohydrates, so grasses contain more cell wall and less lignin than legumes at similar vegetative stages, which limits the feeding time of grasses more than that of legumes. This establishes that quality, palatability of the feed initiate feeding behavior (Baumont, 2000). It is an important and sensitive aspect of the ruminant animal.

Also nutritive value of diets has been found to contribute to feeding behaviour of ruminants. Carlotto (2010) reported that diets with high fibre content increases the chewing and ruminating time. Feeding time of high quality silages depends on meal sizes and it's availability between meals. Studies show that among factors that influence feeding behaviour are particle size, forage dry matter content, height and density of sward (Baumont, 1996).

Ruminants divide their feeding time into a series of meals separated by non-feeding intervals. The intersection point between, within-meal and between-meal distributions define the meal criterion for ruminant animal (Mayes et al., 2010). Moreover, ruminant usually exhibits daily rhythm of maintenance behaviour. Factors such as space availability, social dominance and feeding regime influenced feed intake and milk yield (Olofesson, 2000). Furthermore, an aspect like feeding has an impact on the rumen environment, where less frequent feeding have a negative influence (Le Liboux et al., 1999) and increased feeding frequency increases milk yield (Faverdin et al., 1995).

The nature of the ruminant's compartment makes them to be able to digest fibrous materials. Larger particles are discriminately retained in the reticulo-rumen, to be subjected to microbial fermentation. It has been reported that longer retention times increase digestibility but gut fill due to longer retention time reduces feed intake (Le Liboux et al., 1999). Studies also show that individual forage quality is likely to affect retention time, especially when fed to ruminants (Zanine, 2007; Carlaotto, 2010; Marcio, 2012).

However, there is a substantial effort in studying how animals respond to roughage diets. Ruminant animals have evolved the ability to consume and digest fibrous material (Nsahlai et al., 2003). Roughages quality is important as it affects subsequent utilization by ruminant animals which may in-turn affect patterns of nutrient absorption (Morris, 1998). The production performance of farm animals within their genetic limits depends on the level of

intake and the quality of the diet ingested (Coleman and Moore, 2003). Accurate measurement of feed intake and digestibility are, in this respect, important to meet nutritional requirements of the animal and optimize production (Mayes et al., 2000). Feed intake, diet composition and dietary nutrient digestibility are, however, difficult to measure accurately in free-ranging animals, and often indirect methods have to be used.

Adaptations of specific species to diets due to physiological characteristics of the gut and body size are contributing factor to passage rate (Gordon et al., 1994; Robbins et al., 1995). Rate of passage regulates the length of time feed spends in the digestive tract. Extent of digestion depends on retention time (Okine et al., 1991). Digesta passage rate varies with the feed structure and livestock species. For example Zhigang (1996) reported that roughage feeders generally have longer retention times, larger gut fill and more complete digestion of forage than do concentrate selectors. Therefore, this study aims at (1) evaluating seasonal ruminant feeding behaviour and roughage qualities, (2) seasonal effects on in vitro digestibility and particle passage rate in ruminants, (3) seasonal effects on body weight changes, and (4) verify of the accuracy of calibrate weight tape for cattle and goats.

4.2 Materials and methods

4.2.1 Livestock and management system

Two communities (Nxamalala and Madulaneni) were selected at Msinga Municipality based on the population of livestock. Major breeds of cattle and goats found in this area are the “Nguni breeds”. Farmers with both small and large ruminants were used for this trial. The herd of selected farmers consists of cows, heifers, bulls, steers and calves while individual flock of goats consist of bucks and does of different ages. Livestock farmers were selected from Nxamalala and Madulaneni communities. During the night, cattle and goats are kept in separate kraals. Every farmer has self-built and fenced area called Kraal where they keep livestock arriving back from grazing (Appendix 7). Fences are either wire or wood. During

the day, animals are free to graze on the communal system of farming. Sometimes, farmers herd cattle to graze on cultivated garden plots having leftover from harvested maize plots (Focus Group Discussion), animals graze the same communal land repeated. At trial times, animals were followed for observation at a distant range.

4.2.2 Experimental procedures and data collection

Data collection was divided into four phases based on the objectives of this trial, which are behaviour observation data, weight change data, passage rate, digestibility of feed.

Behaviour observation

This study was directed in the north central part of KwaZulu-Natal province, Umzinyathi District, Msinga Municipality of South Africa. It is encompassing area of 2500kms^2 with six traditional authorities. The study commenced with three seasonal sessions. The first phase came up at dry season (24th July – 15th August), second phase resumed at early wet season (5th December – 20th December), while the third phase started at late wet season (21th February – 6th March).

A total number of seven (7) ruminants were selected three (3) goats X four (4) cattle from each community. Observation data were recorded every 2 minutes between the hours of 08:00 to 16:00 every day for two (2) days (Appendix 8). Data collection was repeated over 3 seasons namely: dry season, early wet season and late wet season. Kraal containing both cattle and goats are selected. The average body weight of goats and cattle were 27±6.1 kg and 268±20.3 kg respectively. Recorded behaviours were grazing, walking, ruminating/chewing, resting, standing, horning, drinking and urinating as described in Table 4.1.

Table 4:1 Behaviour definitions

Behaviour	Description
Standing	Animal is standing, without doing any physical activity
Resting	Animal lying down, without doing any other physical activity.
Grazing	Animal either standing or walking in grass with its head in a downward position.
Combating/Playing	Two animals of the same or different species interacting, for example fighting, mating, wooing.
Ruminating/chewing	Animal chewing, without any physical foodstuff in the month both when resting, standing and moving.
Walking	Animal moving (slow or fast), without engaging in any other physical activity like horning or playing.
Urinating	Animal is standing passing out liquid waste, without doing any other physical activity.
Drinking	Animal is standing with its head in a downward position to suck water, without doing any other physical activity.

***In-vitro* digestibility determination and gas production**

Livestock were released on free range system, to feed on available forage and grasses on the field at various seasons. During week sampling for each season, forage samples were taken on pastures based on what animals were observed to feed on and taken to the laboratory for identification. A list of sampled forages and shrubs in different seasons that animals were observed to feed on pasture during the feeding behaviour studies is presented (Table 4.2). Each of these dietary items was sampled, prepared for *in-vitro* digestibility by oven drying at 100^0C for 3 days and milling through a 1- mm sieve (Tilly and Terry, 1963; Nsahlai, 2003, Appendix 9). These samples were incubated using a two stage procedure where feed samples

were initially digested under anaerobic conditions for 44 hours before centrifuging and decanting the supernatant.

In vitro gas production was done in duplicates following the method described by Schofield (1994). Salivary buffer solution was prepared agreeing to Okine (1991). Approximately, 76 mL solution of the buffer solution was added to each bottle containing 1g of feed sample and blank bottle. Then bottles were kept in the incubator at 39^0C for 1 hour to allow soaking pending the addition of the rumen fluid. Temporarily, rumen fluid was collected into a litter bottle after filtering through four layers of cheese clothes and kept in a pre-warm flask at 39^0C that had been repeatedly flushed with CO_2. After adding rumen fluid to bottles containing the sample with buffer solution, it was deoxygenated by blowing with CO_2 then bottle lids tightened. Pressure was logged at 20 min intervals for 48 hours incubation. Gas production for 6 hours, 20 hours and 44 hours were calculated.

Table 4:2: Observed consumed seasonal forages and shrubs

Season	Forage	Common name	Types	Codes
Dry	*Rhus rehmanniana*	Blunt-leaved currant	Browse	G1
	Senna didymobotrya	African senna	Legume	G2
	Cynodon dactylon	Bermuda grass	Grass	G3
	Digitaria erintha	Finger grass	Grass	G4
	Rhus chirindensis	Red currant	Browse	G6
	Boscia foetida	Smelly shepherd's tree	Shrub	G8
	Maize stover	-	Grass	G9
	Lueucine grass	Lueucine grass	Grass	G10
Early Wet	*Hyparrhenia hirtaspp*	Common thatching grass	Grass	G11
	Acacia karroo	Karoo Thorn	Shrub	G7
	Dactyloctenium spp	Egyptian crowfoot grass	Grass	G12
	Urochloa panicoides	Herringbone grass	Grass	G13
	Cynodon spp	Dog's Tooth grass	Grass	G14
	Sporobolus africanus	Parramatta Grass	Grass	G15
Late Wet	*Brachiaria brizantha*	Signal grass	Grass	G16
	Eragrostis cilianensis	Stink grass	Grass	G17
	Eragrostis plana	Tough Love-grass	Grass	G18
	Brachiaria serrata	Red top grass	Grass	G19
	Eleusine coracana	Finger millet	Legume	G20
	Themeda triandra	Red grass	Grass	G5

Rate of passage of feed particles

The particulate marker used was chromium mordanting for fibrous materials as solid marker or using Ytterbium. Preparation of chromium and Ytterbium markers were done according to Uden et al (1980). Approximately 0.128g of $Yb.6H_2O$ or 40g of Cr-mordanted fibre was dosed to a goat and 0.64g of $Yb.6H_2O$ or 60g of Cr-mordanted fibre was dosed to cattle. Cr-mordanted fibre contained 4.8% Cr DM (g^{-1}). Markers were introduced into the rumen 30 - 40 minutes before animals were allowed to graze on the field, then faecal collections were

taken during the following times (0, 3, 6, 9, 12, 24, 27, 30, 33, 36, 48, 60, 72, 84, 96, 108, 120, 132, 146, 158, and 170) hours after dossing. Samples were placed in kaki envelopes, air dried and subsequently dried at 60^0C for 72 hours. These samples were later milled into 2-mm sieve using laboratory hammer miller. Later, 1-g samples were ashed at 550^0C, (Nsahlai, 1991), the ashed solution using nitric acids and made to a final volume of 100 ml. These faecal sampled were analysed for Chromium or Ytterbium using Inductively Coupled Plasma Mass Spectrometry (ICP-MS, Appendix 10) (Yip et al., 2007).

Live weight and calibrated tape measurements

A total 66 cattle and 132 goats were sampled for live weight changes, heart girth and length. All these animals were weighed for body weight and heart girth and length were taken over three seasons (Dry, Early wet and Late wet seasons). During each season, live weight was taken at the beginning and end; to capture weight changes for that particular season. Periods of measurement were as follows: Dry season (1^{st} week of June and 3^{rd} week August); Early wet (2^{nd} week September and 3^{rd} week December) and Late wet (3^{rd} week December and 1^{st} March).

A total of 44 cattle and 141 goats were used to predict body weight by calibrated weight tape. Predicted values were obtained using weight tapes of cattle or goats. The measurement for cattle was only taken in dry and late wet seasons while the measurement for goats was taken in early wet and late wet. A tape was used to measure the heart girth and the length of the animals. Length was measured as the distance from the poll to the rump of goat and from the poll to the tail head of cattle; and heart girth was the chest conference. These measurements were later converted to live weight using a calibrated weight tape for cattle and goats. The relationship of the weight and the live weight of animals were compared.

4.2.3 Statistical Analysis

Relating to the effect of season on goats and cattle feeding behaviour, in vitro digestibility of sampled forages, live weight changes and in vitro gas production were analyzed using the general linear models (GLM) procedure of SAS program (2013). The statistical model accounted for behavioural responses of goats and cattle, dry matter digestibility, initial and final weight changes, particles passage rate in the rumen and hind gut, particles retention times in the rumen and hind gut. Separation of means was done using the Student Newman Keuls Test (SNK) (SAS, 2013). Live weight changes of goats and cattle, and predicted weight by calibrated tape were subject to the analysis of variance using the regression model of SAS (SAS, 2002). Statistical models were:

(a) For feeding behaviour of animals:

$$Y_{ijk} = \mu + S_i + C_j + e_{ijk}$$

Where: Y_{ijk} = dependent variable (management routines by gender), μ = overall mean, S_i = Effect of dry, early and late wet seasons, C_j = Effect of community

(b) For in vitro digestibility: Apparat dry digestibility and gas production:

$$Y_{ijk} = \mu + S_i + G(S)_j + e_{ijk}$$

Where: Y_{ijk} = dependent variable (Apparate dry matter digestibility or gas production), μ = overall mean, S_i = Effect of dry, early and late wet seasons, $G(S)_j$ = Effect of grass within season.

(c) For particle passage rate:

$$Y_{ijklm} = \mu + S_i + C_j + A_k + S*A_l + e_{ijklm}$$

Where: Y_{ijklm} = dependent variable (particle passage rate), μ = overall mean, S_i = Effect of dry, early and late wet seasons, C_j = Effect of community, A_k = Effect of animal type, $S*A_l$ = Effect of animal and season interaction.

(d) For body lives weight:

$$Y_{ijkl} = \mu + S_i + C_j + S \times C_{(ij)} + e_{ijkl}$$

Where: Y_{ijkl} = dependent variable (live body weight changes), μ = overall mean, S_i = Effect of dry, early and late wet seasons, C_j = Effect of communities, $S \times C_{(ij)}$ = Effect of community and season interaction.

(e) For predicted live body weight:

$$\mathbf{Y}_{ij} = \mu + b_i X + e_{ij}$$

Where Y_{ij} = final live body weight of the animal, μ = intercept, b_i = slope, **X** = live body weight from calibrated tape weight.

4.3 Results and Discussion

4.3.1 Feeding behavioural response of cattle and goats to different seasons

Feeding behaviour of cattle

Season affected (P <0.01) the length of time the cattle spent: standing/combating (F_{Value} = 8.07; P < 0.01), ruminating/resting (F_{Value} = 5.55; P < 0.01) and walking (F_{Value} = 6.06; P < 0.01), grazing (F_{Value} = 3.87; P < 0.05) and drinking time (F_{Value} = 3.31; P < 0.05) (Table 4.3). Cattle spent similar length of time in dry season (mean= 28.75) and early wet season (mean=35.41) standing/ horning which was higher than in late wet season (mean= 11.00). Cattle also spent more time grazing in early wet season than in late wet season, both of which were similar to dry season. Cattle spent more time ruminating in early wet season than in dry season and in dry season than in late wet season. Cattle spent more time drinking in early wet season than in late wet season, both of which were similar to dry season. Cattle spent more time walking in early wet season than in dry season both of which differed from late wet season.

Seasonal effects had a direct impact on feeding behaviour. This compliment the report on factors affecting intake by grazing ruminants and related quantification by Decruyenaere (2009) quoting Dumont (2003) that "environment herbivores learning also plays an important role in resource utilization. Therefore, there is a relationship between grazing animals and the environment (keeping into memory food allowance, location and distribution). The time cattle spent on standing/horning, walking and ruminating/resting was significantly different in dry/ early wet season compare to late wet season. This confirms Baumont (2000) that seasons contribute to ruminant behavoiur. Due to low temperature in winter, cattle were more

active in late wet season (standing, horning, and walking) so as to increase body temperature. Social activities were intensed coupled with the metabolic heat generated. This is to maintain the alteration in temperature caused by seasonal effects. This accords with the study reported by Atrian (2007) and Tucker (2007) that high ambient temperature reduces ruminant activities. Another cattle behaviour that is affected by seasonal changes is walking ($P < 0.01$).

Cattle spent more time searching for food items from available roughages to graze. Walking is another activity that increases body temperature. Because less forage is availability and poorly distributed spatially during dry and early wet seasons, cattle increase their walking behavioural activities in search of forage (Garcia et al., 2003). The rate of cattle rumination and resting increases with changes to the environment ($P < 0.01$). This is as a result of fall in ambient temperature. Therefore, cattle keep high metabolic rate in order to increase heat production and maintain normal body temperature (Tarr, 2007). When rumination increases, it places a demand on intake rate, which will definitely increase as well. But when there is no available forage to meet the intake rate demand, it results to loss of energy and live weight.

Furthermore, intake is affected by seasonal changes in grazing and drinking time. Seasonal effect was significantly different to grazing and drinking ($P <0.05$). Grazing behaviour (time) was very higher in dry and early wet seasons compared to late wet season. This supports the observation reported by Boval (2007) that defoliation increases the total grazing times. Because of high forage defoliation in dry and early wet seasons, little was left over on the pastures for grazing. Reduction in grazing time during the day at late wet season was also a behavoiural response of ruminants to seasonal temperature. This was also confirmed by Baumont (2000) that ruminants tends to adjust their grazing behaviour to early or late hours at late summer when temperature is above 25%, such that it will not affect the daily intake rate.

Cattle tend to graze more in early wet season because new succulent grasses are sprouting up. This agree with the report by Decruyenaere (2009) that ruminant increases bite rate with increase in grazing time. This behaviour is also motivated by cattle being able to find preferred forage on pasture. They graze less in winter because of the availability of dry matter on pasture is low (Awad et al., 2012). High retention time caused by the seasonal forages also contribute to less grazing time of cattle. Urinating behaviour was not significantly different in all the seasons.

Walking is another behaviour that was influenced by seasonal changes. There was more walking in the early wet season than dry season, which is greater than late wet season. This is because cattle tend to walk long distances in search for forages in dry season and for more choices of forages in late wet season.

Table 4:3: Effect of season on feeding behaviour of cattle and goats

Livestock Variable	**Seasons**					
	Dry	**Early wet**	**Late wet**	***RMSE***	**F_{Value}**	**P - value**
Cattle						
Standing/Combating	28.8^{a}	35.4^{a}	11.0^{b}	15.38	8.07	**
Grazing	177.3^{ab}	220.9^{a}	150.1^{b}	62.93	3.87	*
Ruminating/Resting	24.2^{b}	45.3^{a}	11.7^{b}	25.02	5.55	**
Drinking	9.3^{ab}	13.7^{a}	2.3^{b}	10.88	3.31	*
Urinating	4.5^{a}	7.1^{a}	1.3^{a}	5.82	3.03	NS
Walking	83.1^{b}	114.0^{a}	62.3^{b}	36.64	6.06	**
Goats						
Standing/Combating	33.2^{a}	10.1^{b}	19.5^{b}	17.40	7.14	**
Grazing	200.7^{a}	152.9^{a}	188.9^{a}	70.23	2.01	NS
Ruminating/Resting	48.0^{a}	26.6^{a}	33.1^{a}	36.63	1.43	NS
Drinking	2.81^{a}	0.1^{a}	1.1^{a}	4.13	1.73	NS
Urinating	3.0^{a}	1.0^{a}	2.9^{a}	2.89	2.48	NS
Walking	104.9^{a}	76.6^{a}	88.7^{a}	45.43	1.56	NS

Means in the same with different super-scripts are significantly different. ** Significant different ($P < 0.01$); * Significant different ($P < 0.05$); ^{NS} Not significant

Feeding behaviour of goats

Goats spent more ($P<0.01$) time standing or horning one another in dry season than early and in early wet season than in late wet season. Goats spent similar length of time in grazing (180.3±70.2), ruminating/resting (35.8±36.6), drinking (1.4±4.1), urinating (2.3±2.9), and walking (90.0±45.4) across the three seasons. This may changes in ambient temperature which directly affects goats' activities, thus contradicting Donkin (2006) that goats are more active in early wet season temperature than dry season. It could well be that when feed is less available goats vent this frustration by fighting.

Consequently, standing and horning was very high in goats' during dry season compare to early and late wet seasons. Because heat generated through fermentation is very low compared to require body temperature, so goats engaged more activities to sustain them against cold temperature in winter. But grazing behaviour, ruminating behaviour, drinking behaviour, urinating behaviour and walking were not affected by seasons. It disputes the study by Klopfenstein (2001) that availability of nutritious forages in respective of seasons, may increase ruminants time spend on walking. And also, it does not support the report made by Dziba (2003) that rumination rate increases from dry to wet seasons by 50%. Sibbald (2000) had similar report that interaction between ruminant and pasture quality influence ruminant behaviour. Grazing time of small ruminants is higher in homogenous vegetation when the pasture size ($200m^2$) per head will not have a negative impact on intake (Grant et al., 2001).

4.3.2 *In vitro* digestibility of consumed forages

Differences among dry matter digestibility of consumed forages were significant for forage within a season. ($P< .001$, Table 4.4), but the effect of season was not ($P > 0.05$). This implies that forage qualities hardly varied from season to season. Allen (2000) stated that seasonal

changes affect forage qualities which at the same time influences forage digestibility in ruminants.

Table 4:4: Effect of season on *in vitro* gas production of consumed forages

Grass codes	Dry	Early wet	Late wet	*RMSE*	Season	Grass(Season)
G1	44.620^{cd}	-	-	-	-	-
G2	66.230^{a}	-	-	-	-	-
G3	35.115^{cde}	-	-	-	-	-
G4	74.165^{a}	-	-	-	-	-
G6	43.720^{cd}	-	-	-	-	-
G8	47.890^{bcd}	-	-	-	-	-
G9	32.420^{de}	-	-	-	-	-
G10	24.840^{e}	-	-	-	-	-
G7	-	49.117^{bcd}	-	-	-	-
G11	-	48.675^{bcd}	-	-	-	-
G12	-	47.640^{bcd}	-	-	-	-
G13	-	44.260^{cd}	-	-	-	-
G14	-	23.850^{e}	-	-	-	-
G15	-	41.650^{cd}	-	-	-	-
G16	-	-	33.490^{cde}	-	-	-
G17	-	-	51.510^{bc}	-	-	-
G18	-	-	61.865^{ab}	-	-	-
G19	-	-	68.655^{a}	-	-	-
G20	-	-	34.713^{cde}	-	-	-
G5	-	-	35.430^{cde}	-	-	-
ADM	45.2^{b}	41.0^{c}	50.8^{a}	5.29	0.2251	< 0.0001
Gas production						
6 hours	21.2	19.1	9.8	5.59	<0.0001	0.0100
20 hours	34.9	37.2	32.8	11.34	0.3787	0.0057
44 hours	45.6	67.5	51.6	13.10	0.0057	0.0428

Gas production

Grass within season affect the apparate dry matter digestibility of consumed grasses. Seasonal changes affected the *in vitro* gas production of consumed forages at 6 hours ($P < .0001$) and 44 hours ($P < 0.05$). Comparison among forage within a season was also

significant at 6 hours ($P < 0.01$) and at 44 hours ($P < 0.05$) in gas production (Table 4.4). Season means at early hours of *in vitro* gas production (6 hours) was significantly different; dry and early wet seasons compared to late wet season. Comparing dry and early wet seasons to late wet season at 44 hours revealed different *in vitro* gas production (Table 4.4). This condord with Krauss (2007) and Mohamed (2011) that seasonal changes of consumed forages have direct effect of the quality of forages, rumen fermentation and gas processes in goats and cattle.

