Milk Production and Calf Performance in Nguni and Crossbred Cattle Raised on Communal Rangelands of the Eastern Cape Province of South Africa

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Declaration

I, the undersigned, declare that this dissertation has not been submitted to any university, and that it is my original work conducted under the supervision of Professor M. Chimonyo and Professor K. Dzama. All assistance towards the production of this piece of work has been acknowledged in the Acknowledgements and Reference sections.

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Dedication

I dedicate this study to my late grandfather and grandmother (January and Nomayeza Mapekula), my parents and my leaders (Malgas and Nomzi), my wife, Ntomboxolo, my brothers, my children (Luthando, Busisiwe, Somilangaye and Hlumelo), the rest of Mapekula family, Ngwedu and family. I want to say this thesis does not only belong to me but it also belongs to you all. This is a result of your motivation, assistance and your prayer messages. I wish to leave you with a message stating that with God everything is possible. To those who are still scholars in the Mapekula, Ngwendu and Ndwayana families, I want to say I have set the pace. Your responsibility is to raise the standard. Finally, education is a weapon you can use to fight enemies irrespective of how dangerous they are and from which part of the world they are coming from.

List of abbreviations

CISFA: CIS fatty acids *cis* fatty acids (unsaturated fatty acids in which the adjacent hydrogen atoms are on the same side of the double bond

C18n1n9t: Oleic acid (trans double bond at carbon 9)

EPA: Eicosapentenoic acid

FA: Fatty acids

GLM: Generalised Linear Model

MUFA: Mono Unsaturated Fatty Acids

n3:n6: a ratio of n3 to n6 fatty acids

PUFA: Polyunsaturated Fatty Acids

PUFA/MUFA ratio: Polyunsaturated Fatty Acids: Monounsaturated Fatty Acid ratio

SAS: Statistical Analysis Systems

SFA: Saturated fatty acids

UFH: University of Fort Hare

Abstract

Milk Production and Calf Performance in Nguni and Crossbred Cattle Raised on Communal Rangelands of the Eastern Cape Province of South Africa

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Information on milk production could be useful in designing strategies that would help to improve milk production in communal farming systems. This study was conducted to determine milk production and calf performance of Nguni and crossbreds under smallholder cattle production conditions. Four trials were conducted in the study. The objective of the first trial was to determine farmer perceptions on milk production and calf rearing in smallholder areas. Data were obtained from 218 smallholder farmers, using a structured questionnaire. Smallholder farmer sector is constituted by small scale commercial farmers and communal farmers. Small-scale commercial farmers in South Africa obtained farms from the government through land claims or they bought the farms. Their farming background is a communal type. Communal farmers are farmers that are sharing the same grazing land and animals are managed according to the experience of the owner. The findings in this study indicated that there were numerous constraints to milk production in smallholder areas. These included lack of technical expertise and poor veterinary support services. The farmers also indicated that calf performance was low.

The second trial was conducted to determine if there were differences in calf performance, gastrointestinal parasites and nutritionally-related blood metabolites between Nguni and crossbred calves. Body weights and faecal samples were collected monthly until weaning at six months. The levels of total protein, albumin, globulins, non-esterified fatty acids (NEFA), glucose, cholesterol and minerals were determined monthly. Nguni calves had higher birth weights than crossbreds (P<0.05). Average daily gain and weaning weights of Nguni calves were greater than crossbred calves (P<0.05. Nguni calves had lower total protein at early age after birth (P<0.05). However, at weaning Nguni calves had higher total protein than crossbreds (P<0.05). Nguni calves had higher levels of glucose and NEFA concentrations than crossbred calves (P<0.05).

In the third trial, milk utilisation patterns in smallholder areas of the Eastern Cape were assessed. Cattle owners (n = 130) were randomly selected in three different regions to determine milk consumption patterns, milk sales, prices and factors influencing these activities. The information was gathered using milk recording sheets, which were administered in February (early lactation) and June (late lactation) in 2009. Milk consumption per household was similar among the three districts (P>0.05). Milk was utilised as both fresh and sour. Fresh milk was utilised with tea/coffee and porridge. Excess fresh milk was utilised to feed pets (mostly cats and puppies). The puppies were fed on mostly whey, and, at times, on fresh milk. Sour milk was utilised to prepare of *umvubo* (a mixture of sour milk and scrambled porridge (*umphokoqo*) or a mixture of sour milk and bread). In some cases, excess milk was given to neighbours as a form of social investment and fame.