4.3.3 Rate of passage of feed particles in the rumen and hind gut

Particle passage rate in the rumen and hind gut of goats and cattle

The rate passage of particle through the rumen (0.035 in cattle vs 0.036 in goats) and hindgut (0.083 in cattle vs 0.068) was not affected ($P > 0.05$) by animal species, consequently these animals have similar transit time (53.72h in cattle vs 10.6h in goats), rumen retention time (46.8h in cattle vs 52.6h in goats), hindgut retention time (16.7h in cattle vs 21.9h in goats) and mean retention time (117.2 in cattle vs 85.1h in goats) (Table 4.5). Season affected ($P <0.0001$) the rate passage of particle through the rumen whereby it was the highest in late wet season (0.052), intermediate in early wet season (0.041) and slowest in dry season (0.013). The interaction of animal species and season affected both rates of passage through the rumen ($P < 0.001$) and hindgut ($P < 0.01$). Values for goats and cattle were similar in dry season but became respectively very different in early wet (0.027 vs 0.055) and late wet seasons (0.067 vs 0.037) (Appendix 12, Table 4.5).

As reported by Taweel (2004) ruminants responses to seasonal changes by reconditioning and controlling the metabolic activities in the rumen. Passage rate of particle in the rumen is slow in drought areas and dry season because decreases in intake level (Coleman and Moore, 2003), but both ruminants responded to season at different times due to their body morphological function and capacity. Goats responded faster and have higher rate of particle

passage in the rumen in late wet season due to the fact that forages are more palatable and succulent with high moisture content in this season compare to dry and early seasons. While at late wet seasion, cattle responded averagely compare to goats because they are large ruminants. Grant (2001) reported that large ruminants respond slowly (via their body conditions) to seasonal effects. Particle passage rate in the hind gut, also follow the same pattern with late wet, dry and early wet sesons because late wet season pasture are easily digest and move faster in the digestive tract.

Season failed to affect the transit time through the gastro intestinal trait (dry (10.0h, early wet 25.1h, and late wet seasons 61.4h). Season affected the retention time of particle through the rumen whereby it was the highest in dry season (91.1h), intermediate in early wet season 93.4h) and slowest in late wet season (23.2h). In dry season, rate of digestion is slow because forages are tough with high dry matter, low moisture and crude protein contents, and is insufficient therefore necessitating longer rumen retention time at lower rate of digestion (Allen, 2000).

Rumen retention time of particle is highest in dry season, compared to early and late wet seasons. This is because there is forage scarcity in winter on the grazing pastures which is traceable as a seasonal effect. This suggest that when given limited amount of fibrous forage, ruminant would tend to retain the limited volume of digesta for a longer period, as such helping in digestion. This agreed to the study made by Allen (2000) that rate of intake initiate rumen particle passage rate which influences the retention time. Also the quality of roughage determines rumen retention time (Klopfenstein, 2001). The toughness or succulent of forage affects the dry matter digestibility which in turns has the ability to influence the rumen retention time. Conversely to other seasons where ruminants found more available forages on pasture which increases the intake, the rumen retention time and transition time of particle was faster (Morris, 1998). Rumen retention time and hind gut retention time of particle of

goats are higher than cattle which agree with Forbes (1995) that small ruminants have more rumen control ability than large ruminants. Also, quality differences of consumed foragedue to seasonal changes can affect dry matter digestibility, as it was reported by Allen (2000) that different types of pasture and their qualities affects % dry mater digestibility.

Our results on *in vitro* gas production during 6 hours agree with Mucheru-Muna et al (2007) and suggest that pasture regrow was very slow because of delay in rainfall during early wet season. This agrees with the study made by Mucheru-Muna (2007) and Oladapo (2009) that quality of forage during wet seasons is of poor nutritive value.

Table 4:5: Means of particles passage rate in different seasons of goats and cattle

	Seasons	**Ap1**	**Kp1**	**AP2**	**KP2**	**Ttp**	**Rrtp**	**Hrtp**	**Mrtp**
Goat	Dry	2.2	0.014	2.0	0.041	5.0	97.5	31.5	83.3
	Early wet	2.6	0.027	3.0	0.058	11.6	44.0	24.1	79.7
	Late wet	5.9	0.067	6.4	0.106	15.2	16.4	10.1	41.7
Cattle	Dry	1.9	0.013	3.1	0.105	14.9	84.7	13.8	113.5
	Early wet	3.4	0.055	3.5	0.086	111.3	25.7	17.9	154.8
	Late wet	2.0	0.036	2.7	0.059	34.9	29.9	18.4	83.3
Effects	*RMSE*	1.36	0.02	1.96	0.04	85.61	30.73	13.24	94.1
	Coeff. Var.		45.23		48.76	320.61	63.35	65.68	98.72
	Community		0.93		0.49	0.36	0.13	0.15	0.13
	Season		<.0001		0.71	0.38	<.0001	0.31	0.26
	Animal		0.82		0.23	0.17	0.59	0.28	0.35
	Season*Animal		0.0006		0.004	0.40	0.42	0.10	0.52
	P Value		<.0001		0.02	0.39	0.0002	0.05	0.24

Kp1- particle passage rate in the rumen, Ap1- Intercept point, Kp2- particle passage rate in the hind gut, Ap2- intercept point, Ttp- Transaction time of particle, Rrtp- rumen retention time particle, Hrtp- hind gut retention particle, Mrtp- mean retention time particle

4.3.4 Livestock live weight changes

Cattle live weight

Live weights at the start of the season were similar, and so were heart girth and back length (Table 4.6). Live weight changes were negative in dry and late wet seasons but positive in early wet season with outstanding differences ($P < 0.0001$). Consequently, the final live weight differed among seasons in the order: early wet > late wet > dry.

The weight loss observed in dry season was higher than late wet season, because there is no forage on the pasture, available feed were leaves of trees and sweetverd grasses during dry season. Cattle regained weight in early summer as a result of enough sprouting of grasses which were succulent with high nutritive value. During early wet season, cattle have more choices of forage they can select from on pasture compared to dry and late wet seasons. Therefore, cattle only have the chance of recovering weight loss during dry and late wet seasons are in early wet season.

Heart girth and back length decreased in late wet season (14.8m ±4.0) than in dry season (15.4m ±2.3). Hearth girth and length changes can be related to insufficient feed intake during late summer because feeding at ad libitum will increase the chest circumference size due to expansion in the rumen and hind gut. Though, other factors such as growth rate, sex and age also affect ruminant girth and back length. Seasons has little effect on girth and back length. Community effects on live weight changes, hearth girth and length of cattle were also reported (Appendix 13).

Table 4:6: Effect of different seasons on cattle weight, heart girth and back length (mean± SD)

	Seasons					
	Dry	**Early wet**	**Late wet**	***RMSE***	**F Value**	**Pr > F**
Cattle	**(n = 23)**	**(n = 18)**	**(n = 25)**			
Initial Weight (kg)	247.9±96.5	279.2±92.2	269.3±96.5	91.16	0.68	0.5125
Final Weight (kg)	214.8±83.6	317.3±91.7	261.2±87.9	85.00	7.51	0.0012
Live weight change (kg)	-842±873.8	604±146.4	-126.±647.7	661.98	23.93	<.0001
Heart Girth (kg)	15.4±2.3	-	14.8±4.0	3.31	0.30	0.5849
Back length (kg)	17.7±1.6	-	16.9±3.7	3.06	0.65	0.4262
Goat	**(n =31)**	**(n = 70)**	**(n = 71)**			
Initial Weight (kg)	23.6±7.9	22.4±7.1	22.7±7.6	7.49	0.68	0.5096
Final Weight (kg)	21.1±7.3	22.9±9.1	24.6±7.9	8.28	1.38	0.2549
Live weight change (kg)	-65.3±83.8	75.8±22.8	30.8±41.1	48.11	78.83	<.0001
Heart Girth (kg)	-	7.3±1.1	7.5±1.1	1.12	1.60	0.2080
Back length (kg)	-	8.9±1.3	8.6±.2	1.25	1.29	0.2582

Goats live weight

Live weight of goats at the start of the season was similar and so were heart girth and back length (Table 4.6) above. Live weight changes were negative in dry season (-65.3 kg ±83.8) but positive in early wet (75.8 kg ±22.8) and late wet seasons (30.8 kg ±41.1) with outstanding differences ($P < 0.0001$). Hence, the final live weight differed among seasons in the order: early wet > late wet > dry. Goats recover fast in early wet season as they lose weight fast during dry season. This is because goats adjust easily to environmental changes than cattle (means = -65.29 kg, -842.17 kg), respectively. Because goats are small ruminants, malnutrition and poor grazing reflected on live weight easily than large ruminants. There was a gradually recovery of body weight loss in early wet to late wet seasons. Mysterud (2001) reported that small ruminant responsed to seasonal changes through feeding behaviour and

live weight than large ruminants. So goats would tend to browse 75% of the time, which is much higher than in cattle. Community differences on goats weight change, hearth girth and length were also reported (Appendix 13).

4.3.5 Relationship between live weight and calibrated tape weight measurement

There was very poor linear relationship between predicted body weight and live weight of cattle (R^2 = 0.265, Figure 4.1), while the relationship was average with live weight of goats (R^2 = 0.5513, Figure 4.2).

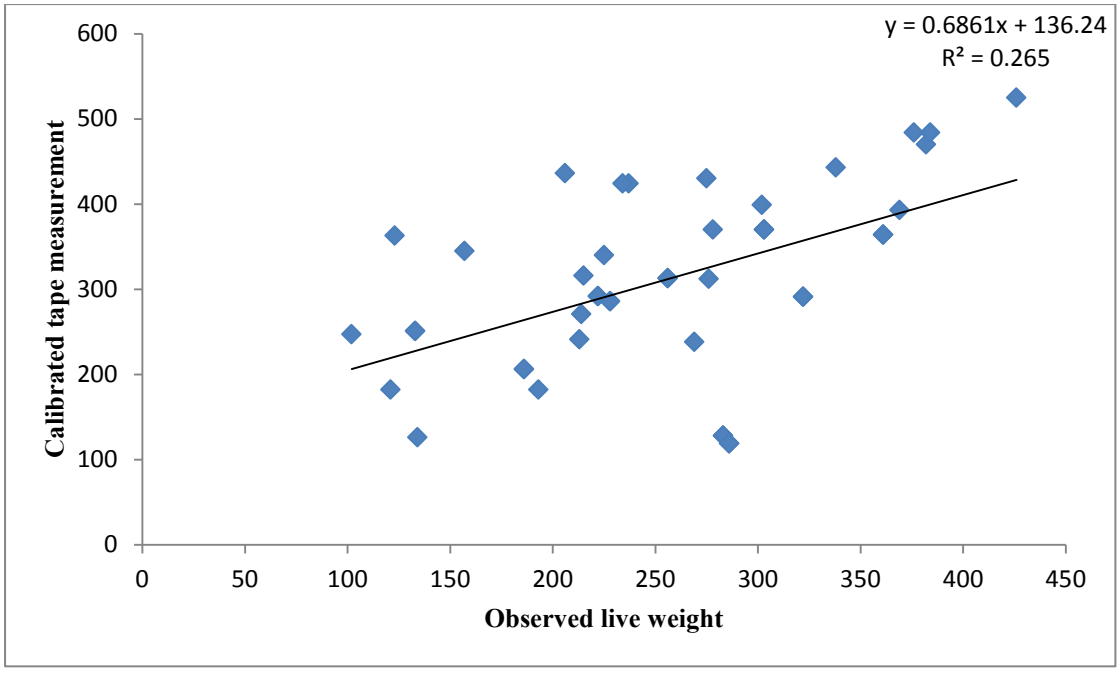


Figure 4:1: The relationship between observed and predicted live weight of cattle

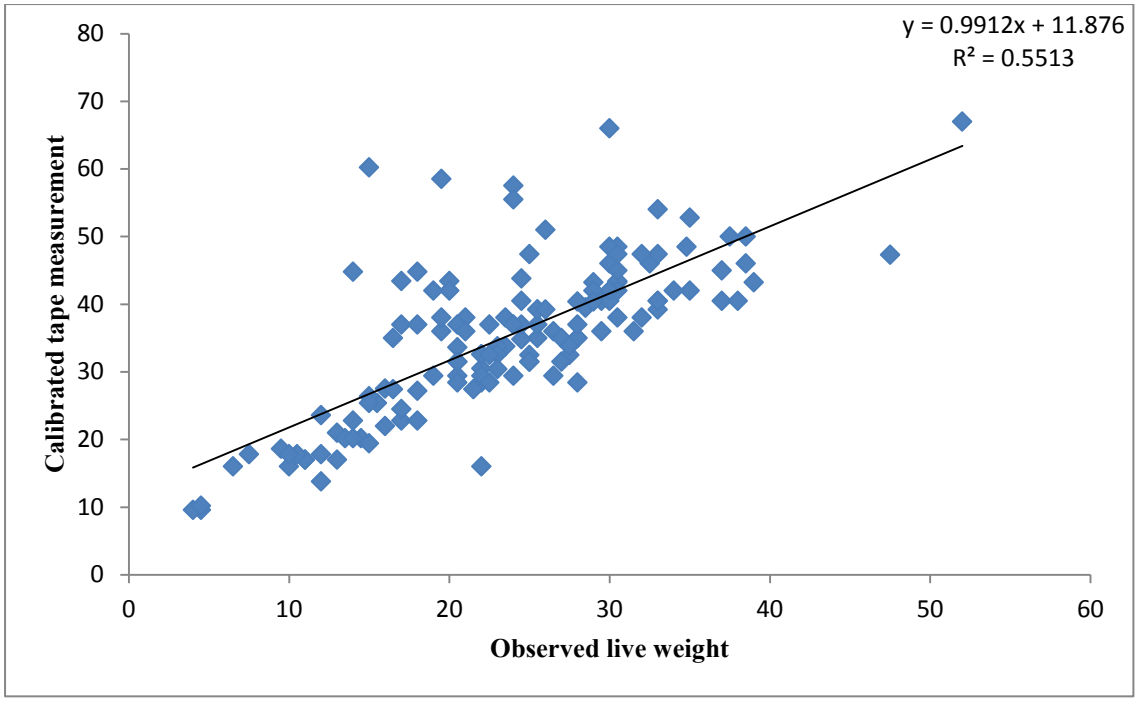


Figure 4:2: The relationship between observed and predicted live weight of goats

Regression relationship between the predicted live weight and observed live weight of goats was strong ($P < 0.01$, Table 4.7). This implies that the predicted tape has less error when used to measure live weight of goats. The intercept of this relationship was not different from zero and the slope was not different from unity. Goat calibrated weight-tape can be used to measure live-weight changes across seasons. For every change in Predicted weight (Pwt), the rate of change of final weight (Y) increases by 1.03. The P – value of goat live weight (0.0001) is significant; therefore the predicted weight is an important factor that determines the final weight value.

Table 4:7: Regression relationship between observed and tape – weight predicted live weight of cattle and goats

	Parameter estimate	**Standard error**	**T - Value**	**P - value**
Cattle				
Intercept	190.02	63.96	2.97	0.0042
Final weight	0.10	0.23	0.44	0.6641
R^2	0.0030			
Goat				
Intercept	4.95	3.37	1.47	0.1444
Final weight	1.03	0.13	7.49	< .0001
R^2	0.2516			

4.5 Conclusion

This study established that seasons had an indirect relationship on ruminants feeding behaviour and influence grazing time of ruminants, walking time, standing time, combating time and drinking time. Livestock productivity can be improved with adequate management that fit into different seasons.

Also, season contributed to rate of digestion and passage rate through the rumen and hindgut of digesta through the quality and quantity of available forages. Seasonal effects were hardly observed through hind girth and back length changes. Provision of supplement and buying of grass will contribute to livestock productivity by enhancing effective and smooth passage of ingesta both in the rumen and hind gut.

Provision of additional feed will reduce livestock weight loss during drought season and regular supply of supplements will help the animal to maintain the normal metabolizable energy needed during each season. It is important for rural small-scale farmers to be aware of factors that contribute to ruminant production, especially season of production as it motivates ruminant feeding behaviours, rumen microbial activities, forage intake and digestibility rate. It will also equip farmers with forehand knowledge of how to modify management practices during each season towards maximum livestock production. Therefore, it will be of great importance for rural farmers to have structured management practices to enhance cattle and goats productivity.

Furthermore, seasonal effects leads into either loss or gain in live weight of ruminants because of forage scarcity on pasture during drought season. Lastly, the calibrated weight tape for cattle and goats by the Department of Agriculture and Environmetal Affairs, KwaZulu-Natal was suitably suited for goats measurement and can be used by rural farmers who can avoid mechanize weighing scale, but the scale for cattle was not accurate enough.

Chapter 5

General Discussion, Conclusion and Recommendations

5.1 General discussion

Ownership and seasons are two separate factors considered in this study to affect goats and cattle production in a communal farming system and their usefulness to increase goats and cattle productivity. These two major ruminants that have been domesticated by man over centuries and they have been found to contribute tremendously to man's livelihood especially in rural areas. Literature reviews had recorded many activities and researches involving goats and cattle. Farmers derived some cultural benefits from goats and cattle such as fresh milk for drinking; skin as house decoration, mat and cultural dress codes; meat as food and ancestral worship. Other benefits are cultural prestige, gifts during ceremonies and paying of charges in the tradition court system as revealed in chapter 3. This study suggested that goats and cattle are good sources of income and their productivity will contribute to the socio-economic development in Msinga. The study also through organized farmers' workshop, brought awareness of adequate management practices with good vaccination programs against common diseases.

The high drought and temperature in the area, effect of season on feeding behaviour and live weight of goats and cattle were considered in chapter 4. Season has a direct effect on ruminant behaviour, especially in winter compared to spring and summer. Grazing time and walking was higher in winter than spring and summer while standing and horning was higher in summer than spring and winter. Live weight change was also affected by season. There was drastically weight loss in winter compare with spring and summer and there was weight gain in summer but not as has been lost in winter. Recovery was slow and still negative on life weight change. Season has no effect on heart girth and back length of goats and cattle.

Lastly, the study evaluated the effects of seasons on liquid and particle passage rate in goats and cattle; and on nutritive value of grasses. Dry matter digestibility was evaluated with *in vitro* fermentation process. Dry matter digestibility was affected by different seasons and particle passage rate and rate of digestion were slow in dry season compared to early and late wet seasons. Rumen retention time and transition time of particles throughout the digestive tract in dry season is longer compared to early and late wet seasons. Reason being that ruminant tends to slow down passage of particle to sustain the rumen because intake rate is slow. Hind gut retention time in early wet season was slow as well, this was because there was a delay in rainfall which affects the regrowth of pasture grasses. Therefore additioning forage (lucerne and grass hay) provided by livestock owners will sustain animal nutritional demands at drought periods.

5.2 Conclusion

Understanding the profit making aspect of livestock (goats and cattle) farming will eradicate poverty of rural famers' by improving their standard of living. This will cumulate in socio-economic development of rural communities as well. Due to reoccurrence of diseases, a good vaccination programs will contribute greatly to livestock health, thereby reducing the rate of mortality especially in winter. Farmers' involvement in feeding ruminants with roughages from farming plots will improve the condition of animals during drought seasons. Preparation of hay and silos for drought seasons will reduce loss of live weight in during harsh seasons; since it takes longer time for grass to regrow due to lack of rainfall. Feeding concentrate with roughages will help to increase rate of digestibility and boost nutritive value of roughage.

5.3 Recommendations

This study has extensively evaluated the prospect of goats and cattle in a communal farming system in Msinga Municipality. Results showed that goats and cattle have great economic value which is yet to be explored in the area. This opportunity will contribute to the socio-

economic life of rural-farmers and development of the community. Increased cattle and goat productivity at Msinga, will contribute to the national agricultural sector by reducing the rate of importation of goats from other countries such as Namibia.

References

Abdalla, H. O. (1986). Compensatory Gain in Calves Following Protein Restriction. Ph.D. dissertation. Cornell University, Ithaca, N.Y.

Agricultural Research Council (ARC) (1980). The Nutrient Requirements of Ruminant Livestock. Technical Review. Farnham Royal, U.K. Commonwealth Agricultural Bureaux.

Allen, M. S. (1996). Physical Constraints on Voluntary Intake of Forages by Ruminants. J. Ani. Sci. 1996, 74:3063-3075.

Allen, M. S. (2000). Effect of diet on short-term regulation of feed intake by lactating dairy cattle. J. Dairy Sci. 83: 1598 - 1624.

Anderson, S. D., Bradford, B. J., Harner, J. P., Tucker, C.B., Choi, C. Y., Allen, J. D., Hall, L. W., Rungruang, S., Rajapaksha, E., Collier, R.J. and Smith, J. F. (2012). Effects of adjustable and stationary fans with misters on core body temperature and resting behavior of lactating dairy cows in a semi-arid climate. J. Dairy Sci. 9697: 4738-4750.

Atrian, P. and H. A. Shahryar (2012). Heat stress in dairy cows (a review). Res. in Zoology. 2 (4):31-37.

Awad, O. A. and O. A. Elhadi (2012). Season variability in nutritive value of ruminant diets under open grazing system in the system-arid rangeland of Sudan (South Darfur State). Agric. Biol. J. N. Am. 1(3): 243-249.

Ball, D. M., M.Collins, G. D., Lacefield, N.P., Martin, D.A., Mertens, K.E., Olson,D.H.,

Putnam,D.J. Undersander and Wolf. N.W. (2001). Understanding Forage Quality. American Farm Bureau Federation Publication 1-01, Park Ridge, IL.

Baumont, R. (1996). Palatability and feeding behaviour in ruminants. A review. Ann. Zootech 45: 385-400.

Baumont, R., Prache, S., Meuret, M. and Morand-Fehr, P. (2000). How forage characteristics influence behaviour and intake in small ruminants: A review. In : Ledin I. (ed.), orand-Fehr P. (ed.). Sheep and goat nutrition: Intake, digestion, quality of products and rangelands. Zaragoza : CIHEAM, p. 11-25 (Cahiers Options Méditerranéennes; n. 52).

Beverlin, S. K., K. M. Havstad, E. L. Ayers, and M. K. Petersen. (1989). Forage intake responses to winter cold exposure of free-ranging beef cows. Appl. Anim. Behav. Sci. 23:75-85.

Bezabiha, M., W. F. Pellikaana, A. Tolerab and W. H. hendriksa. (2012). Estimate of feed intake and digestibility in cattle consuming low-quality tropical roughage diets using molasses-based n-alkane boluses. Ani. Feed Sci. Tech. 177: 161-171.

Bilik, K., Niwińska, B., Topuszańska-Rusek, M. and Fija, J. (2012). Effect of type of roughage on chemical composition and technological value of milk from cows fed TMR diets. Ann. Anim. Sci. 12(4):633–648).

Bossio, D. A., Scow, K.M., Gunapala, N. and Graham, K. J. (1997). Determinants of Soil Microbial Communities: Effects of Agricultural Management, Season, and Soil Type on Phospholipid Fatty Acid Profiles. Microb. Ecol. 36:1–12.

Boudon, A., Peyraud, J. L., Faverdin, P., Delagarde. R., Delaby, L. and Chaves, L. V. (2009). Effect of rumen fill on intake of fresh perenial ryegrass in young and mature dairy cows grazing or zero-grazing fresh perenial ryegrass. Animal. 3: 1706- 1720.

Boval, M., Fanchone, A., Archimede, H. and Gibb, M. J. (2007). Effect of structure of a tropical pasture in ingestive behavoiur of diet and daily intake by grazing cattle. Grass Forage Sci. 62: 44-54.

Bruininx, E. M., Peet-Schwering, C. M., Schrama, J. W., Vereijken, P. F., Vesseur, P. C., Everts , H., Hartog, L. A. and Beynen, A. C. (2001). Individual measured feed intake characteristics and growth performance of froup-housed weaning pigs: effects of sex, intial body weight and nody weight distribution within groups. J. Anim. Sci. 79:301-308.

Campling, R.C. (1966). A preliminary study of the effect of pregnancy and of lactation on the voluntary intake of food by cows. British Journal of Nutrition 20, 25–39.

Carlotto, S. B., Medeiros, R. B., Pellgrini, C. B., Garcia, R. P. A., Liboa, C. A. V. and Saibro, J. C. . (2010). Comportamento ingestivo diurno de vacas primíparas em pastagem nativa dominada por capim-annoni-2 com suplementação protéica e mineral em diversas estações climáticas. Rev. Brasi. de Zoo. 39(3): 454-461.

Census 2011 Agricultural Households, (2013). Statistics South Africa. Pretoria: Statistics South Africa. Report no. 03-11-01 pp 27.

Chawatama, S., Mutisi, C. and Mupawaenda, A. C. (2005). The socio-economic status of smallholder livestock production in Zimbabwe: a diagnostic study. Livestock Research for Rural Development Article #143. Available at: http://www.lrrd.org/lrrd17/12/chaw17143.htm.

Chilibroste, P., Tamminga, S., Van Bruchem, J. and Van der Togt, P.L.. (1998). Effect of allowed grazing time, inert rumen bulk and length of starvation before grazing, on the weight, composition and fermentative end-products of the rumen contents of lactating dairy cows. Grass Forage Sci. 53:146–156.

Ching-Sen, C. Y., Hui-Ting, Z., Chih-Ying, C. and Che-Ling, L. (2013). Orographic effects on heavy rainfall events over northeastern Taiwan during the northeasterly monsoon season. Atmos. Res. 122: 310–335.

Coetzee, R. J. (1998). Socio-economic aspect of sustainable goat production. In Webb, B.C. Cronje P. B. (eds). Research and training strategies for goat production systems in South Africa. Department of Animal and Wildlife Sciences, Univeristy of Pretoria, South Africa.

Coleman, S. W. and J. E. Moore (2003). Feed quality and animal performance. Field Crops Res. 84: 17–29.

Conrad, H. R., Pratt, A. D. and Hibbs, J. W. (1964). Regulation of feed intake in dairy cows: Change in importance of physical and physiological factors with increasing digestibility. Journal of Dairy Science 47, 54–62.

Dado, R. G. and M. S. Allen (1995). Intake limitations, feeding behavior, and rumen

function of cows challenged with rumen fill from dietary fiber or inert bulk. J. Dairy Sci. 78:118–133.

DAEA. (2013). Department of Agriculture and Environmetal Affairs, KwaZulu-Natal. www.kzndae.gov.za. Accessed June 2014.

Decruyenaere, V. (2009). Evaluation of green forage intake and digestibility in ruminants using infrared reflectance spectroscopy (NIRS): Developing a global calibration. Anim. Feed. Sci. Technol. 148 (2-4):138-156.

Decruyenaere, V., A. Buldgen and D. Stilmant (2009). Factors affecting intake by grazing ruminants and related quantification methods: a review. Biotechnol. Agron. Soc. Environ. 13(4): 559-573.

Delfino, J. G. and Mathison, G. W. (1991). Effect of cold environment and inatke level on the energetic efficiency of feedlot steers. J. Anim. Sci. 69:4577-4587.

DARD (2005). Department of Agriculture and Rural Development, KwaZulu-Natal, South Africa. www.kzndae.gov.za/en-us/agriculture/agricpublications/productionguides/.12 August, 2014.

DAFF (2012). Department of Agriculture, Forestry and Fishery. A profile of the south african beef market value chain. http://www.nda.agric.za/docs/AMCP/Beef2012-13. 26 July, 2014.

DRDLR (2013). Department of Rural development and Land Reforms. Goats commerciation in KwaZulu-Natal: Interview. www.ruraldevelopment.gov.za. 15 Ferbuary 2014.

Devendra, C. (1999). Goats: Challenges of increased productivity and improved livelihoods. Outlook. on Agric. 28:215-226.

Dieckmann. N. (1994). The integration of social and gender issues in smallholder dairy production. World Animal Review No. 79, FAO, Rome.

Dohmen. C (1992). The role of livestock in the farming system and involment of women. Social Forestry Project, Pakistan.

Donkin, E. and K. Ramsay (2006). A Review of the Current Status of Goat Research and Development in South Africa. Paper presented at the Regional Workshop on Goat Development in Southern Africa, Mangochi, Malawi, 31st July to 4th August 2000, convened by Bunda College of Agriculture, University of Malawi.

Dove, H. (1996). The ruminant, the rumen and the pasture resource: Nutrient interactions in the grazing animal. p. 219-246. In J. Hodgson and A.W. Illius (ed.) The ecology and management of grazing systems. CAB Intl., Wallingford, OX, UK.

Dumont, B. and I. J. Gordon (2003). Diet selection and intake within sites and across landscapes. In: herrera-Camacho C.A. & Sandoval-Castro J., eds. Proceedings of the 6th international symposium on the nutrition of herbivores, 9-24 October 2003, University Autonoma de Yucatan, merida, Mexico. 175-194.

Du. Toit P. J., Louw J. G. and Malan A. I. (1940). A study of the mineral content and feeding value of natural pastures in the Union of South Africa. Onder. J. Vet. Res. 14: 123 - 127.

Duvel, G. H. and Stephamus, A. L. (2000). A comparison of economic and cultural incentives in the marketing of livestock in some districts of the northern communal areas of Namibia. Agrekon. 39(4): 656-664.

Dzakuma, J. M., Risch, E., Smith, C.O. and Blackburn, H. D. (2004). Level of feed intake on perfomance of two goats genotypes South Africa. J. Anim. Sci. 34 (Supplement 1).

Dziba. L. E, Scogings. P. F, Gordon. I. J, 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 Rum. Res. 47: 17–30.

Els, J. F., Jessen, P. T. and Von Seydlitz, H. (1999). Strategies for dry season feeding of animals in Namibia. Proceedings of a joint ZSAP/FAO Workshop held in Harare, Zimbabwe http://www.fao.org/docrep/004/ac152e/ac152e03.htm. 12 May, 2014.

Fafchamps, M. and Gabre-Madhin, E. (2001). Agricultural Markets in Benin and Malawi: Operation and performance of traders. World Bank Policy Research Working Paper No. 2734 (December 2001), Washison, DC; World Bank.

FAO (1998). Foods and Agricultural Organization. Gender and Participation in Agricultural Development Planning, FAO, Rome.

Faverdin, P., Baumont, R. & Ingvartsen, K.L. (1995). Control and prediction of feed intake in ruminants. In: Recent Developments in the Nutrition of Herbivores. Proc. IVth Int. Symp. Nutrition of Herbivores. Eds Journet, M., Grenet, E., Farce, M.H., Thériez, M. & Demarquilly, C., Paris, 11-15 September 1995. INRA Editions, Paris. pp. 95-120.

Felix, M. K. and Fair, M. D. (2009). Production parameters for Boer goats in South africa. Department of Animal Science, Wildlife and Grass Lnad Science. Univeristy of Free State. South Africa.

Fereira, Ana. C., Ronaldo, Lopes, Adriana, Regina, Gleidson, Giordano Pinto de C., Raimundo, Nunes Vaz S. and Paulo. Andrade. (2012). Intake, digestibility and intake behaviour in cattle fed different levels of palm kernel cake. Rev. MVZ Córdoba 17(3):3105-3112.

Forbes, J. M. (1995). Voluntary food intake and diet selection in farm animals. CAB International. Oxon, UK.

Fox, D. G., Sniffen, C. J. and Connor. J. D. O. (1988). Adjusting nutrient requirements of beef cattle for animal and environmental variations. J. Anim. Sci. 66:1475–1495.

Garcia, F., Carrere, P., Soussana, J. F. and Baoumont, R. (2003). How do severity and frequency of grazing affects sward characteristics and the choices of sheep during the grazing season? Grass Forage Sci. 58: 138 -150.

Gasa, K., Holtenius, K., Sutton, J. D., Dhanoa, M. S. and Napper, D. J. (1991). Rumen fill and digesta kinetics in lactating Friesian cows given two levels of concentrates with two types of grass silage ad lib. Bri. J. Nutri. 66: 381-398.

Givens, D. I., Owen, E., Axford, R. F. E. and Omed, H. M. (2000). Forage evaluation in ruminant nutrition. British Library, London, UK.

Gordon, I. J. and A. W. Illius (1994). The functional significance of the browser-grazer

dichotomy in African ruminants. Oecologia 98: 167-175.

Govender, N., Trollope, S. W. and Brian, W. V. W. (2006). The effect of fire season, fire frequency, rainfall and management on fire intensity in savanna vegetation in South Africa. J. App. Eco. 43:748-758.

Grant, R. J. and Albright, J. L. (2001). Effect of animal grouping on feeding behavoir and intake of dairy cattle. J. Dairy Sci. 84 (E. Supply.):E156-E163.

Guicharnaud, R. A., Arnalds, O. and Paton, G. I. (2010). The effect of season and management practices on soil microbial activities undergoing nitrogen treatments-interpretation from microcosm to field scale. Icel. Agric. Sci. 23: 123-134.

Havlin, J. L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. (1999). Soil Fertility and Fertilizers: an Introduction to Nutrient Management. 6th edition. Prentice Hall, Inc.. Saddle River, New Jersey.

Hebinck, P. and Smith, L. (2012). Livelihoods and Rural Transformation in the central Eastern Cape. Development Studies Association Annual Conference 'Different Poverties, Different Policies' Institute for Development Policy and Management, University of Manchester 10 - 12 September 2001.

Helena, J. and J. Jens (2010). Foraging behavoiur of cattle, sheep, goats on semi-arid pastures in Kenya. Epsilon 85.

Hodgson, J., Fornes, T.D.A., Armstrong, R.H., Beattie, M.M. and Hunter, E.A. (1991). Comparative studies of the ingestive behaviour and herbage intake of sheep and cattle grazing indigenous hill plant communities. J. App. Eco. 28, 205–227.

Horaki, I. G., Nyangiwe, N., De matos, E, C. and Neves, L. (2009). Species composition and geographic distribution of ticks infesting cattle, goats and dogs in a temperate and in a subtropical region of south-east Africa. Onder. J. Vet. Res. 76:263–276.

Hurt, C. R., Hardy, M. B., Tainton, N. M. (1993). Identification of key grass species under grazing in the Highland Sour-veld of Natal. Afri. J. Range For. Sci. 10(2):96-102.

IFAD (2007a). International Fund for Agricultural Development. Innovation in Women's Small-scale Poultry Activities. http://www.ifad.org/gender/learning/sector/agriculture/w_i.htm. 19 June 2014.

IFAD (2007b). International Fund for Agricultural Development. Women and Milk Production. http://www.ifad.org/gender/ learning/sector/agriculture/w_m.htm. 19 June 2015.

Illius, A.W. (1998). Advances and retreats in specifying the constraints on intake in grazing ruminants. In: Buchanan-Smith, J.G., Bailey, L. and McCaughey, P. (eds) Proceedings of XVIII International Grassland Congress, Vol III. Association Management Centre, Calgary, pp. 39–44.

Illius, A. W. and Allen, M. S. (1994). Assessing forage quality using integrated models of

intake and digestion by ruminants. In: Fahey, G.C., Collins, M., Mertens, D.R. and Moser, L.E. (eds) Forage Quality, Evaluation and Utilization. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, Wisconsin, pp. 869–890.

Ingvartsen, K. L., Andersen, H.R, Foldager, J. (1992). Effect of sex and pregnancy on feed-intake capacity of growing cattle. Acta Agric. Scan. Sec. Anim. Sci. 42(1): 40-46.

Jeremy, L. (2011). Europe braces for serious crop losses, blackouts as record dry season persists. ClimateWire: http://www.eenews.net/stories/1059950159. 20 June 2014.

Klopfenstein, T. J., Mass, R.A., Creighton, K.W, Patterson, H.H. (2001). Estimating forage protein degradation in the rumen. J. Anim. Sci. 79 (E. Suppl.), E208-E217.

Knononoff, P. J., Heinrichs, A. J. and Lehman, H. A. (2003). The effect of corn silage particle size on eating behaviour, chewing activities and rumen fermentation in lactating dairy cows. J. Dairy Sci. 86: 3343-3352.

Krause, D. O. and Pell. A. N (2003). Plant cell wall degradation in the rumen: ecology, constraints to digestion and modelling. In Matching herbivore nutrition to ecosystems biodiversity. Mannetje, L.'t, L. Ramirez-Aviles, (Ed. C. A. Sandoval-Castro and J. C. Ku-Vera). Proceedings of the Sixth International Symposium on the Nutrition of Herbivores. Universidad Autonoma de Yucatan, Mexico: pp. 129-150.

Krauss, K. W., Bobby, D. K., James, A. A., Katherine, C. E. and Darren, J. J. (2007). Effects of Season, Rainfall, and Hydrogeomorphic Setting on Mangrove Tree Growth in Micronesia. Biotropica. 39(2):161-170.

Le Liboux, R. and L. Peyroud (1999). Effect of forage particle size and feeding frequency on fermentation patterns and sites and extent of digestion in dairy cows fed mixed diets. Anim. Feed Sci. Tech. 76: 297-319.

Ley, T. W., Stevens, R. G., Topilec, R. R. and Neibling, W. H. (2004). Soil water monitoring and measurement. Washington-Oregon-Idaho, USA, Pacific Northwest Publications. http://cru.cahe.wsu.edu). 22nd June 2014.

Llamas-Lamas, G. and D. K. Combs (1990). Effect of alfalfa maturity on fiber utilization by high producing dairy cows. J. Dairy Sci. 73:1069.

Lo Bianco and Andrea (2007). Agribusiness for Development: A Socioeconomic Analysis of the Milk Market Chain in the IFAD-financed Western Sudan Resource Management Programme Area. Rome: IFAD.

Luo, J., A. L. Goetsch, I. V. Nsahlai, J. E. Moore, M. L. Galyean, Z. B. Johnson, T. Sahlu, C. L. Ferrell and F. N. Owens. (2004). Voluntary feed intake by lactating, Angora, growing and mature goats. Small Rum. Res. 53: 357-378.

Mac Donald, A. J., Poulton, P. R., Powlson, D. S. and Jenkinson,D. S. (1997). Effects of season, soil type and cropping on recoveries, residues and loss of ^{15}N-labelled fertilizer applied to arable crops in spring. J. Agric. Cam. 129:125-154.

Mahrous, U. E., Madeha Darwish and Meneeh, I.S. (2006). Influences of roughages type, concentrate level and stage of lactation on behavior; milk yield and composition of dairy cows. Ass. Univ. Bull. Environ. Res. Vol. 9 No. 1.

Manteca. X and A. J. Smith (1994). Effects of poor forage conditions on the behaviour of grazing ruminants. Trop. Anim. Health Prod. 26(3): 129-138.

Mantysaari, P., Khalili, H. and Sariola, J. (2006). Effect of feeding frequency of a total mixed ration on the performance of high-yielding dairy cows. J. Dairy Sci. 89: 4312-4320.

Manzano, R. P., Paterson, P., Harbac, M. M. and Lima, R. O. (2012). The effect of season on supplemental mineral intake and behavior by grazing steers. Prof. Anim. Sci. 28:73–81.

Marcio, A. B., Wander, S., Orlando, R B., Ulysses, C., Alexandre, K. and Edicarlos, O. Q. (2012). Behaviour of beef cattle and the microclimate with and without shade. Acta Scientiarum. Anim. Sci. Maringá. 34(4):409-415.

Mayes, R. W. and H. Dove (2010). Measurement of dietary nutrient intake in free-ranging mammalian herbivores. Nutr. Res. Rev. 13:107–138.

McCollum, F. T., Cravey, M.D., Gunter,S.A., Mieres, J.M., Beck,P.B., R.San Julian, R. and Horn. J. W. (1992). Forage availability affects wheat forage intake by stocker cattle. Oklahoma Agric. Exp. Sta. MP-136:312–318.

Mendes, R. S., Silva, A. M. A., Silva, G. L. S., Nnbrega, G. H., Lobo, K. M. and Preira

Filho, J. M. (2010). Exigência líquida de zinco, cobre e ferro para cordeiros em pastejo no semiárido. Acta Scientiarum. Anim. Sci. 32(3):279-284.

Mertens, D.R., 1993. Rate and extent of digestion. In: J.M. Forbes and 3. France (Editors), Quantitative Aspects of Ruminant Digestion and Metabolism. CAB International, Cambridge University Press, Cambridge, pp.13-51.

Minson, D. J. (1990). Forage in Ruminant Nutrition. San Diego: Academic.

Mohamed, E. A. (2011). Effect of different nitrogen sources on growth, yield and quality of fodder maize (Zea mays L.). J. Saudi Soc. Agric. Sci. 10(1):17-23.

Morris, C. D. and P. L. Du Toit (1998). The performance of Boer goats browsing leucaena Leucocephala in KwaZulu-Natal, South Africa. Trop. Gids. 32:188-194.

Mrema, M. N. (1996). The economic of indigenous goats production among small holder farmers in Botwana. In: proc. VI Intl. Conf. on goats, Beijng, China, May 6-11. pp 245-248.

Mucheru-Muna, M., Daniel, M., James, K., Jayne, M. and Andre, B. (2007). Effects of organic and mineral fertilizer inputs on maize yield and soil chemical properties in a maize cropping system in Meru South District, Kenya. Agroforest Syst 69:189–197.

Mullin, G. R. (1995). Kenya's women dairy farmers. Forgotten Partners in National Dairy Development. In: Kenya Farmer (9): 5-10.

Mysterud, A., Stenseth, N. C. and Yoccoz, N. G. (2001). Non-linear effects of large-scale climate variability on wild and domestic herbivores. Nature 410:1096 - 1099.

NAMC. (2005). National Agricultural Marketing Council. Investigation by the Goat Working Group (a Committee of the NAMC) into the marketing potential for the South Africa goat industry. Report on the Investigation into the Potential for The South African Goat Industry. www.nda.agric.za/docs/AAPS?NAMC1.pdf. 4 June 2014.

Naomi, A. B. (2007). The feeding behavoiur of dairy cows:considerations to improve cow welfare and productivity. Tri-State Dairy Nutrition. Columbus. USA.

Nardone. A, Ronchi, B., Lacetera, N., Ranieri, M. S. and Bernabucci, U. (2006). Climate effects on productive traits in livestock. Vet. Res. Comm. 30 (Suppl. 1): 75-81.

Nassif, N. and A. Amiri (2011). Goat production systems in a mountainous community of the Middle Atlas, Morocco. In : Bernues, A. (ed), Boutonnet, J P. (ed), Cassasus, I. (ed), Chentouf, M. (ed), Gabina, D. (ed), Joy, M. (ed), lopez-Francos, A. (ed), Morand-Fehr, P. (ed), Pacheco, F. (ed). Economic, Social and Environmental sustainability in sheep and goat production systems. Zaragoza:CIHEAM/FAO/CITA_DGA.p.199-203. http://resources.ciheam.org/util/search/series.php?langue=fr. 3rd August 2014.

Newman, J. A., Parsons, A. J. and Penning, P. D. (1994). A note on the behavioural strategies used by grazing animals to alter their intake rate. Grass For. Sci. 49: 502–505.

NRC (1984). National Research Council. Nutrient Requirements of Beef Cattle. National Academy of Sciences, Washington, D.C.

NRC (1987). National Research Council. Predicting Feed Intake of Food-Producing

Animals. Washington, D.C.: National Academy Press.

Niamir-Fuller, M. (1994). Women Livestock Managers in the Third World: A Focus on Technical Issues Related to Gender Roles in Livestock Production. IFAD Staff Working Paper 18. Rome.

Nsahlai, I. and Apaloo, J. (2007). On the suitability of Illius and Gordon's model for simulating the intake and digestibility of roughage diets by ruminants. S. Afri. J. Anim. Sci. 37(4): 275-289.

Nsahlai, I. V. (1991). The effect of quantity and quality of dietary nitrogen on the utilization of roughage diets by steers. Ph.D. thesis, University of Reading, UK.

Nsahlai, I. V., Ngwa, A. T. and Bonsi, M. L. (2003). Feed intake and dietary preferences of sheep and goats offered hay and legume-tree pods in South Africa. Agro. Forest Sys. 57: 29-37.