The quality of milk from Nguni and crossbred cows was compared in the fourth trial. Milk samples were evaluated for quality in early (February), mid (April) and late (June) lactation in 2009. The essential amino acids, non-essential amino acids and fatty acids were determined. Nguni milk had higher amino acids and fatty acids concentration than crossbreds

(P<0.05). Nguni milk had higher arginine levels in the early and mid lactation periods compared to crossbred cows (P<0.05). Nguni milk had higher methionine and threonine levels than crossbred cows (P<0.05). Methionine levels in Nguni were 0.15, 0.19 and 0.18 in early, mid and late lactation while crossbred had 0.05, 0.05 and 0.06 (g/100ml), respectively. There were significant interactions between lactation stage and genotype for lysine levels with Nguni milk having higher (P<0.05) lysine levels in the mid and late lactation periods. Nguni cows had higher tyrosine, glycine and proline levels than crossbred cows (P<0.05). In the early lactation, Nguni cows had higher serine levels than crossbred cows (P<0.05). In mid lactation crossbred cows had higher serine levels than Nguni cows (P<0.05). There were significant differences between genotypes on fatty acid composition. Nguni milk had higher C12:0 levels than crossbreds (P<0.05). However, milk from crossbred cows had higher C14:0 levels than that for Nguni cows (P<0.05) and also had higher levels of C16:0 and C18:0 fatty acids compared to Nguni cows. Crossbred milk had higher levels of C18n1n9t in early lactation period than Nguni and decreased as the stage of lactation progressed (P<0.05). In the early lactation, the levels of C18n1nC in Nguni milk were higher (P<0.05) than in late lactation. In the mid and late lactation, crossbred cows milk had higher C18n1nC levels than in early lactation (P<0.05). Lactation stage and genotype affected saturated fatty, mono-unsaturated fatty acids, cis-fatty acids and omega 3 (n-3) to omega 6 (n-6). In general, Nguni milk had higher mineral composition than crossbred milk (P<0.05). In conclusion, Nguni calves performed better than crossbred calves under communal rangelands. There is a need for crossing Nguni cows with dairy breeds in commercial dairying by smalhoder farmers as a strategy for improving both milk quality and quantity.

Key words: Amino acids, communal production systems, fatty acids, gastrointestinal parasites, milk utilisation, minerals

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CHAPTER 1: General Introduction

1.1 Introduction

Approximately 80% of agricultural land in South Africa is suitable for extensive livestock farming (National Department of Agriculture, 2004). Although Eastern Cape Province has the largest number of livestock, productivity is generally low. Over 65% of livestock is owned by communal farmers (National Department of Agriculture, 2004). In general, the total number of cattle, sheep and goats in South Africa was 42.5 million in 2003 (National Department of Agriculture, 2004). The total number of cattle in South Africa is about 13.5 million, consisting of various dairy and beef cattle breeds (National Department of Agriculture, 2003). Commercial dairy cattle herd size varies between 50 and 300, averaging approximately 110 cattle per farm.

Cattle farming in South Africa are divided into commercial and smallholder sectors. The smallholder sector includes the communal production system, resettlement and small scale commercial farming areas (Blinguaut *et al.,* 2009). In communal production systems, farmers share the same grazing land, but each individual farmer manages his/her animals using his/her own experience. Resettled farmers received farms through the land redistribution programme. These farmers manage their animals privately. Small scale commercial farmers bought their own farms but produce at a lower scale when compared into large-scale commercial farmers (Western and Finch, 2004).

Cattle production in the communal production systems is complex. This is the result of multiple ownership of the grazing land by both livestock farmers and community members with no livestock and grazing of different types of livestock species on the same grazing land.