Nsoso, S. J., Monkhe, M. and Modise, O. M. (2005). A survey of Indigenous Tswana Farmers in some Extension Areas of Kgatleng Agricultural Districts in Botswana: Demographic, production and Marketing parameters. Bots. J. Agric. App. Sci. 1(1): 10-18.

Okine, E. K. and Mathison, G. W. (1991). Effects of feed intake on particle distribution, passage of digesta, and extent of digestion in the gastrointestinal tract of cattle. J. Anim. Sci. 69:3435-3445.

Okitoi, L. O., Ondwasy, H. O., Obali, M. P. and Murekefu, F. (2007). Gender issues in poultry production in rural households of Western Kenya. Livestock Research for Rural Development. Volume 19, Article #17. from http://www.lrrd.org/lrrd19/2/okit19017.htm. 16 July 2015.

Oladapo, A. F., Folu, I. A., Ayobami, B. J. A. and Kehinde, A. E. (2009). Effects of defoliation time of maize on leaf yield, quality and storage of maize leafs as dry season forage for ruminant production. Rev. Bra. de Ciên. Agrá. 4(3):353-357.

Oladele, O. I. and Monkhei, M. (2008). Gender ownership patterns of livestock in Botswana. Volume 20, Article #156. from http://www.irrd.org/irrd20/10/ola20156.htm. 17 June 2014.

Olofesson, J. (2000). Feed availability and its effects on intake, production and behavior in dairy cows. . Agriculture Science, Ph. D. Thesis Ada Universities. Azerbaijan.

Olojede, J. C. and Njoku, M. E. (2007). Involvement of women in livestock production: a means of reducing hunger and malnutrition in Ikwuano local government area of Abia State, Nigeria. Agric. J. 2: 231–235.

Oluka, J., Owoyesigire, B., Esenu, B. and Sssewannyana, E. 2005. Small stock and women in livestock production in the Teso Farming System region of Uganda. Pp. 151-161 in Small stock in development. Proceedings of a workshop on enhancing the contribution of small livestock to the livelihoods of resource-poor communities. Edited by T. Smith, S.H. Godfrey, P.J. Buttery, E. Ssewannyana & E.Owen. Natural Resources International Ltd., Aylesford, Kent, U.K. ISBN: 0-9546452-5-1.

Orr, R. S., Rutter, S. M., Penning, P. D. and Rook, A. J. (2001). Matching grass suppy to grazing patterns for dairy cows. Grass For. Sci. 56: 352-361.

Ørskov, E. R., Reid, G.W. and Kay, M. (1998). Prediction of intake of cattle from degradation characteristics of roughages. Anim. Prod. 46: 29-35.

Peacork, C. (2005). Goats-A pathway out of poverty. Small Rum. Res. 60: 179-186.

Penning, P. D., Parsons, A. J., Orr, R. J. and Treacher, T. T. (1991). Intake and behaviour responses by sheep to changes in sward characteristics under continuous stocking. Gra. For. Sci. 46, 15–28.

Peoples, A. C. and Gordon, F. J. (1989). The influence of wilting and season of silage harvest and the fat and protein concentration of the supplement on milk production and food utilisation by lactating cattle. Anim. Prod. 48, 305–317.

Poats, S. V. (1991). The role of gender in agricultural development. Issues in Agriculture 3. CGIAR (Consultative Group on International Agricultural Research), Washington, DC, USA. 63 http://www.worldbank.org/html/cgiar/publications/issues/issues3.pdf. 18 May 2014.

Ramsay, K. A. and E. F. Donkin (2000). "A Review of the Current Status Of Goat Research and Development in South Africa." Paper presented at the Regional Workshop on Goat Development in Southern Africa, Mangochi, Malawi, 31st July to 4th August, 2000, convened by Bunda College of Agriculture, University of Malawi.

Reddy., G. (2005). With Respect to Sex: Negotiating Hijra Identity in South India. (Worlds

of Desire: The Chicago Series on Sexuality, Gender, and Culture). University Of Chicago Press.

Redfearn, D. and Zhang, H. (2002). Forage Quality Interpretations. Oklahoma Cooperative Extension Fact Sheets. :http://osufacts.okstate.edu. 20 October 2014.

Reid, R.L, Jung, G.A. and Thayne, W.A. (1998). Relationships between nutritive quality and fibre components of cool season and warm season forages: a retrospective study. J. Anim. Sci. 66, 1275–1291.

Robbins, C. T., Spalinger, D. E. and Hoven, W. (1995). Adaptation of ruminants to browse and grass diets: Are anatomical-based browser-grazer interpretations valid?. Oecologia 103: 208-213.

Rodriquez, A. B., Landa, R., Boda, R., Prieto,N., Mantecon,A.R. and Giraldez, F.J. (2008). Carcass and meat quality of Asaaf milk fed lambs: Efect of rearing system and sex. Meat Sci. 80: 225-230.

Romney, D.L., Blunn, V. and Leaver, J.D. (1997). The responses of lactating dairy cows to diets based on grass silage of high or low DM and supplemented with fast and slowly fermentable energy sources. In: Proceedings of the British Society of Animal Science, 1997, Scarborough. British Society of Animal Science, Edinburgh, p. 84.

Rossini, S. C., Emerson, A., Regis, L. M., Jose, N. M., Joao, R., Jonathan, C. M., Antonio, S. J. and Jose, M. R. (2012). Feeding behaviors of feedlot bulls fed concentrate levels and babassu mesocarp meal. R. Bras. Zootec., 41(7):1727-1736.

Rushton, J. and Ngongi, S. N. (1998). Poultry, Women and Development: Old Ideas, New Applications and the Need for More Research. Rome: Food and Agriculture Organization of the United Nations.

Sakata, R., Shimada, S., Arai, H., Yoshioka, N., Yoshioka, R., Aoki, N., Kimoto, N., Sakamoto, A., Melling, L. and Inubushi, K. (2014). Effect of soil types and nitrogen fertilizer on nitrous oxide and carbon dioxide emissions in oil palm plantations. Soil Sci. Plant Nutri. 54:1–13.

Sam, W. Coleman and John, E. Moore (2003). Feed Quality and Animal performance. Fie. C. Res. 84: 17-29.

SAS. (2013). SAS System for Windows, Release 9.1 (TS1M3), SAS Inst., Inc., Cary, NC, USA

Schofield, P., Pitt, R.E. and Pell, A.N. (1994). Kinetics of fiber digestion from in vitro gas production. J. Anim. Sci. 72:2980-2991.

Schwartzkopf-Genswein, K. S., Beachemin, K. A., Gibb, D. D., Crews, D. H., Hickman, D. D. and McAllister, T. A.. (2003). Effect of bunk management on feeding behavior, ruminal acidosis and performance of feedlot cattle: A review. J. Anim. Sci. 81:E149-E158.

Sebei. P. J, McCrindle. C. E and W. E. C (2004). "An economic analysis of communal goat production." J. S. Afr. Vet. Ass 75(1): 19-23.

Scoones, I. (2009). Livelihood perspectives and rural development. J. Pea. Stud. 36(1):

171-196.

Sibbald, A. M., Shellard, L. J. and Smart, T. S. (2000). Effects of space allowance on the grazing behaviour and spacing of sheep. Appl. Ani. Behav. Sci. 70(1): 49-62.

Simela, L., Webb, E. C. and Bosman, M. J. C. (2008). Acceptability of chevon from kids, yearling goats and mature does of indigenous South African goats: A case study. S. Afr. J. Anim. Sci. 38:3-10.

Sinyangwe, P. (1995). Livestock Concerns in Animal Traction: Cattle Distribution and Supply for Draft Purposes. Proceedings of the Fourth Annual Animal Draft Power Workshop-Lusaka, Zambia.

Tafaj, M., kolaneci, V., Junck, B., Maulbetsch, A., Steingass, H., and Drochner, W. (2005). Influrence of fiber content and concentrate level on chewing activity, ruminal digestion, digesta passage rate and nutrient digestibility in dairy cows in late lactation. Asian-Aust. J. Ami. Sci. 18(8): 1116-1124.

Tahir, M. N., Marten. H, and Martinsson. K, (2008). Voluntary intake by dairy cattle. Department of Agricultural Research for Northern Sweden Rapport 3:

Tarr, B. (2007). Cold stress in Cows. Factsheet Agdex: 420/51. Order#: 07-001. htt/:www.omafra.gov.on.ca/english/livestock/beef/facts/07-001.htm. 18 October 2014.

Taweel, H. Z. (2004). Perenial ryegrass for dairy cows: grazing behaviour, intake, rumen function and performance., PhD thesis, Wageningen University, The Netherlands.

Teller, E., Vanbelle, M. and Kamatali, P. (1993). Chewing behaviour and voluntary grass silage intake by cattle. Liv. Prod. Sci. 33, 215–227.

Tesha. N (1998). Projects with women in agriculture, Ministry of Community Development, Intercooperation, Vera Mugittu, Lucy Maarse. Tanzania.

Tilley, J. M. and R. A. Terry (1963). A two-stage technigue for the in vitro digestion of forage crops. J. Brit. Grass. Soc. 18: 104 -11.

T.M.P (2015). TrueNorth Mapping, Pietermaritzburg. KwaZulu-Natal. South Africa.

Tom, H. and D. C. Church (2010). Beef Cattle Specialist: OMAFRA Beef Production and the Greenhouse Effect. Texas A & M University. USA.

Tucker, C. B., Rogers, A. R. and Shutz, K. E. (2007). Effect of solar radiation on dairy cattle behaviour, use of shade and body temperature in a pasture-based system. Appl. Anim. Behav. Sci. 109:141-154.

Valdivia, C. (2001). Gender, Livestock Assets, Resource Management, and Food Security: Lessons from the SRCRSP. Agric. Human Values 18(1):27-39.

Van Soest. P. J (1994). Nutritional ecology of the ruminant. Second edition. Cornell University Press. New York. USA.

Van Soest, P.J. (1965). Symposium on factors influencing the voluntary intake of herbage by ruminants: voluntary intake in relation to chemical composition and digestibility. J. Anim. Sci. 24, 834–843.

Wilson, G. (2012). Market access isn't only hurdle for Africa small-small farmers.

Marketplace. America, America Public Media's.

Wilson, J. R. and Kennedy, P. M. (1996). Plant and animal constraints to voluntary feed intake associated with fibre characteristics and particle breakdown and passage in ruminants. Aus. J. Agric. Res. 47: 199–225.

World Bank (2008). Gender in agriculture. http://www.worldbank.org/gender. 14 January 2014.

Wooldridge, J. (2006). Effects of early season and autumn nitrogen applications on young 'Keisie' canning peach trees on a sandy, infertile soil. S. Afri. J. Plant. Soil: 23(3): 173-180

Yip, Y. and Sham, W. (2007). Application of collision/ reaction-cell technology in isotope dillution mass spectrometry. Trac. Trends. Anal. Chem. 26 (7):727-733.

Yisehak, K. (2008). Gender responsibility in small-holder mixed crop–livestock production systems of Jimma zone, South West Ethiopia. Livestock Research for Rural Development. Volume 20, Article #11. from http://www.lrrd.org/lrrd20/ 1/yise20011.htm. 5 May 2014.

Yiu-Kwok Chan, W. A. M., and Ma, B.L. (2013). Effects of inorganic fertilizer and manure on soil archaeal abundance at two experimental farms during three consecutive rotation-cropping seasons. App. Soil Eco. 68:26–35.

Young, B. A., Walker, B., Dixon, B. A. E. and Walker, V.A (1989). Physiological adaptation to the environment. J. Anim. Sci. 67:2426–2432.

Zanine, A. M., Santos, E. M., Parente, H. N., Ferreria, D. J., Oliveira, J. S. and Lana, R. P. (2007). Hábito de pastejo de novilhas em pastagens do gênero Brachiaria. Acta. Sci. Anim. Sci. 29(4):365-369.

Zayed, B. A., Elkhoby, W.M., Salem, A.K., Ceesay, M. and Uphoff, N.T. (2013). Effect of Integrated Nitrogen Fertilizer on Rice Productivity and Soil Fertility under Saline Soil Conditions. J. Plant Bio. Res. 2(1): 14-24.

Zhigang, J. and Robert, J. H. (1996). Digestive responses of wapiti Cervus elaphus canadensis to seasonal forages. Acta Ther. 41(4): 415-423.

Zhongqiu, L. (2013). Sex-Age related rumination behavoir of Pere David's deer under contraints of feding habitat and rainfall. Plos. One. 8(6): e66261. doi:10. 1371/journal.pone0066261.

Appendices

Appendix 1: English version

Cover Page

Agriculture has emerged as one major aspect of achieving a strong economy in South Africa. To this end, Water Resource Commission has appointed a research team to analyse agricultural value chains for enterprises such as cattle and goats to see how they can be strengthened.

The overall focus is to understand how subsistence and emerging farmers can be incorporated into the mainstream of the economy. This model will enable both the Water Resource Commission and Department of Animal & Poultry Science at UKZN to provide necessary support or recommendations to other parties to ensure sustainable and progressive development. This questionnaire is thus aimed at establishing an understanding of various issues related to livestock production – including water use.

In Case of any questions regarding the questionnaire, do not hesitate to contact the Researcher on;

- Name: Adetoyese Adeyemo
- Phone: 0732709537
- Email: toyese_ade@ymail.com

Thank you for your kind response.

Muden Goats & Cattle Project Sanctioned by WRC

District of interviewee:…….…….
Municipality: ……...…….
Ward: ……...…….
Traditional authority: ……...…….
Community: ……...…….

Personal Information
Farmer's name:…..……Tel:..……House number:…….
Gender: M ☐ F ☐

1. **Rank the following sources of income (starting with 1 as the most important and 6 as the least important)**

Permanent work	Temporary work	Livestock	Crops	Grants	Other, specify

2. What are your current livestock figures? What were your numbers in June 2012?

Livestock	Current figures	June 2012
Goats		
Cattle		
Chickens		
Sheep		
Donkeys		

3. If your goat and cattle numbers have increased since last year, is due to what?

Livestock	Buying	Reproduction	Gifts	Other

				(specify)
Goats				
Cattle				

4. Why do you keep livestock? Just tick again

Reason	Goats	Importance	Cattle	Importance
Income				
Meat / milk				
Cultural purposes				
Prestige				
Ploughing				
Other (specify)				

5. What are your other farming activities?

Activity	Yes / no	Scale
Dry-land crop production		Size (ha)
Homestead garden		Size (m x m)
Irrigated farming		No of beds
Other		

6. What types of goats do you have? ☐ Indigenous (Zulu) ☐ Boer ☐ Others

7. What types of cattle do you have? ☐Local breed/ Nguni ☐Other specify:

Land tenure arrangement

8. Where do you graze your livestock?

☐ Communal grazing land ☐Irrigation scheme ☐Private Land ☐Rented Land

☐ other (specify……..)

If the land is private or rented, who does it belong to?_____

9. Do you have access to other grazing areas during very dry seasons? ☐ Yes ☐No

When do you experience feed shortages?

☐ Never ☐All year ☐Specific times of year (describe):_____

Management level and skills

10. Do you use any of the following items for your livestock?

Item	Cattle (Yes/No)	Goats (Yes/No)
Traditional medicine		
Modern medicine		
Dip (bought yourself)		
Bought feed		
Crop residues		
Hired labour		

11. What amount of time do you or your family spend doing the following with your livestock e.g. 1 hour per day or 1 hour per week

Activity	Cattle	Goats
Herding		
Fetching		
Collecting water		
Collecting feed		
Other (specify)		

12. Have you received any training in livestock care? ☐ Yes ☐No
If so, by whom ……..
what topics?.....

13. Where do your livestock stay at night?
☐ Kraal ☐ Yard ☐ leave them outside ☐other(Specify_

14. Where do your livestock get water?
☐ Canal ☐River ☐Stream ☐Tap ☐Other (specify) _____

15. Do you take animals to drink? If so, where?.....

16. Do you provide water at your homestead or at some other place? If so, for

which animals_____, which times of year_____, how

frequently _____and how much?_____

17. What is your livestock's main feed? _____

17b. Please name some indigenous feeds that your cattle like very much.
…….....

17b. Please name some indigenous feeds that your goats like very much.
…….....

18. Do you provide additional feed to your livestock? ☐**Yes** ☐**No**

18b. What feed do you give them**?**

☐ Concentrates (feed in a bag) specify if possible_____
☐ A lick (specify name if possible)
☐ Hay
☐ Maize Stover
☐ Other crop residues (e.g. sweet potato leaves) specify_____
☐ Pasture (Specify)_____
☐ Other (specify)

Which seasons?

☐ Summer☐ Autumn☐Winter ☐ Spring

Additional detail - especially if different feed at different times of year:

_____

NOTE: Collect samples of feed provided if available

19. Do you follow a vaccination plan for

a. Your goats ☐ Yes ☐ No
If yes, describe:_____

b. Your cattle ☐ Yes ☐ No
If yes, describe:_____

20a. Are there any diseases common to your goats? ☐ Yes ☐ No
if yes name…….
How are you treating/ preventing it. ……

20b. Are there any diseases common to your cattle? ☐ Yes ☐ No
if yes name…….

How are you treating/ preventing it. ……

21. Risks and mitigation

	List the possible things that can prevent your livestock production from being successful		What needs to be done to prevent this happening?
1a		1b	
2a		2b	
3a		3b	
4a		4b	
5a		5b	

Marketing aspects

22. How many goats and cattle did you sell in 2012 and so far in 2013?

	2012	2013(6mths)
Goats sold		
Cattle sold		

23a. How do you sell your goats?

☐ People come to buy livestock from me at home
☐ I take my livestock to a market place
☐ I take my livestock to an auction
☐ Itake them to abattoirs
☐ Other (specify)…….

23b. How do you sell your cattle?

☐ People come to buy livestock from me at home
☐ I take my livestock to a market place
☐ I take my livestock to an auction
☐ I take them to abattoirs
☐ Other(specify)…….

24. Who buy your livestock?

☐Community member/neighbour
☐Trader
☐Auctioneer
☐Butcher
☐Other (specify)

25. What challenges do you face with selling your livestock currently?.....
……

26. Do buyers want to buy more livestock than you have for sale?

☐ Yes ☐ No
If yes, ☐ Goats ☐ Cattle

27a. What class of cattle is most demanded?

Gender: ☐ Male ☐Female ☐Castrate
☐ Mature ☐Immature

27b. what class of goat is most demanded?

Gender: ☐ Male ☐Female ☐Castrate
☐ Mature ☐Immature

28. Is there any goat or cattle market place / auction in the vicinity/community?

☐ Yes ☐ No If yes,
How far is it from your homestead?
Does it sell goats? ☐ Yes ☐ No
Does it sell cattle? ☐ Yes ☐ No
If yes, is it? ☐Formal ☐Informal

29. When cattle are slaughtered at home, what do you do with the skin?

☐ Discard ☐Sell it ☐ Keep it for my use ☐ Other
(specify)……..

29b. When goats are slaughtered at home, what do you do with the skin?

☐ Discard ☐Sell it ☐ Keep it for my use ☐ Other
(specify)……..

30. Do you sometimes milk your cattle and use the milk at home?

☐ Yes ☐ No

31. Uses of goats and cattle in the past 12 months.

	June-Dec 2012	**Jan-June 2013**

Number of goats stolen		
Number of goats given out (as gifts)		
Number of goats consumed at home as food		
Number of goats used for ceremonies this year		
Number goats used to pay charges / fines / damages		
Number of goats used for other purposes (specify		
Number of goats sold		
Approximate selling price for an adult female		

	June-Dec 2012	**Jan-June 2013**
Number of cattle stolen		
Number of cattle given out (as gifts)		
Number of cattle consumed at home as food		
Number of cattle used for ceremonies this year		
Number of cattle used to pay charges / fines / damages		
Number of cattle used for other purposes (specify		
Number of cattle sold		
Approximate selling price for an adult female		

Willingness to be part of a group and of the industry

32. Do you belong to a livestock association or other group? ☐ Yes ☐ No

If yes, what is the name of the association?.....

Has the farmer association assisted you in any way towards marketing or caring for your livestock? \☐ Yes ☐ No

If yes, describe:_____

If not, would you like to participate in some sort of livestock association / cooperative?

☐ Yes ☐ No

Why……..

33. Would you like to join other local livestock farmers to be able to market Animals more easily?

☐ Yes ☐ No

Institutional support for Livestock production

34. What stakeholders do you have any contact with related to livestock?

If yes, what role do they play?

☐ Traditional authority _____

☐ Private vet _____

☐ State vet _____

☐ Animal health technician _____

☐ Extension officer _____

☐ Auctioneer _____

☐ Shop selling inputs _____

☐ Neighbours _____

☐ Buyers / traders _____
☐ Other (specify) _____

35. Is there any agreed time to graze certain areas of the irrigation scheme?

☐ Yes ☐ No
If yes, describe:_____

36. Do you buy any inputs (medicine/ feed) collectively with other livestock owners?

☐ Yes, regularly ☐Yes, sometimes ☐ No
If yes, what items and with whom? _____

Do you ever join with other owners to hire a herder to take your cattle out to graze?

☐ Yes ☐ No

Thank you for sparing your valuable time in answering this questionnaire.

……

Appendix 2: Isi-Zulu version

Cover Page

Ezolimo sezibonakale njengendlela ethembisayo ukuthuthukisa umonotho waseNingizimu Afrika. Abakwa Water Research Commission abakhethe iqembu lezocwaningo ukuhlaziya ukubaluleka kwezolimo njengezinkomo nezimbuzi nokubhela ukuthi zingaxhaswa kanjani.

Inhloso yalolucwaningo ukuqonda umthelela owenziwa abalimi basemakhya (abafuyi bezinkomo) emnothweni.Le modeli izosiza ekutheni umnyanago waka Water Resource Commission kanye ne Department of Animal & Poultry Science ekunikezeni ngosizo ulufanele kanye nezincomo ezidingekayo ukuze kube khona inqubekela phambili no kuthuthuka ekugcinweni kwe mfuyo. Lolu cwaningo lubuka kakhulu ekusunguleni kanye naseku qondisiseni izinhlobo ezahlukene eziphathelene noku khiqizwa kwamfuyo.

Umangabe kukhona ofisa ukukubuza mayelana nalolu cwaningo, ungathintana no Project Manager, kulezi zinombolo ezilandelayo;

- Inamba yocingo:
- I-email:

Ngiyabonga kakhulu ngokuphendula kwakho.

Yimi ozithobayo

Muden Goats & Cattle Project Sanctioned by WRC

Idistrikthi:……. Umasipala:……...…….

Iwadi:…… Inkosi ephethe:.……...…….

Indawo:……..……...…….

Personal Information

Igama:…..……..……umakhalekhukhwini:..…….……

Inambauasendli ni:……...Ubulili: M ☐ F ☐

1. Uqale ngeyokuqala njengebalulekile ukuya kweyesithumba njengebaluleke kancane

Osebenza ngokugcwele	Obambe itoho	Imfuyo	Olomayo	Imali yesiboneleo	Okunye

2. onyakeni odlule June 2012, inciphile noma yandile ☐Yebo ☐Cha

Imfuyo	Isibalo	June 2012
Izimbuzi		
Izinkomo		
Izinkukhu		
Iziklabhu		

Imbongolo		

3. umangabe isibalo sezumbuzi kanye nezinkomo senyukile ngonyaka odlule, ngabe imbangela yini?

Imfuyo	Ukuthenga	Ukuzalana	Izipho	Okunye, cacisa
Izimbuzi	( )	( )	( )	
Izikomo	( )	( )	( )	

4. Kungani ufuyile? Khetha impendulo ngokumaka

Isizathu	**Izimbuzi**	**Ukubaluleka**	**Izinkomo**	**Ukubaluleka**
Inzuzo				
Inyama/ Ubisi				
Okwamasiko				
Isithunzi				
Ukulima				
Okunye, cacisa				

5. imiphi eminye imisemenzi yokulima oyenzayo?

Umsebenzi	**Yebo /Cha**	**Ubukhulu bendawo**
Ukutshala endaweni eyomile		Ubukhulu (ha)
Ukutshala ekhaya		Ubukhulu (m x m)
Ukutshala ngokuchelela		Isibalo samabede
Okunye		

6. Uhlobo olonjani lewezimbuzi ozifuyile? ☐Indigenous (

7. Uhlobo olonjani lewezinkomo ozifuyile ☐izinkomo zesintu (amanguni) ☐Olonye uhlobo

Land tenure arrangement

8. indowa lapho izinkomo zidla khona?

☐ Emasimini okanye aphalukweni ☐lapho ekuchelelwa khona ☐Endaweni yazo zodwa ☐ zidla emhlabeni oqashiwe ☐oku

Uma umhlaba uqashiwe, ubani umnikazi wawo?_____

9. izinkomo zinayo imvume yokudla kwezinye izindawo ebusika? ☐ Yebo ☐ Cha

Inini lapho enishoda kokudla **?**

☐ asishodi ☐minya yonke ☐cacisa isikhathi sonyaka (chaza):_____

Management level and skills

10. Ingabe niyakusebenzisa yini lokhu okulandela emfunyweni?

izinto	**Inkomo(Yebo/Cha)**	**Izimbuzi(Yebo/Cha)**
Imithi yesintu		
Imithi ethengwayo		
Diphi		
Ukuthenga ukudla		
Izinsalela zesivuno		
Ukuqasha abantu		

11. Nithatha isikhathi esingakanani ukwenza lokhu okulandeyo emfuyweni sibonelo, ihora elilodwa ngosuku okanye ihora elilodwa ngeviki

Activity	**Izinkomo**	**Izimbuzi**
ukulusa		
Ukubamba nokuzibopha		
Ukukha amanzi		
Ukulanda ukudla		
okunye (cacisa)		

12. Ingabe lukhona uqeqesho onulitholile ngokunakekelwa kwezinkomo? ☐Yebo ☐Cha

Uba likhona, nilenziswe ubani……..

Belikhuluma ngani?.....

13. Ingabe imfuyo ihlalaphi ebusuku?

☐ Esibay ☐ebaleni/eyadini ☐sishiywa ngaphandle ☐okunye(cacisa)_

14. Ingabe imfuyo iwathola kephi amanzi?

☐ Canal ☐imfuleni ☐emadamini ☐impompini ☐okunye (cacisa) _____

15. Ingabe niyazihambisa izinkomo emfuleni? Uma nizihambisa, izisisa kephi?.....

16. nizika amanzi ekhaya(eyadini) okanye kwezinye izindawo? Uma nizikika, eyiphi imfuyo _____, ngasiphi isikhathi onyakeni_____,kangakhi _____ kangakanani?_____

17. ingabe yini esemqoka edliwa yimfuyo? _____

17b. sicela usho ukudla ukuthandwa izinkomo zakho.

…….....

17b. sicela usho ukudla ukthandwa izimbuzi zakho.

…….....

18. ingabe niyayiziphakela imfuyo? ☐Yebo ☐Cha

18b. niziphakela hlobo luni lokudla**?**

- ☐ Ukudla ukugayiwe (ukusemasakeni) specify if possible_____
- ☐ A lick (specify name if possible)
- ☐ Utshani obomisiwe
- ☐ amahlanga
- ☐ izinsalela zemvuno (e.g. sweet potato leaves) specify_____
- ☐ amadlelo aluhlaza (cacisa)_____
- ☐ okunye(cacisa)

Kweziphi izigxenye zonyaka?

☐ ihlobo☐ inkwindla☐ebusika ☐ntwasahlobo

Chaza kabanzi - ikakhulukazi uma ukudla ngotholakala kuhlukana kswezingxenye zonyaka : _____

ukubalulekile: thatha izicuzu zokudla

19. Ingabe niyazigoma

a Izimbuzi ☐ Yebo ☐ Cha

Uma nizigoma, chaza:_____

b. Izinkomo ☐Yebo ☐Cha

Uma nizigoma, chaza,:_____

20a. Ingabe zikhona izifo zezimbuzi emphakathini? ☐ Yebo ☐Cha

Uma zikhona, zibale …….

Uzivimba kanjani/noma uzixazululakanjani. ……

20b. Ngabe zikhona izifo ezijwayelekile ezinkomeni zakho ? ☐ Yebo ☐Cha

Uma uthi Yebo NikeZela Incazelo…….

Uzivikela kanjani Noma ulwisana nazo kanjani …….....

21. Izingozi NoKuvikelwa kwayo

	Bala izinto ezivimbela izinkomo zakho ukuthi zande ziphinde ziphile kahle futhi		Ikuphi okumele kwenziwe ukuvikela lokhu okubalile?
1a		1b	
2a		2b	
3a		3b	
4a		4b	
5a		5b	

***Marketing aspects (*Kwezokuthengisa)**

22. Zingakhi izimbuzi nezinkomo zakho ozidayisile ngonyaka ondlule (2012) namanje kulonyaka (2013)

	2012	2013(6mths)
Izimbuzi ezidayisiwe		
Izinkomo ezidayisiwe		

23a. Uzidayisa kanjani izimbuzi zakho?

☐ Abantu bayeza ukuzothenga izimbuzi lapha kimi ekhaya.

☐ Ngiyazithatha izimbuzi zami ngizise emakethe ukuthi ziyodayiswa.

☐ Ngiyazithatha ngizise ku auction

☐ Ngiyazithatha ngizise esilaheni

☐ Okunye (Chaza)…….

23b. Uzidayisa kanjani izinkomo zakho?

☐ Abantu bayeza ukuzothenga lapha kimi ekhaya.

☐ Ngiyazithatha ngizise emakethe ukuthi ziyodayiswa

☐ Ngiyazithatha ngizise ku auction

☐ Ngiyazithatha ngizise esilaheni

☐ Okunye (Chaza)…….

24. Ubani othenga imfuyo yakho?

☐Umphakathi no makhelwane

☐abadayisi bemfuyo

☐Auctioneer

☐Abantu basesilaheni

☐Okunye (Chaza)

25. Iziphi izinselelo ohlangabezana nazo uma uthengisa imfuyo yakho okwamanje.

……

26. Ngabe abathengi bemfuyo yakho bayafuna ukuthenga imfuyo eningi ngesinye isikhathi kunale osuke unayo ?

☐ Yebo ☐ Cha

Uma Yebo, ☐ Izimbuzi ☐ Izinkomo

27a. Iziphi izinkomo ezifunwa kakhulu abathengi?

Ubulili: ☐ Isilisa ☐Isifazane ☐Ezitheniwe

☐ Ezindala ☐Ezincane

27b. Iziphi izimbuzi ezifunwa kakhulu abathengi?

Ubulili: ☐ Isilisa ☐Isifazane ☐Ezitheniwe

☐ Ezindala ☐Ezincane

28. Ngabe ikhona imakethe endaweni yangakini lapho kungathengiswa khona izi Mbuzi noma Izinkomo noma zibeku auction?

☐ Yebo ☐ Cha Uma yebo,

Isekudeni kangakanani nasekhaya lakho? …….

Ngabe iyazidayisa izimbuzi ? ☐ Yebo ☐ Cha

Ngabe iyazidayisa izinkomo? ☐ Yebo ☐ Cha

Umayebo injani? ☐Isemgangatheni ☐Ayikho emgangathen

29. Nizihlaba nini izinkomo emakhaya, isikhumba sazo nisenzanjani?

☐ Niyasilahla ☐Niyasidayisa☐niyasigcina nisigcinela imisebenzi yenu ☐ Okunye (Chaza)……..

29b. Nizihlaba nini izimbuzi emakhaya, isikhumba sazo nisenzanjani

☐ Niyasilahla ☐Niyasidayisa☐niyasigcina nisigcinela imisebenzi yenu ☐ Okunye (Chaza)……..

30. Ngesinye isikhathi niyazisenga izinkomo zenu ubisi lwazo besenilisebenzisa ekhaya?

☐ Yebo ☐ Cha

31. Ukusetshenziswa kwezimbuzi ne zinkomo ezinyangeni ezi-12 ezendlule.

	June-Dec 2012	**Jan-June 2013**
Isibalo sezimbuzi ezebiwa		
Isibalo sezimbuzi okwaphiswana ngazo (njenge zipho)		
Isibalo sezimbuzi ezahlatshwa zadliwa ekhaya		
Isibalo sezimbuzi ezasetshenziselwa imisebenzi eyahlukene (njengemishado neminye)		
Isibalo sezimbuzi ezasetshenziselwa ukuhlawula		
Isibalo sezimbuzi ezasetshenziselwa ezinye izinto (chaza)		
Isibalo sezimbuzi ezadayiswa		
Linganisela inani okudayiswa ngalo izimbuzi ezindala zesifazane		

	June-Dec	**Jan-June**

	2012	2013
Isibalo sezinkomo ezebiwa		
Isibalo sezinkomo okwaphiswana ngazo (njenge zipho)		
Isibalo sezinkomo ezahlatshwa zadliwa ekhaya		
Isibalo sezinkomo ezasetshenziselwa imisebenzi eyahlukene (njengemishado neminye)		
Isibalo sezinkomo ezasetshenziselwa ukuhlawula		
Isibalo sezinkomo ezasetshenziselwa ezinye izinto (chaza		
Isibalo sezinkomo ezadayiswa		
Linganisela inani okudayiswa ngalo izinkomo ezindala zesifazane		

Uma waba nemfuyo eyebiwa Chaza ukuthi yebiwakuphi:

32. Ikhona inhlangano okuyo eyezokufuywa noma inhlanganiselwa nabanye abantu? ☐

Yebo ☐ Cha

Uma uthi yebo isho igama lenhlangano?.....

Ngabe inhlangano ekhona eyabafuyi kukhona eyake yanisiza ngakho emfuyeni yenu? njengasekudayiseni nasekunakekeleni imfuyo?

☐ Yebo ☐ Cha

Uma uthi yebo chaza:_____

Uma cha, ungathanda yini ukuba yilunga lenhlangano yabafuyi bezilwane zasekhaya njengo kuba kwi cooperative?

☐ Yebo ☐ Cha

Ngoba?……

33. Ungathanda yini ukuba yilunga lezinye izinhlangano zabafuyi ezikhona endaweni yangakini khona uzokwazi ukudayisa imfuyo yakho kalula?

☐ Yebo ☐ Cha

Izifundazwe ezisiza ekukhiqizweni kwemfuyo

34. Ngabe ibaphi aba thengi noma osomabhizinisi onesivumelwano nabo mayelana nemfuyo yakho? If yes, what role do they play?

☐ Amakhosi endabuko _____

☐ Abazimele _____

☐ Izwe lonkane _____

☐ Odokotela bezilwane _____

☐ abaluleki _____

☐ Abadayisi abasemthethweni (Auctioner)_____

☐ Isitolo esidayisa izinsiza _____

☐ Omakhelwane_____

☐ Abathengi noma abadayisi _____

☐ Okunye (chaza) _____

35. Sikhona yini isikhathi okuvunyelwana ngaso uma imfuyo kumele idle emadlelweni anamanzi aniselwayo?

☐ Yebo ☐Cha

Uma uthi yebo Chaza:_____

36. Ngabe uyazithenga izinsiza zemfuyo njenge mithi no kudla kanye kanye nabanye abafuyi?

☐ Yebo, ngijwayele ☐Yebo, kodwa ngesinye isikhathi ☐ Cha

Uma uthi yebo iziphi izinsiza ozithengayo uzithenga nobani?_____Wake wahlanganyela nabanye abafuyi naqasha i herder lokuthatha izinkomo zenu ziyo kudla? ☐ Yebo ☐Cha

Ngiyabonga kakhulu ngesikhathi sakho kanye nokuphendula lemibuzo.

……

Appendix 3

Check list for focus group discussion

The irrigation scheme
Does the irrigation scheme and the canals affect your livestock in any way – positively or negatively?
What do you use the irrigation for?
Do your livestock drink from the irrigation scheme?

Diptank
How does the dipping system work? *Payment for dip, diptank committee, intervals, etc*
Does the diptank association/committee have any other function/purpose?
Do you use the dip tank ? How often ?

Marketing
Where is the closest auction? Has anyone in the group used it? For what?
How do people generally sell their livestock?
What problems do you face related to marketing?

Access to tools, equipment and vehicles
What equipment/tools do livestock owners have access to for managing their livestock? Do they own it or how do they get access to it?

Health routine
How do you treat your livestock? Call Vent/ friends/ self?
How often do you experience outbreak of diseases? What season?
Can you recognise some diseases? Any vaccination programme for your livestock?

Cultural practices
Do people herd their cattle? Female/male?
Do they hire herders?
Are animals of different owners herded as one group?
Does anyone have access to a fenced grazing camp? Who does it belong to? What is it used for?

Sources of income
What gives you highest income?
Do you market your livestock when you are financially down?
Do you engage in any other work?

Cultural views
Why do you keep livestock?
Cattle and goats are used for what cultural purposes?
How often do you use them?

General
What do you think needs to be done to boost livestock production?
What are the challenges livestock owners are facing?

<u>Appendix 4:</u> Focus groups Discussion

Auctioneers:

- What was their objective and aims for organizing the auction?
- What prompted the idea?
- What steps did they take to achieve the aims and objectives?
- What was the impact on the farmers?
- What challenges did you face with organizing and holding the auction?

Sellers (livestock association)

- What interested (motivated) you to sell your goat sat the auction?

What advantage or gain did?

- Do you have in selling your livestock at the auction?

- Did you get the price you wanted for your goats? Was there any stress or difficulties you went through in selling your livestock at the auction?
- Was there any special demand in teams of age, gender, type of livestock requested by the buyer?
- Did your goats meet the demands of buyer?
- Would you sell goats at an auction again?
- What could be done to improve the auction or make you more willing to participate again?

Livestock auctioneers (AAM: Buyers)

- What motivated you to attend the auction?
- For what purpose were you buying goats?
- Did you buy for yourself, on behalf of someone else or to sell again?
- Were the prices affordable?
- What types, gender and age are you interested in buying?
- Will you attend another goat auction if opportunity arises?
- What could be done to improve the auction?

Department Rural Development and Land Reform (DRDLR)

- Why did you organize such event in Msinga?
- What were your objectives and aims?
- Did you achieve them? In what way?
- What impact do you think it had on the farmers in Msinga?
- Are you planning to organize another action? When? How will it differ from the previous auction?
- What will be the impact on farmers and the community at large?

Department of Agriculture and Environmental Affairs (DAEA)

What was the role that you played in the auction?

What was your evaluation of the auction? How could it have been improved?

Why have such auctions not been held in the past?

What will your role be in the next auction?

Appendix 5

Productivity of livestock number over 12 months

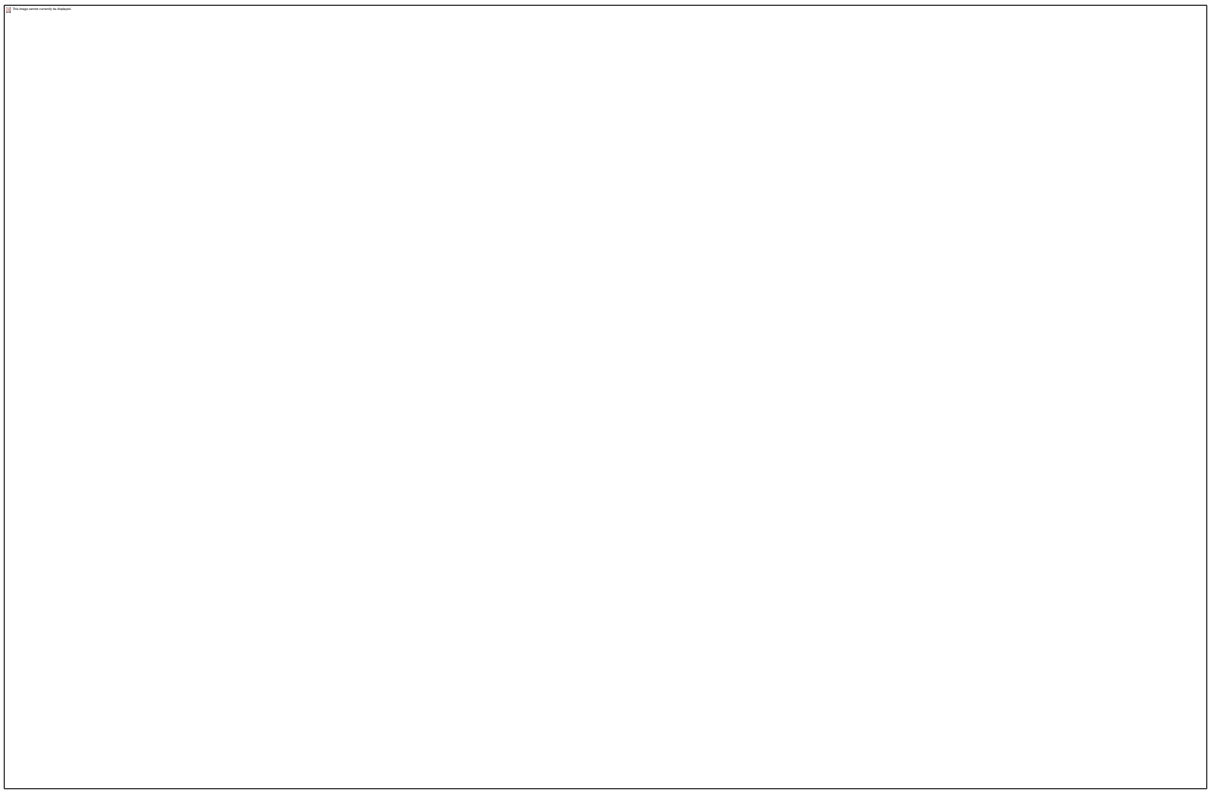
Livestock	Female		Male			
	No	Yes	No	Yes	F value	Pr > F
Curent_goat 2013	9	22	5	54	1.57	0.2132

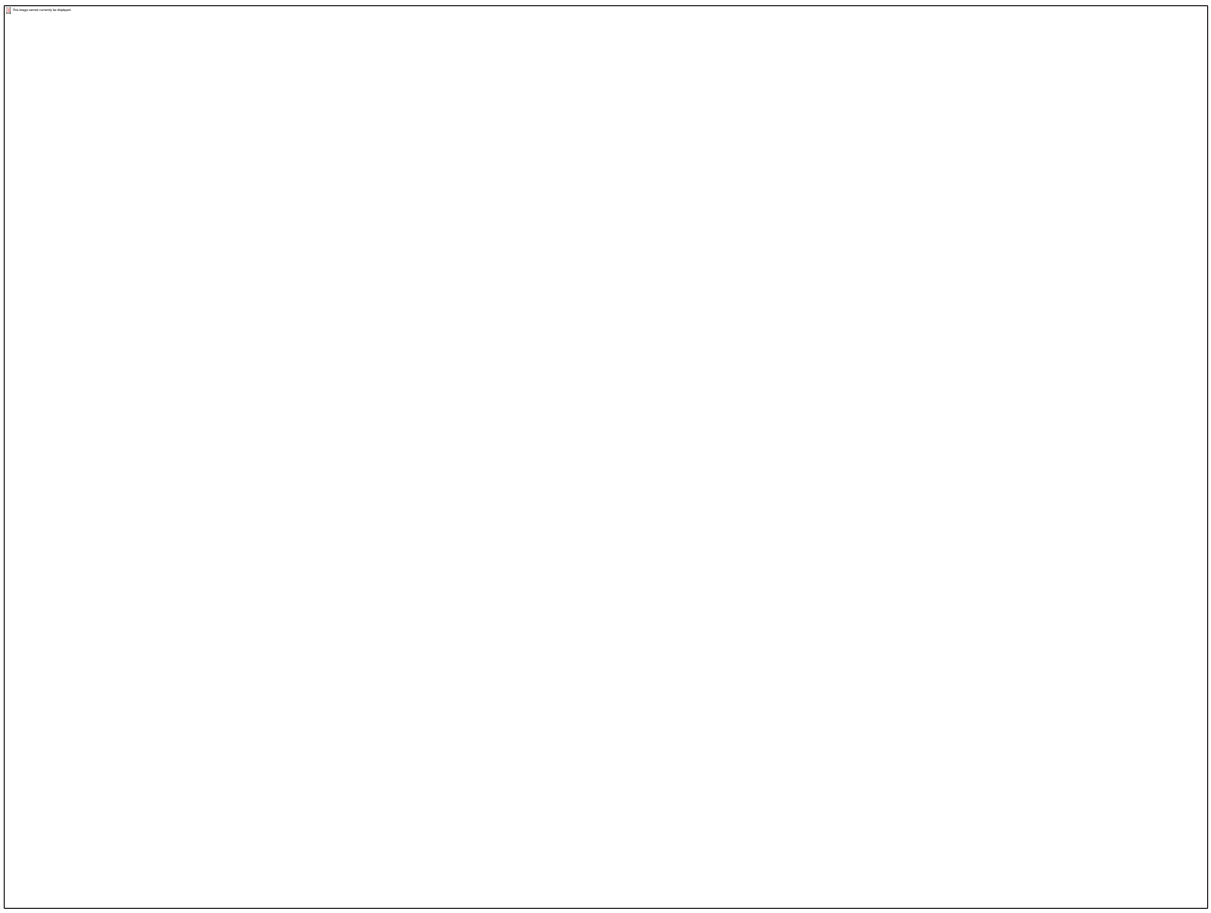
Curent_goat 2012	8	23	16	43	0.7	0.4044
Curent_cattle 2013	10	21	18	41	0.27	0.6037
Curent_cattle 2012	11	20	30	29	3.42	0.0676
Curent_poultry 2013	20	11	49	10	6.58	0.012
Curent_poultry 2012	19	12	50	9	2.8	0.0976
Curent_sheep 2013	28	3	59	0	2.88	0.0933
Curent_sheep 2012	28	3	59	0	3.29	0.0729