However, grazing of mixed species may actually have some benefits under proper grazing management systems. There is no land that is designated to be grazed by cattle, sheep and goats separately. This increases complexity of livestock production in communal production systems. There is also disappearance of the adapted genotypes due to unplanned replacement or crossing of local cattle with exotic breeds (National Department of Agriculture, 2004). Exotic breeds lack the ability to adapt, survive and produce in the harsh environments experienced in communal production systems. There is little research and development efforts to improve sustainability and viability of communal cattle production. Cattle breeds that are commonly kept in the communal production systems of Eastern Cape are crosses between indigenous and exotic breeds (National Department of Agriculture, 2004).

In communal production systems, cattle are kept for various reasons. These include traction, security, manure, milk, as a means of investment, savings (source of ready cash), socio-cultural roles (lobola) and meat (Sibanda, 1999). Of the aforementioned factors, milk is also one of the most important products from cattle. The extent of milk production and milk utilization in communal production systems of South Africa is, however, not known. It is, therefore, important to determine milk production and utilization in communal production systems. Currently, the production levels are unknown because there is limited research conducted on milk yield in communal production systems of Eastern Cape Province of South Africa, but it is assumed that they are generally low. Mutukumira *et al*. (1995) and Mutukumira *et al*. (1996) reported low milk yield produced by cows in communal areas. These are Zimbabwe studies, there are no similar studies carried out in South Africa. Efforts should also be made to develop methods of increasing milk production in these systems.

Yilma *et al.* (2006) indicated that in Ethiopia indigenous cattle breeds milk yields ranged between 500 and 700 litres in less than 100 days of lactation period, under good management conditions. Pedersen and Madsen (1998) reported that the average milk yield over a 150 day period was 5 litres per day. In addition, there is high degree of individual variation existing within each herd. Due to low milk production, there is low production and hence low calf performance in rural communities. This gives rise to a general lack of commercialization, as the numbers and quality of animals that are slaughtered are low and fetch low prices in the commercial market (Dikeman, 1987; Musemwa *et al.,* 2008). Low milk production in communal production systems affects availability of milk for calves and human consumption. This highlights the importance of milk in communal production systems.

Poor calf performance could be one of the reasons why herd sizes remain small in communal production systems. Calf performance affects the number of animals to be marketed, quality of the meat and consequently, economic returns to the farmer. There is a need to evaluate calf rearing and production systems in smallholder areas. Breed, age of the dam, nutrition and severity of internal parasites affect calf performance (Craig, 1988). Although it is generally agreed that milk and meat off take from communal areas is low (National Emergent Red Meat Producers' Organisation, NERPO, 2007), there is little, if any efforts to assess calf performance and the rearing methods used thereof. In order to evaluate milk production and calf performance levels in communal production systems, it is pertinent to conduct studies with the active participation of the smallholder farmers to increase the adoption of developed technologies and to understand the constraints and priorities of farmers (Lyimo *et al.,* 2004).

1.2 Justification

There is little information known on milk production levels of Nguni cows. Unavailability of such information leads to a poor understanding on the extent to which the rural population consumes milk. The Eastern Cape Department of Agriculture and the University of Fort Hare both are embarked on a programme to introduce the indigenous Nguni cattle breeds in communal areas of the Eastern Cape, with the aim of upgrading the existing crossbred cattle. Famers in communal production systems aim to get both beef and milk from their cattle. The impact of the current efforts to re-populate the rural areas with Nguni cattle on milk production is not known, while on beef production is well known. It is, therefore, pertinent to evaluate both milk yield and milk quality of the introduced Nguni and the crossbred cows. Information on the levels of milk production will be useful in designing improvement strategies, such as selection or crossbreeding. The Department of Agriculture, for example, will use the information to transmit the farming technology that could be used as a tool by the Department to address farming systems in communal production systems. Non-Governmental organisations will also make use of this information to develop farmers. Currently, there is little information available on milk production, calf rearing, milk utilization and calf performance in communal production systems of Eastern Cape.