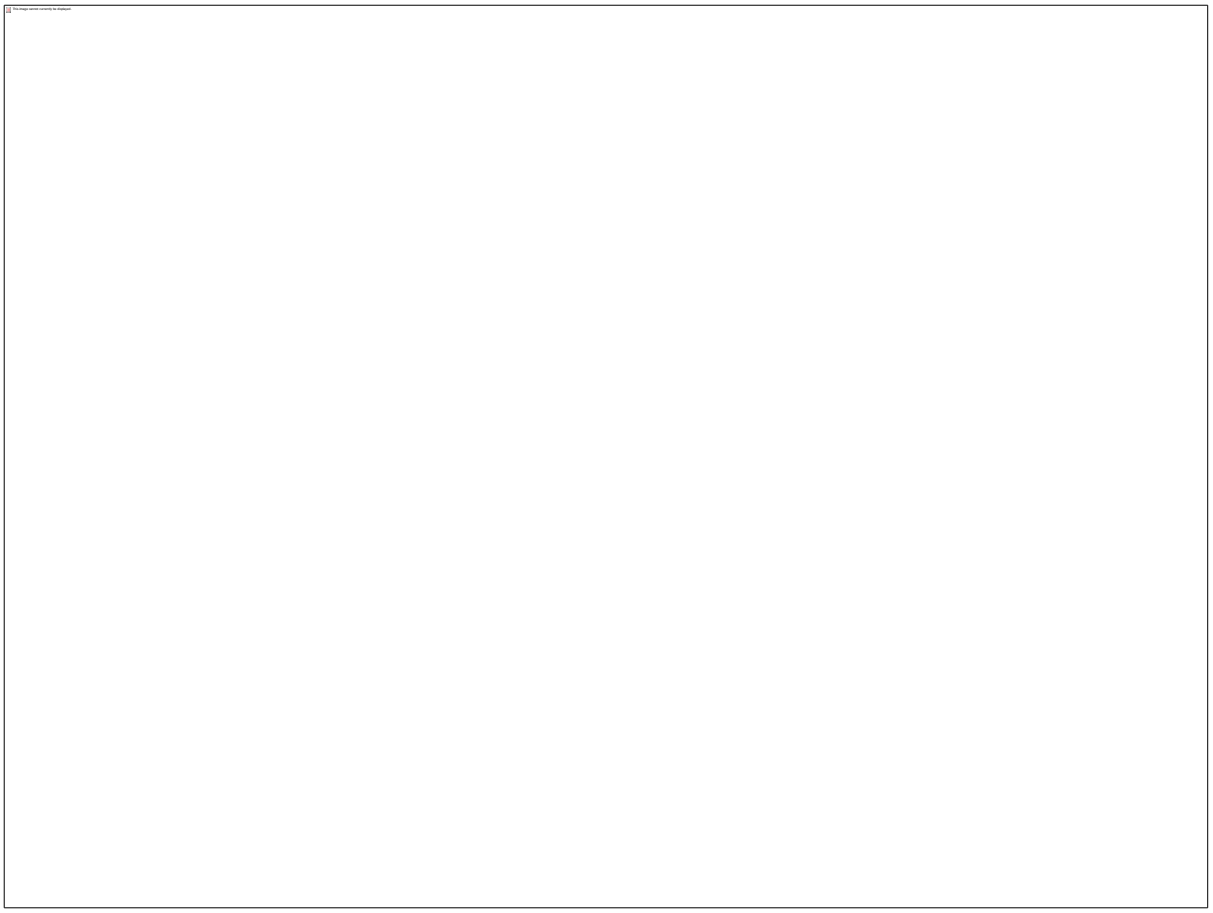
Appendix 6: Household numbers and their purposes of rearing cattle and goats

	Household Numbers	**Percentage (%)**
Cattle		
Income only	19	30.65
Meat only	16	25.81
Milk only	2	3.23
Cultural purposes only	7	11.28
Prestige only	5	8.06
Multi-purposes uses	13	20.97
Total number of Households with cattle	62	100
Goats		
Income only	13	17.11
Meat only	12	15.78
Milk only	1	1.32
Cultural purposes only	24	31.58
Prestige only	15	19.74
Multi-purposes	11	14.47
Total number of Households with goats	76	100

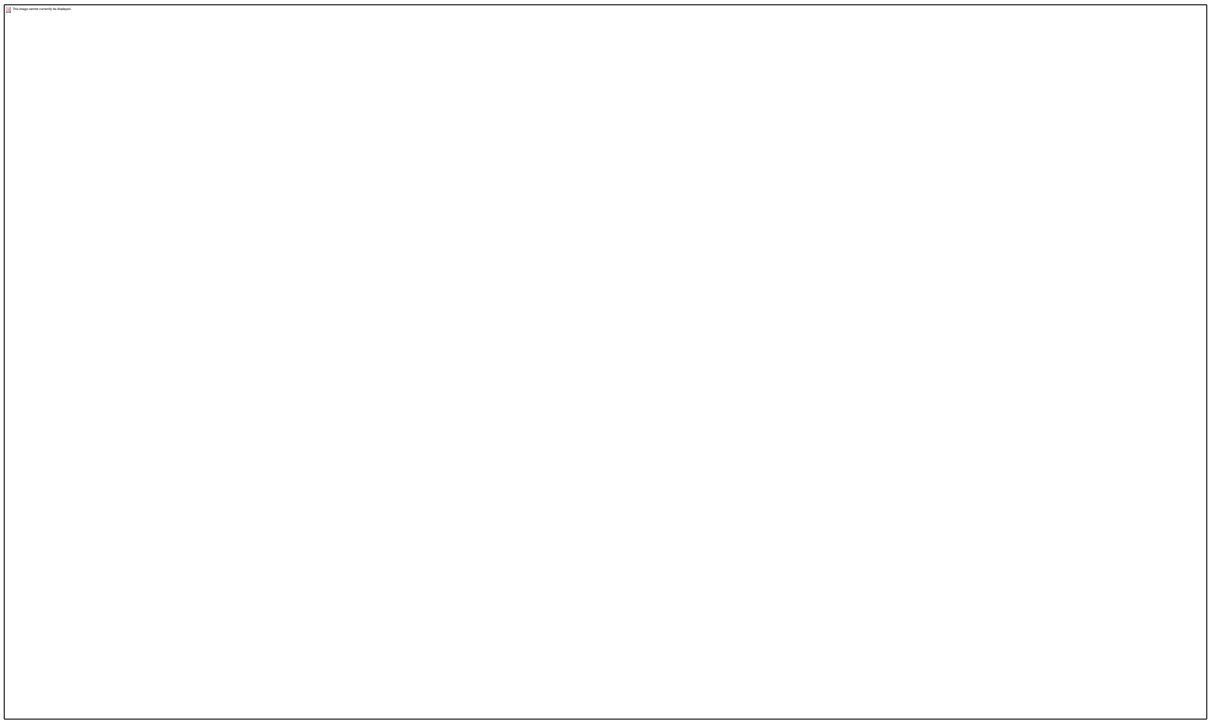
Appendix 7 Kraal

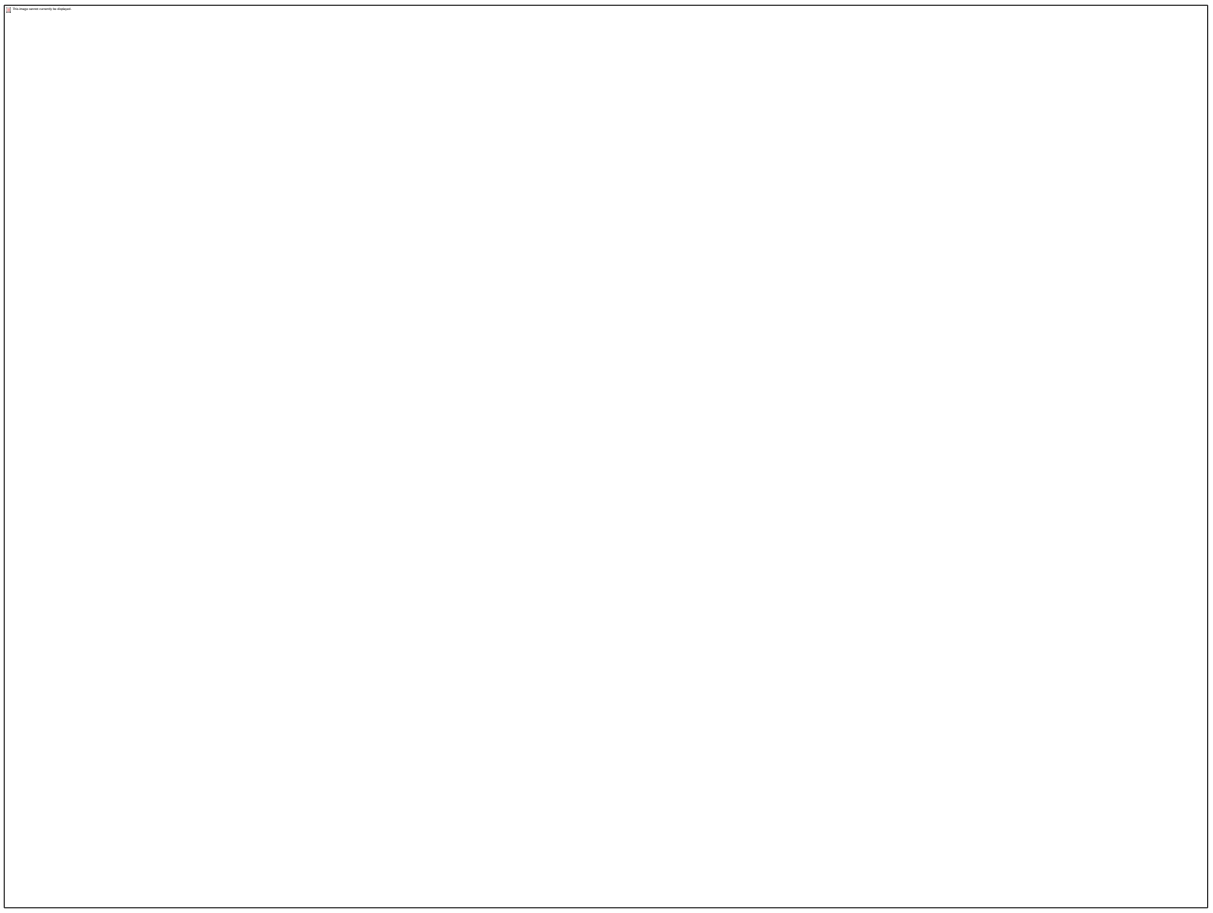




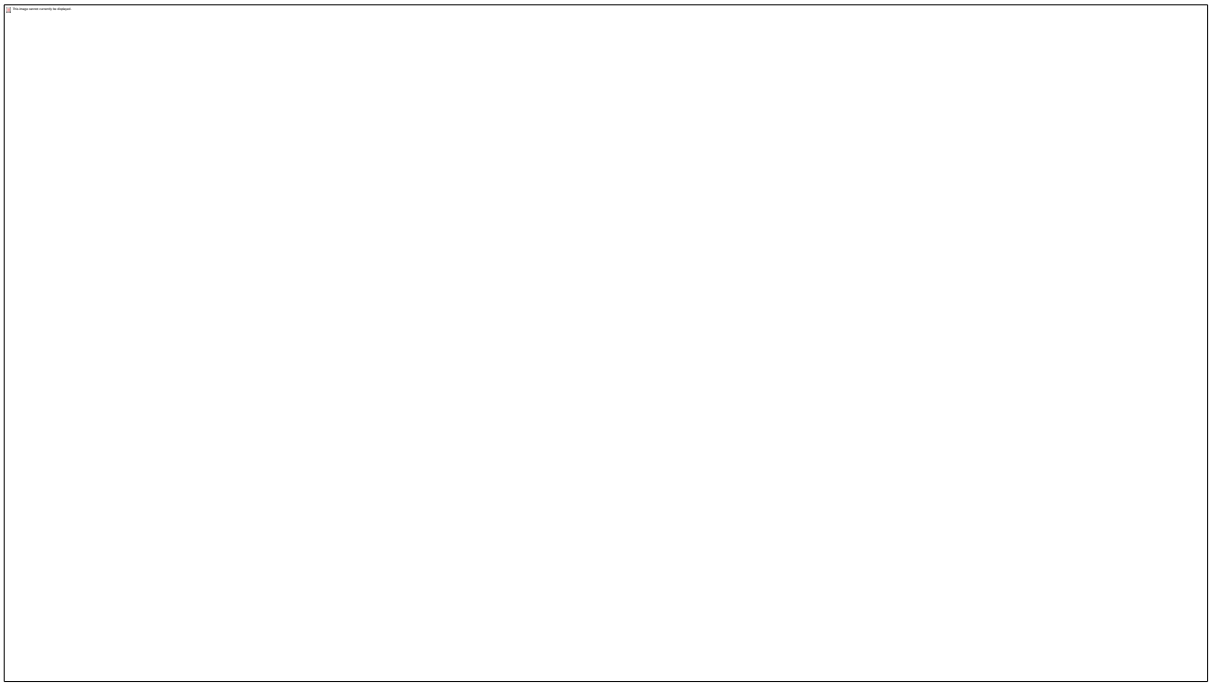


Appendix 8 Feaca data collection on the field

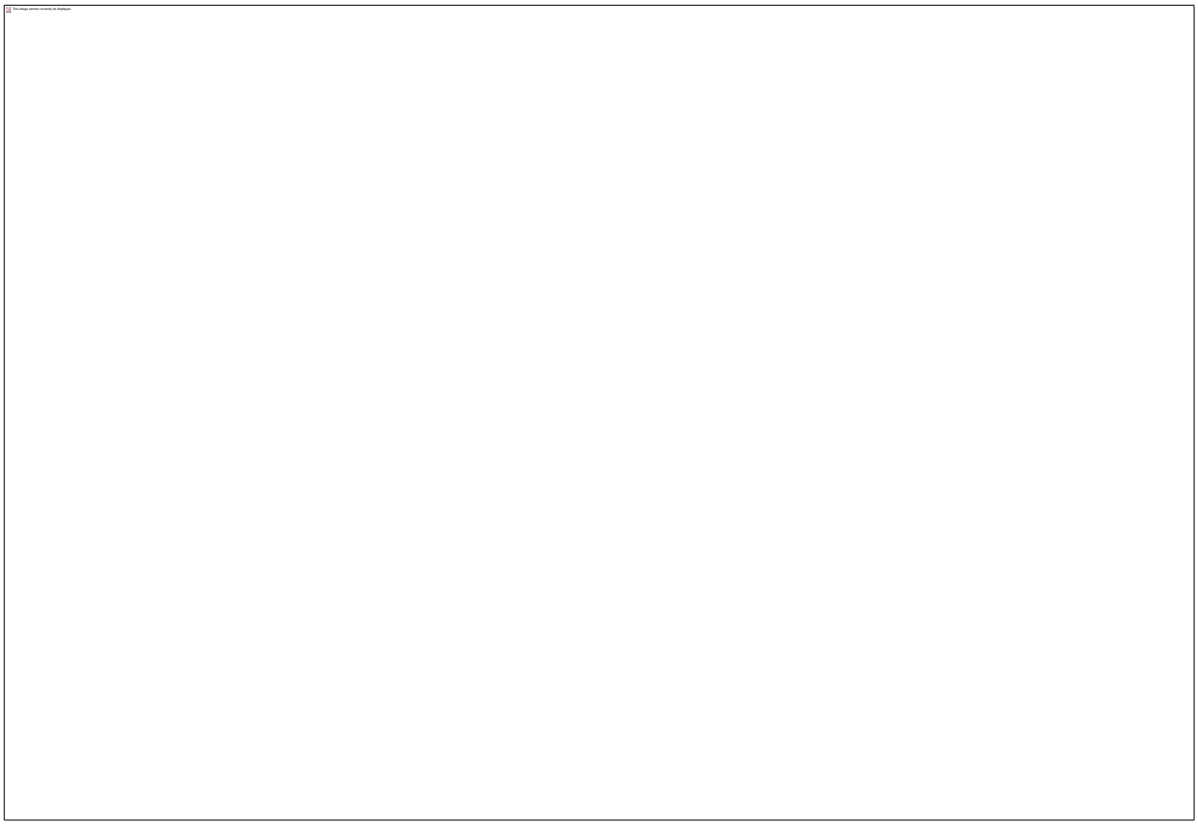




Appendix 9 *In vitro* machine



Appendix 10 Inductively Coupled Plasma Mass Spectrometry



Appendix 11 Effect of season on *in vitro* gas production of consumed forages

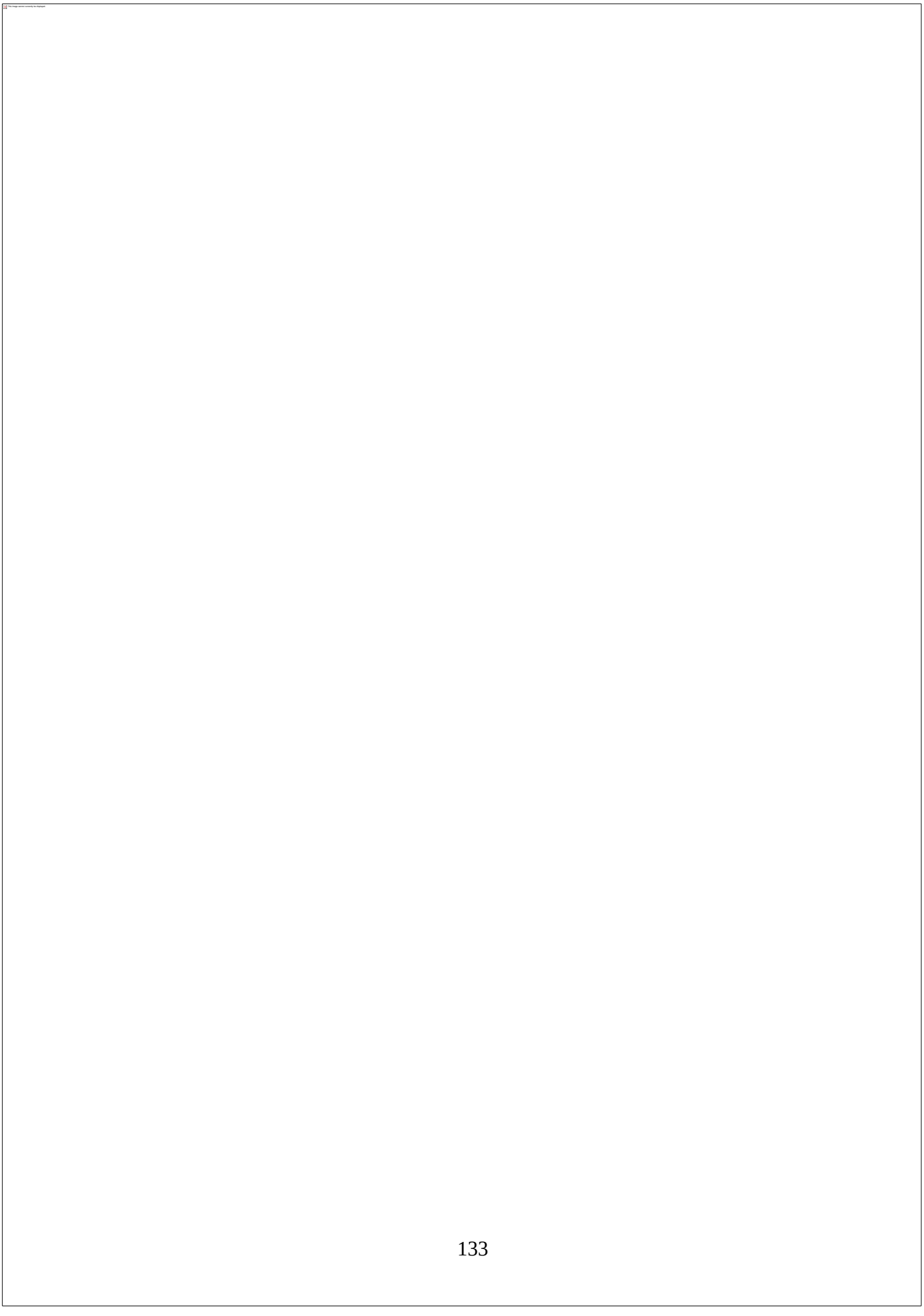
	6 hours			20 hours			44 hours		
Grasses	Winter	Early Sumer	Late Summer	Winter	Early Summer	Late Summer	Winter	Early Summer	Late Summer
G1	22.1045	-	-	33.5000	-	-	41.1886	-	-
G2	16.8873	-	-	28.5574	-	-	37.0697	-	-
G3	29.5184	-	-	35.9713	-	-	35.0697	-	-
G4	26.4980	-	-	44.0718	-	-	68.6476	-	-
G5	23.3402	44.7582	-	28.8320	52.1722	-	35.9713	-	-
G6	10.4344	-	-	35.9713	-	-	-	-	-
G7	21.8299	21.1434	8.5123	33.9119	33.9119	21.9672	47.6414	43.5226	50.7992
G8	19.2213	-	-	28.4201	-	-	29.6557	-	-
G9	20.7315	-	-	42.9734	-	-	52.0349	-	-
G10	21.6926	-	-	32.1271	-	-	35.4221	-	-
G11	-	9.4733	-	-	25.5369	-	-	42.5615	-
G12	-	35.1476	-	-	63.7050	-	-	136.4715	-
G13	-	16.4754	-	-	38.7172	-	-	62.8812	-
G14	-	8.5123	-	-	17.7110	-	-	-	-
G15	-	18.6721	-	-	49.7009	-	-	76.0616	-
G16	-	-	9.3360	-	-	47.5041	-	-	60.1353
G17	-	-	10.2971	-	-	28.0082	-	-	33.7746
G18	-	-	9.1987	-	-	24.7131	-	-	47.9160
G19	-	-	7.2766	-	-	34.0492	-	-	57.5267
G20	-	-	13.7295	-	-	42.5615	-	-	63.2931
Means	21.226^{a}	19.072^{a}	9.835^{b}	34.888^{a}	37.180^{a}	32.814^{a}	42.562^{b}	67.504^{a}	51.596^{b}

Appendix 12 Means of particles passage rate in different seasons and Animal

Season	**Ap1**	**Kp1**	**AP2**	**KP2**	**Ttp**	**Rrtp**	**Hrtp**	**Mrtp**
Early Summer	2.989	0.041	3.269	0.072	61.4	34.8	20.9	117.3
Late Summer	3.978	0.516	4.545	0.083	25.1	23.2	41.3	62.5
Winter	2.067	0.131	0.587	0.073	10.0	91.1	22.7	123.7
Animal								
Cattle	2.454	0.035	3.101	0.083	53.8	46.8	16.7	117.2
Goat	3.568	0.036	3.832	0.068	10.6	52.6	21.9	85.1

Appendix 13 Significance levels for the effect of season and community on cattle weight

Livestock weight	**Class**	**P-Value**	**Significance**
Cattle			
Initial Weight	Season	0.5125	NS
	Community	0.5173	NS
Final Weight	Season	0.0012	**
	Community	0.6469	NS
Live Weight Gain	Season	0.0001	**
	Community	0.5397	NS
Heart Girth Conference	Season	0.5849	NS
	Community	0.5962	NS
Back Lenght	Season	0.4262	NS
	Community	0.9476	NS
Goats			
Initial Weight	Season	0.5096	NS
	Community	0.0302	*
Final Weight	Season	0.2549	NS
	Community	0.3060	NS
Live Weight Gain	Season	0.0001	**
	Community	0.0057	**
Girth length	Season	0.2080	NS
	Community	0.0079	**
Back Length	Season	0.2582	NS
	Community	0.2773	NS



Appendix

Data analzed for animal live body weight and calibrated tape weight measurement

Obs	Season	Com	Animal	Farmer	AnID	days	Iwt	FWt	Iwc	HGirth	Length	Pwt
1	Winter	Madulane	Cattle	1	1	44	281.0	276	-113.64	16.1	18.8	312
2	Winter	Madulane	Cattle	1	2	44	433.0	382	-1159.09	18.7	20.6	470
3	Winter	Madulane	Cattle	1	3	44	147.0	123	-545.45	17.0	18.0	363
4	Winter	Madulane	Cattle	1	4	44	307.0	206	-2295.45	18.2	18.5	436
5	Winter	Madulane	Cattle	1	5	44	209.0	157	-1181.82	16.7	19.6	345
6	Winter	Madulane	Cattle	1	6	44	146.5	102	-1011.36	12.5	14.8	247
7	Winter	Madulane	Cattle	1	7	44	170.5	121	-1125.00	13.3	15.0	182
8	Winter	Madulane	Cattle	1	8	44	211.0	213	45.45	14.7	15.0	241
9	Winter	Madulane	Cattle	1	9	44	265.0	237	-636.36	18.0	18.8	424
10	Winter	Nxamalal	Cattle	1	1	36	281.0	256	-694.44	16.1	16.5	313
11	Winter	Nxamalal	Cattle	1	2	36	154.5	133	-597.22	14.9	16.7	251
12	Winter	Nxamalal	Cattle	1	3	36	288.0	283	-138.89	10.8	19.0	128
13	Winter	Nxamalal	Cattle	1	4	36	291.0	286	-138.89	10.5	18.0	119
14	Winter	Nxamalal	Cattle	1	5	36	292.0	228	-1777.78	15.6	17.8	286
15	Winter	Nxamalal	Cattle	1	6	36	463.0	322	-3916.67	15.7	17.8	291
16	Winter	Nxamalal	Cattle	1	7	36	191.0	186	-138.89	13.9	15.9	206
17	Winter	Nxamalal	Cattle	1	8	36	328.0	303	-694.44	17.1	18.9	370
18	Winter	Nxamalal	Cattle	1	9	36	249.0	222	-750.00	15.7	18.0	292
19	Winter	Nxamalal	Cattle	1	10	36	395.0	361	-944.44	17.1	18.9	364
20	Winter	Nxamalal	Cattle	1	11	36	135.0	128	-194.44	.	.	0
21	Winter	Nxamalal	Cattle	1	12	36	165.0	142	-638.89	.	.	0
22	Winter	Nxamalal	Cattle	1	13	36	198.0	179	-527.78	.	.	0
23	Winter	Nxamalal	Cattle	1	14	36	102.0	95	-194.44	.	.	0
24	Spring	Madulane	Cattle	1	1	64	153.0	196	671.88	.	.	0

25	Spring	Madulane	Cattle	1	2	64	356.0	404	750.00	.	.	0	
26	Spring	Madulane	Cattle	1	3	64	275.0	312	578.13	.	.	0	
27	Spring	Madulane	Cattle	1	4	64	270.0	302	500.00	.	.	0	
28	Spring	Madulane	Cattle	1	5	64	236.0	265	453.13	.	.	0	
29	Spring	Madulane	Cattle	1	6	64	181.0	223	656.25	.	.	0	
30	Spring	Madulane	Cattle	1	7	64	142.0	178	562.50	.	.	0	
31	Spring	Madulane	Cattle	1	8	64	208.0	253	703.13	.	.	0	
32	Spring	Madulane	Cattle	1	9	64	367.0	406	609.38	.	.	0	
33	Spring	Nxamalal	Cattle	1	1	62	418.0	455	596.77	.	.	0	
34	Spring	Nxamalal	Cattle	1	2	62	285.0	310	403.23	.	.	0	
35	Spring	Nxamalal	Cattle	1	3	62	266.0	293	435.48	.	.	0	
36	Spring	Nxamalal	Cattle	1	4	62	121.0	164	693.55	.	.	0	
37	Spring	Nxamalal	Cattle	1	5	62	298.0	335	596.77	.	.	0	
38	Spring	Nxamalal	Cattle	1	6	62	342.0	396	870.97	.	.	0	
39	Spring	Nxamalal	Cattle	1	7	62	312.0	367	887.10	.	.	0	
40	Spring	Nxamalal	Cattle	1	8	62	371.0	398	435.48	.	.	0	
41	Spring	Nxamalal	Cattle	1	9	62	425.0	454	467.74	.	.	0	
42	Sunmer	Nxamalal	Cattle	1	1	63	365.0	368	47.62	18.8	20.8	476	
43	Sunmer	Nxamalal	Cattle	1	2	63	158.0	142	-253.97	17.3	19.2	380	
44	Sunmer	Nxamalal	Cattle	1	3	63	310.0	315	79.37	16.4	18.4	328	
45	Sunmer	Nxamalal	Cattle	1	4	63	189.0	168	-333.33	15.4	14.4	376	
46	Sunmer	Nxamalal	Cattle	1	5	63	209.0	208	-15.87	15.9	15.3	302	
47	Sunmer	Nxamalal	Cattle	1	6	63	167.0	140	-428.57	13.6	13.8	194	
48	Sunmer	Nxamalal	Cattle	1	7	63	297.0	282	-238.10	16.2	18.2	316	
49	Sunmer	Nxamalal	Cattle	1	8	63	285.0	266	-301.59	16.1	17.5	312	
50	Sunmer	Nxamalal	Cattle	1	9	63	132.0	100	-507.94	12.6	12.8	156	
51	Sunmer	Nxamalal	Cattle	1	10	63	268.0	308.0	634.92	16.9	17.6	368.00	

52	Sunmer	Nxamalal	Cattle	1	11	63	246.0	215.0	-492.06	16.2	16.8	316.00
53	Sunmer	Nxamalal	Cattle	1	12	63	364.0	234.0	-2063.49	18.0	17.6	424.00
54	Sunmer	Madulane	Cattle	1	1	56	288.0	225.0	-1125.00	6.6	17.7	340.00
55	Sunmer	Madulane	Cattle	1	2	56	410.0	384.0	-464.29	8.9	22.5	484.00
56	Sunmer	Madulane	Cattle	1	3	56	331.0	275.0	-1000.00	8.1	8.5	430.00
57	Sunmer	Madulane	Cattle	1	4	56	227.0	269.0	750.00	4.6	6.5	238.00
58	Sunmer	Madulane	Cattle	1	5	56	409.0	426.0	303.57	19.5	20.7	525.00
59	Sunmer	Madulane	Cattle	1	6	56	345.0	376.0	553.57	18.9	19.2	484.00
60	Sunmer	Madulane	Cattle	1	7	56	328.0	338.0	178.57	18.3	18.4	443.00
61	Sunmer	Madulane	Cattle	1	8	56	216.0	214.0	-35.71	15.3	19.6	271.00
62	Sunmer	Madulane	Cattle	1	9	56	359.0	369.0	178.57	17.5	19.5	393.00
63	Sunmer	Madulane	Cattle	1	10	56	299.0	278.0	-375.00	17.1	18.8	370.00
64	Sunmer	Madulane	Cattle	1	11	56	284.0	302.0	321.43	17.6	17.4	399.00
65	Sunmer	Madulane	Cattle	1	12	56	101.5	134.0	580.36	11.7	13.8	126.00
66	Sunmer	Madulane	Cattle	1	13	56	146.0	193.0	839.29	13.3	19.2	182.00
67	Winter	Madulane	Goat	1	1	45	11.5	11.0	-11.11	.	.	0.00
68	Winter	Madulane	Goat	1	2	45	26.0	26.0	0.00	.	.	0.00
69	Winter	Madulane	Goat	1	3	45	16.5	14.5	-44.44	.	.	0.00
70	Winter	Madulane	Goat	1	4	45	30.5	26.5	-88.89	.	.	0.00
71	Winter	Madulane	Goat	1	5	45	19.5	19.5	0.00	.	.	0.00
72	Winter	Madulane	Goat	1	6	45	21.0	18.5	-55.56	.	.	0.00
73	Winter	Madulane	Goat	1	7	45	13.5	17.0	77.78	.	.	0.00
74	Winter	Madulane	Goat	1	8	45	22.5	20.0	-55.56	.	.	0.00
75	Winter	Madulane	Goat	1	9	45	24.5	21.0	-77.78	.	.	0.00
76	Winter	Madulane	Goat	1	10	45	21.0	17.0	-88.89	.	.	0.00
77	Winter	Madulane	Goat	1	11	45	17.5	17.0	-11.11	.	.	0.00
78	Winter	Madulane	Goat	2	1	45	27.5	23.0	-100.00	.	.	0.00

79	Winter	Madulane	Goat	2	2	45	27.5	24.0	-77.78	.	.	0.00
80	Winter	Madulane	Goat	2	3	45	25.0	24.0	-22.22	.	.	0.00
81	Winter	Madulane	Goat	2	4	45	33.0	31.0	-44.44	.	.	0.00
82	Winter	Madulane	Goat	2	5	45	29.0	25.0	-88.89	.	.	0.00
83	Winter	Madulane	Goat	2	6	45	18.0	15.5	-55.56	.	.	0.00
84	Winter	Madulane	Goat	2	7	45	30.5	28.0	-55.56	.	.	0.00
85	Winter	Madulane	Goat	2	8	45	11.5	10.5	-22.22	.	.	0.00
86	Winter	Madulane	Goat	2	9	45	20.0	20.5	11.11	.	.	0.00
87	Winter	Madulane	Goat	2	10	45	14.5	15.5	22.22	.	.	0.00
88	Winter	Nxamalal	Goat	1	1	34	19.5	15.0	-132.35	.	.	0.00
89	Winter	Nxamalal	Goat	1	2	34	20.0	16.5	-102.94	.	.	0.00
90	Winter	Nxamalal	Goat	1	3	34	17.5	12.5	-147.06	.	.	0.00
91	Winter	Nxamalal	Goat	1	4	34	26.0	23.5	-73.53	.	.	0.00
92	Winter	Nxamalal	Goat	1	5	34	20.0	21.5	44.12	.	.	0.00
93	Winter	Nxamalal	Goat	1	6	34	33.5	34.5	29.41	.	.	0.00
94	Winter	Nxamalal	Goat	1	7	34	28.0	15.5	-367.65	.	.	0.00
95	Winter	Nxamalal	Goat	1	8	34	27.5	21.5	-176.47	.	.	0.00
96	Winter	Nxamalal	Goat	1	9	34	29.5	23.5	-176.47	.	.	0.00
97	Winter	Nxamalal	Goat	1	10	34	50.5	46.0	-132.35	.	.	0.00
98	Spring	Madulane	Goat	1	1	57	20.1	23.5	59.65	7.3	8.9	33.75
99	Spring	Madulane	Goat	1	2	57	24.0	28.5	78.95	7.8	9.8	39.50
100	Spring	Madulane	Goat	1	3	57	23.0	26.5	61.40	7.5	8.9	36.00
101	Spring	Madulane	Goat	1	4	57	28.0	30.5	43.860	8.1	9.8	43.25
102	Spring	Madulane	Goat	1	5	57	19.5	24.5	87.719	7.9	9.0	40.50
103	Spring	Madulane	Goat	1	6	57	22.0	25.5	61.404	7.4	8.9	35.00
104	Spring	Madulane	Goat	1	7	57	20.0	23.0	52.632	7.3	9.0	33.75
105	Spring	Madulane	Goat	1	8	57	17.5	21.0	61.404	7.7	8.7	38.00

106	Spring	Madulane	Goat	1	9	57	17.5	22.5	87.719	7.6	9.2	37.00
107	Spring	Madulane	Goat	1	10	57	13.5	19.5	105.263	7.5	9.5	36.00
108	Spring	Madulane	Goat	1	11	57	27.5	29.0	26.316	8.1	9.9	43.25
109	Spring	Madulane	Goat	2	1	56	32.0	37.0	89.286	7.9	10.6	40.50
110	Spring	Madulane	Goat	2	2	56	15.0	20.5	98.214	7.1	8.8	31.50
111	Spring	Madulane	Goat	2	3	56	27.5	33.0	98.214	10.7	8.5	.
112	Spring	Madulane	Goat	2	4	56	32.0	38.5	116.071	8.3	9.9	46.00
113	Spring	Madulane	Goat	2	5	56	25.0	28.0	53.571	7.4	9.9	35.00
114	Spring	Madulane	Goat	2	6	56	35.0	39.0	71.429	8.1	10.8	43.25
115	Spring	Madulane	Goat	2	7	56	13.5	17.0	62.500	7.6	7.9	37.00
116	Spring	Madulane	Goat	2	8	56	15.0	19.5	80.357	9.2	6.8	58.50
117	Spring	Madulane	Goat	2	9	56	10.5	16.0	98.214	6.7	6.5	27.50
118	Spring	Madulane	Goat	2	10	56	18.5	24.0	98.214	9.1	6.8	57.50
119	Spring	Nxamalal	Goat	1	1	56	18.5	22.0	62.500	7.0	9.5	30.50
120	Spring	Nxamalal	Goat	1	2	56	24.5	28.5	71.429	7.8	9.8	39.50
121	Spring	Nxamalal	Goat	1	3	56	22.0	27.5	98.214	7.2	9.3	32.50
122	Spring	Nxamalal	Goat	1	4	56	17.0	20.5	62.500	6.9	8.6	29.40
123	Spring	Nxamalal	Goat	1	5	56	23.0	29.5	116.071	7.5	10.4	36.00
124	Spring	Nxamalal	Goat	1	6	56	25.5	30.0	80.357	7.5	9.8	46.00
125	Spring	Nxamalal	Goat	1	7	56	44.0	47.5	62.500	8.4	10.5	47.30
126	Spring	Nxamalal	Goat	1	8	56	19.5	22.0	44.643	6.8	9.5	28.40
127	Spring	Nxamalal	Goat	1	9	56	17.5	20.5	53.571	7.6	10.3	37.00
128	Spring	Nxamalal	Goat	1	10	56	27.0	33.0	107.143	7.9	9.8	40.50
129	Spring	Nxamalal	Goat	2	1	56	.	24.0	.	6.9	9.2	29.40
130	Spring	Nxamalal	Goat	2	2	56	.	14.5	.	5.9	7.9	20.20
131	Spring	Nxamalal	Goat	2	3	56	.	11.0	.	5.5	7.4	17.00
132	Spring	Madulane	Goat	2	4	56	.	24.5	.	7.4	9.5	34.80

133	Spring	Madulane	Goat	2	5	56	.	16.5	.	6.7	8.4	27.40
134	Spring	Nxamalal	Goat	2	6	56	.	25.0	.	7.1	8.7	31.50
135	Spring	Nxamalal	Goat	2	7	56	.	25.5	.	7.6	9.6	37.00
136	Spring	Nxamalal	Goat	2	8	56	.	24.5	.	7.4	9.0	43.80
137	Spring	Nxamalal	Goat	2	9	56	.	35.0	.	8.0	9.9	42.00
138	Spring	Nxamalal	Goat	2	10	56	.	29.5	.	7.9	9.4	40.50
139	Spring	Nxamalal	Goat	2	11	56	.	23.5	.	7.7	9.7	38.00
140	Spring	Nxamalal	Goat	2	12	56	.	24.5	.	7.6	9.8	37.00
141	Spring	Nxamalal	Goat	2	13	56	.	32.5	.	8.3	9.7	46.00
142	Spring	Nxamalal	Goat	2	14	56	.	31.5	.	7.5	10.5	36.00
143	Spring	Nxamalal	Goat	2	15	56	.	19.5	.	7.7	9.1	38.00
144	Spring	Nxamalal	Goat	2	16	56	.	21.5	.	6.7	8.6	27.40
145	Spring	Nxamalal	Goat	2	17	56	.	30.0	.	7.9	9.9	40.50
146	Spring	Nxamalal	Goat	2	18	56	.	25.0	.	7.2	8.3	32.50
147	Spring	Nxamalal	Goat	2	19	56	.	34.8	.	8.5	9.9	48.50
148	Spring	Nxamalal	Goat	2	20	56	.	13.0	.	6.0	7.8	21.00
149	Spring	Nxamalal	Goat	2	21	56	.	30.5	.	8.5	9.9	48.50
150	Spring	Nxamalal	Goat	2	22	56	.	20.5	.	7.3	8.7	33.60
151	Spring	Nxamalal	Goat	2	23	56	.	6.5	.	5.4	6.3	16.0
152	Spring	Nxamalal	Goat	2	24	56	.	4.5	.	4.5	5.6	9.6
153	Spring	Nxamalal	Goat	2	25	56	.	4.0	.	4.5	6.1	9.6
154	Spring	Nxamalal	Goat	2	26	56	.	11.0	.	5.5	7.4	17.0
155	Spring	Nxamalal	Goat	2	27	56	.	12.0	.	6.3	7.8	23.6
156	Spring	Nxamalal	Goat	2	28	56	.	7.5	.	5.6	6.5	17.8
157	Spring	Nxamalal	Goat	2	29	56	.	4.5	.	4.6	5.5	10.2
158	Spring	Madulane	Goat	2	30	56	.	13.5	.	5.9	7.7	20.2
159	Spring	Madulane	Goat	2	31	56	.	10.0	.	5.4	6.9	16.0

160	Spring	Madulane	Goat	2	32	56	.	30.5	.	8.1	9.8	43.4	
161	Spring	Madulane	Goat	2	33	56	.	30.5	.	8.0	10.3	42.0	
162	Spring	Madulane	Goat	2	34	56	.	33.0	.	8.4	9.9	47.4	
163	Spring	Madulane	Goat	2	35	56	.	18.0	.	7.6	8.0	37.0	
164	Spring	Madulane	Goat	2	36	56	.	15.0	.	9.3	7.9	60.2	
165	Spring	Madulane	Goat	2	37	56	.	9.5	.	5.7	7.6	18.6	
166	Spring	Madulane	Goat	2	38	56	.	18.0	.	6.7	8.9	27.2	
167	Spring	Madulane	Goat	2	39	56	.	10.5	.	5.6	7.0	17.8	
168	Sunmer	Nxamalal	Goat	1	1	64	20.5	22.0	23.4375	6.9	8.8	29.4	
169	Sunmer	Nxamalal	Goat	1	2	64	30.5	34.0	54.6875	8.0	9.0	42.0	
170	Sunmer	Nxamalal	Goat	1	3	64	31.0	37.0	93.7500	8.2	9.0	45.0	
171	Sunmer	Nxamalal	Goat	1	4	64	31.5	35.0	54.6875	8.8	8.9	52.8	
172	Sunmer	Nxamalal	Goat	1	5	64	23.5	27.0	54.6875	7.1	8.9	31.5	
173	Sunmer	Nxamalal	Goat	1	6	64	29.0	30.5	23.4375	8.2	8.3	45.0	
174	Sunmer	Nxamalal	Goat	1	7	64	27.5	30.0	39.0625	8.5	8.5	48.5	
175	Sunmer	Nxamalal	Goat	1	8	64	25.0	28.0	46.8750	7.9	8.9	40.4	
176	Sunmer	Nxamalal	Goat	1	9	64	11.5	13.0	23.4375	5.5	6.9	17.0	
177	Sunmer	Nxamalal	Goat	1	10	64	48.0	52.0	62.5000	9.7	10.1	67.0	
178	Sunmer	Nxamalal	Goat	1	11	64	27.0	30.0	46.8750	8.0	9.0	42.0	
179	Sunmer	Nxamalal	Goat	1	12	64	30.5	33.0	39.0625	7.8	9.5	39.2	
180	Sunmer	Nxamalal	Goat	1	13	64	13.5	15.5	31.2500	6.5	8.1	25.4	
181	Sunmer	Nxamalal	Goat	1	14	64	23.5	26.0	39.0625	8.7	8.6	51.0	
182	Sunmer	Nxamalal	Goat	1	15	60	14.5	16.0	25.0000	6.1	8.4	22.0	
183	Sunmer	Nxamalal	Goat	2	1	60	19.5	22.0	41.6667	5.4	9.2	16.0	
184	Sunmer	Nxamalal	Goat	2	2	60	20.0	22.0	33.3333	7.2	8.5	32.6	
185	Sunmer	Nxamalal	Goat	2	3	60	22.0	25.0	50.0000	7.1	8.9	31.5	
186	Sunmer	Nxamalal	Goat	2	4	60	26.0	29.0	50.0000	8.0	9.9	42.0	