1.3 Objectives

The broad objective of the study was to evaluate milk production and calf performance of Nguni and local crossbred cattle raised under communal production systems in the Eastern Cape Province of South Africa. The specific objectives of the study were to:

1. evaluate farmer perceptions on milk production and calf performance in the communal production systems and small scale areas of the Eastern Cape;

2. assess performance and gastrointestinal parasite loads in Nguni and crossbred calves raised on communal rangelands and;
3. compare the levels of blood metabolites content of Nguni and crossbred calves grazing in the same rangeland;
4. determine milk production and milk utilization in communal areas; and
5. compare the milk quantity and quality in Nguni and crossbred cows.

1.4 Hypotheses

The hypotheses that were tested weret:

1. Farmers perceive milk production and calf performance in communal production systems as low and affected by various factors;
2. Calf performance and gastrointestinal parasite loads in Nguni and crossbred calves are similar;
3. Blood metabolites in Nguni and crossbred calves grazing in the same rangeland are similar;
4. Milk yield in communal production sysyems is low and is utilized in different ways; and
5. Crossbred cows produce the same amount of milk as the Nguni cows and there are also no differences in quality.

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CHAPTER 2: Literature Review

2.1 Introduction

Livestock production is a system in which over 65% of the communal farmers of the Eastern Cape Province are engaged in. This is due to low costs involved in the management of livestock compared to other agricultural practices National Department of Agriculture, 2006). Furthermore, rainfall in the Eastern Cape is unpredictable to allow for meaningful crop production (NDA, 2009). Commercial farmers that are closer to big rivers have engaged themselves in dairy production.

Most communal farmers keep cattle which are crossbred of various breeds. These cattle are generally referred to as non-descript genotypes. The genetic make-up of these crossbreds differs from region to region, depending on crossbreeding programmes used. Common genotypes in communal areas are non-descript breeds, which are crosses of local Nguni cows with imported beef breeds, such as the Africander, Bonsmara and Angus (Collins-Luswati, 2000; Bester *et al.*, 2003; Raats *et al.*, 2004). The main functions of these cattle include provision of beef, milk, manure and hides (Chimonyo *et al.*, 1999). There are efforts to re-introduce the Nguni cattle in the communal areas of South Africa. The Department of Agriculture and the University of Fort Hare are actively involved in this effort (Raats *et al.*, 1997). The intentions of these efforts are to increase the proportion of Nguni genes in the cattle population. The success and sustainability of these efforts, however, rely on calf productivity and performance. Calf productivity in these communal areas is, however, largely unknown. To understand calf rearing issues, it is also pertinent to determine the major factors affecting calf survival and growth. Milk production capacities of cows and how farmers utilise the milk from their cows also requires investigation. The objective of this review is to discuss the milk production and calf rearing performance in smallholder areas.

2.2 Characteristics of cattle production in communal production systems

Communal production systems are characterized by grazing lands that are shared among the community members. In these grazing lands, all animals are entitled to graze irrespective of the animal type and without considering the stocking rate (Scholtz, 2000; Bester *et al*., 2003). Livestock production and crop production are the farming systems practiced by communal farmers. Erratic rainfall and high incidence of droughts in most communal areas of South Africa, particularly in the Eastern Cape Province, influence the majority of the resource-poor farmers to depend on livestock for their livelihoods. Hence, livestock farming has great potential to alleviate household food insecurity and poverty in communal areas of South Africa (Coetzee *et al.*, 2004).

Furthermore, soils in communal areas are also shallow for crop production and there is lack of agricultural equipment for crop production. In communal grazing areas, proper grazing management practices, such as rotational grazing, are rarely used (Raats *et al*., 2004). In most communities, continuous grazing is the most common grazing management system used. Livestock production is the most suitable farming practice for communal farmers. Cattle, sheep and goat production are the most dominant livestock production enterprises. Due to increased livestock theft cases especially on sheep and goat in communal areas, cattle farming predominates (Bester *et al*., 2003).