187	Sunmer	Nxamalal	Goat	2	5	60	31.0	32.0	16.6667	8.4	9.7	47.4
188	Sunmer	Nxamalal	Goat	2	6	60	18.0	19.0	16.6667	6.9	9.0	29.4
189	Sunmer	Nxamalal	Goat	2	7	60	17.0	15.0	-33.3333	6.6	8.8	26.4
190	Sunmer	Nxamalal	Goat	2	8	60	21.0	22.5	25.0000	6.8	9.0	28.4
191	Sunmer	Nxamalal	Goat	2	9	60	26.0	28.0	33.3333	7.4	9.1	35.0
192	Sunmer	Nxamalal	Goat	2	10	60	11.0	10.0	-16.6667	5.6	7.0	17.8
193	Sunmer	Nxamalal	Goat	2	11	60	28.5	32.0	58.3333	7.7	.	38.0
194	Sunmer	Nxamalal	Goat	2	12	60	13.5	15.0	25.0000	5.8	7.8	19.4
195	Sunmer	Nxamalal	Goat	3	1	60	13.5	17.0	58.3333	6.3	7.7	22.8
196	Sunmer	Nxamalal	Goat	3	2	60	24.0	28.0	66.6667	7.6	8.4	37.0
197	Sunmer	Nxamalal	Goat	3	3	60	24.0	26.5	41.6667	6.9	8.6	29.4
198	Sunmer	Nxamalal	Goat	3	4	60	24.0	27.0	50.0000	7.4	8.8	35.0
199	Sunmer	Nxamalal	Goat	3	5	60	24.5	28.0	58.3333	7.2	9.0	28.4
200	Sunmer	Nxamalal	Goat	3	6	60	27.0	30.5	58.3333	7.9	9.5	38.0
201	Sunmer	Nxamalal	Goat	3	7	60	11.0	12.0	16.667	5.6	7.0	17.8
202	Sunmer	Nxamalal	Goat	3	8	60	26.0	27.5	25.000	7.3	8.8	33.8
203	Sunmer	Nxamalal	Goat	3	9	60	31.0	33.0	33.333	7.9	9.4	40.5
204	Sunmer	Nxamalal	Goat	3	10	60	25.0	16.5	-141.667	7.4	9.8	35.0
205	Sunmer	Nxamalal	Goat	3	11	60	34.5	37.5	50.000	8.6	10.0	50.0
206	Sunmer	Madulane	Goat	1	1	61	13.1	18.0	80.328	6.2	10.3	22.8
207	Sunmer	Madulane	Goat	1	2	61	19.0	20.0	16.393	7.0	8.1	43.4
208	Sunmer	Madulane	Goat	1	3	61	23.5	25.5	32.787	7.8	9.0	39.2
209	Sunmer	Madulane	Goat	1	4	61	19.5	21.0	24.590	7.5	7.7	36.0
210	Sunmer	Madulane	Goat	1	5	61	17.5	22.0	73.770	7.2	8.0	32.6
211	Sunmer	Madulane	Goat	1	6	61	19.5	23.0	57.377	7.2	8.4	32.6
212	Sunmer	Madulane	Goat	1	7	61	35.0	38.0	49.180	7.9	14.1	40.5
213	Sunmer	Madulane	Goat	2	1	61	18.5	22.5	65.574	7.2	8.3	32.5

214	Sunmer	Madulane	Goat	2	2	61	24.0	24.0	0.000	7.6	9.4	37.0
215	Sunmer	Madulane	Goat	2	3	61	29.0	30.5	24.590	8.4	9.8	47.4
216	Sunmer	Madulane	Goat	2	4	61	32.0	38.5	106.557	8.6	9.7	50.0
217	Sunmer	Madulane	Goat	2	5	61	12.0	14.0	32.787	6.2	7.2	22.8
218	Sunmer	Madulane	Goat	2	6	61	21.0	23.0	32.787	7.0	8.6	30.4
219	Sunmer	Madulane	Goat	2	7	61	18.0	20.5	40.984	7.1	8.0	31.5
220	Sunmer	Madulane	Goat	2	8	61	24.5	25.5	16.393	7.8	9.0	39.2
221	Sunmer	Madulane	Goat	2	9	61	10.5	12.0	24.590	5.1	7.9	13.8
222	Sunmer	Madulane	Goat	2	10	61	15.5	15.0	-8.197	6.5	8.1	25.4
223	Sunmer	Madulane	Goat	2	11	61	18.5	20.5	32.787	6.8	9.0	28.4
224	Sunmer	Madulane	Goat	2	12	61	21.0	26.0	81.967	7.8	7.9	39.2
225	Sunmer	Madulane	Goat	2	13	61	27.5	29.0	24.590	7.9	9.9	40.4
226	Sunmer	Madulane	Goat	2	14	61	10.5	14.0	57.377	5.9	7.5	20.2
227	Sunmer	Madulane	Goat	2	15	61	30.5	33.0	40.984	8.9	9.5	54.0
228	Sunmer	Madulane	Goat	3	1	52	37.0	31.0	-115.385	11.2	9.2	.
229	Sunmer	Madulane	Goat	3	2	52	14.5	17.0	48.077	8.1	6.1	43.4
230	Sunmer	Madulane	Goat	3	3	52	22.5	25.0	48.077	8.4	7.3	47.4
231	Sunmer	Madulane	Goat	3	4	52	25.0	24.0	-19.231	9.0	7.4	55.5
232	Sunmer	Madulane	Goat	3	5	52	16.0	20.0	76.923	8.0	6.5	42.0
233	Sunmer	Madulane	Goat	3	6	52	33.0	30.0	-57.692	9.6	8.1	66.0
234	Sunmer	Madulane	Goat	3	7	52	17.5	19.0	28.846	8.0	6.2	42.0
235	Sunmer	Madulane	Goat	3	8	52	37.5	33.0	-86.538	10.2	8.9	.
236	Sunmer	Madulane	Goat	3	9	52	16.0	17.0	19.231	6.4	7.7	24.5
237	Sunmer	Madulane	Goat	3	10	52	15.5	18.0	48.077	8.2	6.3	44.8
238	Sunmer	Madulane	Goat	3	11	52	13.0	14.0	19.231	8.2	5.8	44.8

Appendix Data used to analysed for In vitro gas production

Obs	season	community	grass	rep	time	pres	a	gas	rem
1	Spring	Madulane	G11	1	5.94	86.691	4.3956	9.8853	Y
2	Spring	Madulane	G11	2	5.94	86.447	4.0293	9.0615	Y
3	Spring	Madulane	G5	1	5.94	105.250	19.9023	44.7583	D
4	Spring	Madulane	G7	1	5.94	91.697	9.8901	22.2418	Y
5	Spring	Madulane	G7	2	5.94	90.110	8.9133	20.0451	Y
6	Spring	Nxamalal	G12	2	5.94	96.093	15.6288	35.1476	Y
7	Spring	Nxamalal	G13	1	5.94	86.691	3.9072	8.7869	Y
8	Spring	Nxamalal	G13	2	5.94	93.284	10.7448	24.1640	Y
9	Spring	Nxamalal	G14	1	5.94	88.400	5.0061	11.2582	D
10	Spring	Nxamalal	G14	2	5.94	85.714	2.5641	5.7664	D
11	Spring	Nxamalal	G15	1	5.94	89.377	8.3028	18.6722	Y
12	Summer	Madulane	G17	1	5.94	85.836	3.2967	7.4139	D
13	Summer	Madulane	G17	2	5.94	87.546	5.8608	13.1804	Y
14	Summer	Madulane	G18	1	5.94	86.325	4.8840	10.9836	Y
15	Summer	Madulane	G18	2	5.94	85.714	3.2967	7.4139	Y
16	Summer	Madulane	G7	2	5.94	85.348	3.7851	8.5123	Y
17	Summer	Nxamalal	G16	1	5.94	87.546	5.0061	11.2582	Y
18	Summer	Nxamalal	G16	2	5.94	85.958	3.2967	7.4139	D
19	Summer	Nxamalal	G19	1	5.94	85.104	5.2503	11.8074	Y
20	Summer	Nxamalal	G19	2	5.94	82.540	1.2210	2.7459	Y
21	Summer	Nxamalal	G20	1	5.94	81.074	7.9365	17.8484	Y
22	Summer	Nxamalal	G20	2	5.94	84.737	4.2735	9.6107	Y
23	Winter	Madulane	G1	1	5.94	93.895	12.2100	27.4591	Y
24	Winter	Madulane	G1	2	5.94	88.523	7.4481	16.7500	Y
25	Winter	Madulane	G3	1	5.94	92.063	15.8730	35.6968	Y
26	Winter	Madulane	G3	2	5.94	90.354	10.3785	23.3402	Y

27	Winter	Madulane	G4	1	5.94	96.337	13.4310	30.2050	Y
28	Winter	Madulane	G4	2	5.94	91.697	10.1343	22.7910	Y
29	Winter	Madulane	G5	1	5.94	92.063	9.7680	21.9673	Y
30	Winter	Madulane	G5	2	5.94	93.162	10.9890	24.7132	Y
31	Winter	Madulane	G8	1	5.94	91.453	9.5238	21.4181	Y
32	Winter	Madulane	G8	2	5.94	88.889	7.5702	17.0246	Y
33	Winter	Nxamalal	G10	1	5.94	90.965	10.5006	23.6148	Y
34	Winter	Nxamalal	G10	2	5.94	90.842	8.7912	19.7705	Y
35	Winter	Nxamalal	G2	1	5.94	87.790	6.1050	13.7295	Y
36	Winter	Nxamalal	G2	2	5.94	89.621	8.9133	20.0451	D
37	Winter	Nxamalal	G6	1	5.94	89.621	8.1807	18.3976	Y
38	Winter	Nxamalal	G6	2	5.94	84.737	1.0989	2.4713	Y
39	Winter	Nxamalal	G7	1	5.94	82.051	8.5470	19.2213	Y
40	Winter	Nxamalal	G7	2	5.94	91.087	10.8669	24.4386	Y
41	Winter	Nxamalal	G9	1	5.94	92.430	10.2564	23.0656	Y
42	Winter	Nxamalal	G9	2	5.94	90.965	8.1807	18.3976	Y
43	Spring	Madulane	G11	2	20.13	93.773	11.3553	25.5369	Y
44	Spring	Madulane	G5	1	20.13	108.547	23.1990	52.1722	Y
45	Spring	Madulane	G7	1	20.13	97.436	15.6288	35.1476	Y
46	Spring	Madulane	G7	2	20.13	95.726	14.5299	32.6763	D
47	Spring	Nxamalal	G12	2	20.13	108.791	28.3272	63.7050	Y
48	Spring	Nxamalal	G13	1	20.13	95.360	12.5763	28.2828	Y
49	Spring	Nxamalal	G13	2	20.13	104.396	21.8559	49.1517	Y
50	Spring	Nxamalal	G14	1	20.13	89.621	6.2271	14.0041	D
51	Spring	Nxamalal	G14	2	20.13	92.674	9.5238	21.4181	Y
52	Spring	Nxamalal	G15	1	20.13	103.175	22.1001	49.7009	Y
53	Summer	Madulane	G17	1	20.13	98.657	16.1172	36.2460	Y

54	Summer	Madulane	G17	2	20.13	90.476	8.7912	19.7705	Y
55	Summer	Madulane	G18	1	20.13	92.674	11.2332	25.2623	Y
56	Summer	Madulane	G18	2	20.13	93.162	10.7448	24.1640	Y
57	Summer	Madulane	G7	2	20.13	91.331	9.7680	21.967	D
58	Summer	Nxamalal	G16	1	20.13	103.663	21.1233	47.504	Y
59	Summer	Nxamalal	G19	1	20.13	100.244	20.3907	45.857	Y
60	Summer	Nxamalal	G19	2	20.13	91.209	9.8901	22.242	Y
61	Summer	Nxamalal	G20	1	20.13	97.802	24.6642	55.467	Y
62	Summer	Nxamalal	G20	2	20.13	93.651	13.1868	29.656	Y
63	Winter	Madulane	G1	1	20.13	100.366	18.6813	42.012	Y
64	Winter	Madulane	G1	2	20.13	92.186	11.1111	24.988	Y
65	Winter	Madulane	G3	1	20.13	94.994	18.8034	42.287	D
66	Winter	Madulane	G3	2	20.13	93.162	13.1868	29.656	Y
67	Winter	Madulane	G4	1	20.13	108.669	25.7631	57.939	Y
68	Winter	Madulane	G4	2	20.13	94.994	13.4310	30.205	Y
69	Winter	Madulane	G5	1	20.13	93.162	10.8669	24.439	D
70	Winter	Madulane	G5	2	20.13	96.947	14.7741	33.225	Y
71	Winter	Madulane	G8	1	20.13	96.825	14.8962	33.500	Y
72	Winter	Madulane	G8	2	20.13	91.697	10.3785	23.340	Y
73	Winter	Nxamalal	G10	1	20.13	94.750	14.2857	32.127	D
74	Winter	Nxamalal	G2	2	20.13	93.407	12.6984	28.557	Y
75	Winter	Nxamalal	G6	1	20.13	92.796	11.3553	25.537	Y
76	Winter	Nxamalal	G6	2	20.13	104.273	20.6349	46.406	Y
77	Winter	Nxamalal	G7	1	20.13	87.424	13.9194	31.303	Y
78	Winter	Nxamalal	G7	2	20.13	96.459	16.2393	36.521	Y
79	Winter	Nxamalal	G9	1	20.13	101.587	19.4139	43.660	Y
80	Winter	Nxamalal	G9	2	20.13	101.587	18.8034	42.287	Y

81	Spring	Madulane	G11	2	43.23	101.343	18.9255	42.562	Y
82	Spring	Madulane	G7	1	43.23	104.151	22.3443	50.250	D
83	Spring	Madulane	G7	2	43.23	97.558	16.3614	36.795	D
84	Spring	Nxamalal	G12	2	43.23	141.148	60.6837	136.472	Y
85	Spring	Nxamalal	G13	1	43.23	110.745	27.9609	62.881	Y
86	Spring	Nxamalal	G15	1	43.23	114.896	33.8217	76.062	Y
87	Summer	Madulane	G17	1	43.23	100.366	17.8266	40.090	D
88	Summer	Madulane	G17	2	43.23	93.895	12.2100	27.459	Y
89	Summer	Madulane	G18	1	43.23	110.256	28.8156	64.803	Y
90	Summer	Madulane	G18	2	43.23	96.215	13.7973	31.029	Y
91	Summer	Madulane	G7	2	43.23	104.151	22.5885	50.799	Y
92	Summer	Nxamalal	G16	1	43.23	109.280	26.7399	60.135	Y
93	Summer	Nxamalal	G19	1	43.23	108.059	28.2051	63.430	Y
94	Summer	Nxamalal	G19	2	43.23	104.273	22.9548	51.623	Y
95	Summer	Nxamalal	G20	1	43.23	105.128	31.9902	71.943	Y
96	Summer	Nxamalal	G20	2	43.23	104.762	24.2979	54.644	Y
97	Winter	Madulane	G1	1	43.23	106.349	24.6642	55.467	Y
98	Winter	Madulane	G1	2	43.23	93.040	11.9658	26.910	Y
99	Winter	Madulane	G3	2	43.23	95.604	15.6288	35.148	Y
100	Winter	Madulane	G4	1	43.23	113.431	30.5250	68.648	D
101	Winter	Madulane	G5	2	43.23	98.168	15.9951	35.971	D
102	Winter	Madulane	G8	1	43.23	97.802	15.8730	35.697	D
103	Winter	Madulane	G8	2	43.23	91.819	10.5006	23.615	Y
104	Winter	Nxamalal	G10	1	43.23	96.215	15.7509	35.422	Y
105	Winter	Nxamalal	G2	2	43.23	97.192	16.4835	37.070	Y
106	Winter	Nxamalal	G7	1	43.23	95.360	21.8559	49.152	Y
107	Winter	Nxamalal	G7	2	43.23	100.733	20.5128	46.131	Y

108	Winter	Nxamalal	G9	1	43.23	108.425	26.2515	59.037	Y
109	Winter	Nxamalal	G9	2	43.23	102.808	20.0244	45.033	Y

Data used for particle passage rate analysis in the rumen and hind gut

Obs	season	community	animal	id	kp1	Ap1	kp2	Ap2	ttp	rrtp	hrtp	mrtp
1	Spring	Madulane	Cattle	MC2	0.03495	1.41532	0.03358	0.72261	503.993	28.612	29.7835	562.389
2	Spring	Madulane	Cattle	MC4	0.06205	6.07565	0.16206	7.51049	14.347	16.117	6.1705	36.634
3	Spring	Madulane	Goat	MG1	0.01258	1.86132	0.01553	1.67702	0.000	79.512	64.3961	143.908
4	Spring	Madulane	Goat	MG2	0.03340	5.32371	0.03413	5.32585	2.959	29.939	29.3023	62.201
5	Spring	Madulane	Goat	MG3	0.04597	2.94571	0.12564	3.94810	12.583	21.753	7.9595	42.295
6	Spring	Madulane	Goat	MG4	0.02702	2.65255	0.04550	2.68793	1.914	37.011	21.9765	60.902
7	Spring	Nxamalal	Cattle	NC3	0.02614	1.61704	0.06317	2.13382	13.958	38.254	15.8312	68.043
8	Spring	Nxamalal	Cattle	NC8	0.11714	6.54434	0.12716	6.65031	10.578	8.537	7.8643	26.979
9	Spring	Nxamalal	Cattle	NC9	0.03489	1.10305	0.03772	0.36892	0.000	28.661	26.5105	55.171
10	Spring	Nxamalal	Goat	NG1	0.01476	2.03352	0.08137	3.17498	17.137	67.755	12.2898	97.181
11	Spring	Nxamalal	Goat	NG2	0.01780	2.07241	0.05349	4.13864	57.895	56.182	18.6957	132.773
12	Spring	Nxamalal	Goat	NG3	0.02991	2.40616	0.04720	1.81660	0.000	33.429	21.1867	54.615

13 Spring Nxamalal Goat NG6 0.03781 1.45397 0.05890 1.45607 0.099 26.449 16.9779 43.526

14 Summer Madulane Cattle MC5 0.03700 2.54649 0.06010 2.63589 3.871 27.027 16.6403 47.538

15 Summer Madulane Cattle MC9 0.04678 2.08549 0.06477 1.96245 0.000 21.377 15.4390 36.816

16 Summer Madulane Goat MG4 0.06333 4.14081 0.11608 4.84331 13.317 15.792 8.6150 37.724

17 Summer Madulane Goat MG5 0.07516 7.51028 0.11453 8.54335 26.244 13.304 8.7315 48.280

18 Summer Madulane Goat MG7 0.08011 7.15404 0.08573 7.24806 16.727 12.483 11.6643 40.874

19 Summer Nxamalal Cattle NC1 0.02776 0.56073 0.06734 -0.26181 0.000 36.024 14.8498 50.874

20 Summer Nxamalal Cattle NC10 0.03310 1.68561 0.03800 1.58403 0.000 30.210 26.3133 56.523

21 Summer Nxamalal Cattle NC12 0.03698 2.97418 0.06384 7.19699 157.202 27.042 15.6638 199.908

22 Summer Nxamalal Goat NG12 0.07022 5.75088 0.11687 6.55530 17.243 14.241 8.5562 40.040

23 Summer Nxamalal Goat NG2 0.05884 5.03566 0.09018 5.06377 0.897 16.995 11.0889 28.981

24 Summer Nxamalal Goat NG4 0.06746 5.51141 0.11226 6.34130 18.525 14.824 8.9080 42.257

25 Summer Nxamalal Goat NG5 0.05213 6.38282 0.10057 6.29098 0.000 19.184 9.9434 29.127

26 Winter Madulane Cattle MC3 0.01385 1.92624 0.18417 4.33265 14.128 72.214 5.4296 91.772

27 Winter Madulane Goat MG1 0.01176 2.59707 0.05924 3.37091 16.299 85.018 16.8808 118.198

28 Winter Madulane Goat MG3 0.00772 1.24367 0.01449 0.47613 0.000 129.517 68.9944 198.511

29 Winter Madulane Goat MG4 0.00456 1.49737 0.03908 1.80491 8.909 219.108 25.5866 253.604

30 Winter Madulane Goat MG9 0.00749 1.37669 0.01855 0.48464 0.000 133.516 53.8953 187.411

31 Winter Nxamalal Cattle NC1 0.01339 1.94516 0.05114 1.98975 1.181 74.698 19.5548 95.434

32 Winter Nxamalal Cattle NC8 0.01011 1.88202 0.07545 2.94000 16.192 98.905 13.2538 128.351

33 Winter Nxamalal Goat NG3 0.02554 3.24123 0.07746 4.02185 15.037 39.149 12.9102 67.095

34 Winter Nxamalal Goat NG5 0.01940 2.57883 0.03940 2.15059 0.000 51.554 25.3786 76.933

35 Winter Nxamalal Goat NG6 0.01581 2.57867 0.04506 2.19704 0.000 63.240 22.1931 85.433

36 Winter Nxamalal Goat NG8 0.01710 2.16848 0.03830 1.76271 0.000 58.481 26.1114 84.593