Cattle meet multiple objectives required by communal people. These include provision of beef, cash sales and other socio-economic functions (Chimonyo *et al*., 1999; Shackleton *et* *al*., 1999; Dovie *et al.*, 2006, Musemwa *et al.*, 2008). Cattle provide dung for manure, fuel and floor polish/seal and draught power (Bayer *et al.*, 2004). Cattle are an inflation-free form of banking for resource-poor people and can be sold to meet family financial needs such as school fees, medical bills, village taxes and household expenses (Dovie *et al*., 2006; Simela *et al.*, 2006; Musemwa *et al.*, 2008). They are a source of employment, collateral and insurance against natural calamities. Some farmers keep cattle for prestige and pleasure (Shackleton *et al*., 1999). Milk production potential and utilisation by communal farmers is still however, unclear despite that milk is one of the major reasons for cattle rearing by these communal farmers (Tapson and Rose, 1984).

2.3. Milk production in communal areas

Both milk yield and composition need to be evaluated under communal farming systems. It is pertinent to identify constraints to milk production in communal areas, and, consequently, to develop systems to improve the availability of milk for the communal farmers (Dugmore *et al.*, 2004; Lyimo *et al.*, 2004). Cows are usually milked once per day in the morning and there is also no supplementary feeding in place (Bailey and Currin, 1999). This indicates that, although cow milk is an important produce required by farmers from the cows, there are no efforts done by farmers to increase milk yield by cows. This could be attributed to lack of funds and knowledge. There is a need for communal livestock farmers to get involved in milk production to meet the milk demand, especially for the rural areas situated far from the formal milk distribution centres. Milk production in communal areas is also in support of the policies of the National Department of Agriculture of wealth creation in rural areas.

2.3.1 Milk yield

Dairy breeds produce between 10 and 20 kg per day (Moyo, 1996). Milk yield from Nguni and crossbred cows under communal production systems is however, unknown, although milk is in higher demand in communal areas. Milk yield in communal production systems is lower compared to commercial farmers (Smith, 1996; Mapiye *et al.,* 2007; Chinogaramombe *et al.,* 2008). Although Mapiye *et al*. (2007) and Chinogaramomber *et al.* (2008) reported low milk yields in communal production systems; there is no information indicating the composition of milk produced by cattle in these systems.

2.3.2 Milk composition

Milk quality describes the percentage of nutrients and somatic cell counts in milk. These nutrients include indispensable amino acids, vitamins, minerals, milkfat, lactose and fatty acids (Fox and McSweeney, 1998; Reneau, 2007; Watters *et al*., 2008). Milk from Holstein-Friesian cows contains approximately 4.9% lactose, 3.4% total fat and 3.3% protein (Flynn and Casman, 1997). No information is available on the milk quality of Nguni and crossbred cattle.

The knowledge on milk quality is important because milk is the sole source of nutrients for the calf prior to feeding on forage material. The calf needs well-balanced nutrients in order to survive in the new environment, which is very different from that of the dam. From the milk a calf get immunity systems that help the calf to resist against infections and diseases (McDonald *et al.*, 1995). Milk proteins are responsible for calf growth, growth hormone and enzyme production that are necessary for digestion, respiration and other functions (Kenny *et al*., 2001). Fatty acids also form part of milk composition and are responsible for fat formation to protect the calf against cold environments (McDonald *et al.*, 2002). Milk has plenty of energy sources for the calf which is in the form of lactose (McDonald *et al*., 2002). Lactose provides energy to the newly born calf until a calf can feed on grass. Milk is also a source of minerals (Ozrenk and Inci, 2008). There are macro (phosphorus, potassium, magnesium, calcium, and iron) and micro minerals (cobalt, chlorine and zinc). Vitamins are also found in milk which form part of calf's feed. These are fat soluble and water soluble vitamins which have different functions in the body of a calf. Since communal cows' milk is also consumed by humans in communal areas, it is important to determine its nutrient status. However, there is little information available currently on milk off take from cattle in the communal farms of Eastern Cape.

Though not a component of milk quality, somatic cell counts are an indirect and universal indicator of udder infection (Fox and McSweeney, 1998). If a cow's milk has more than the normal standard number of somatic cell counts, that milk is regarded as being unsuitable for human consumption (Walshe, 2002). Individual cow somatic cell counts should be less than 100 000 SCC. Milk with somatic cell count above 400.000/ml and isolated pathogenic microorganisms in it is the mastitic milk (Walshe, 2002; Reneau, 2007; Mijic *et al.*, 2009). Information on somatic cell counts is largely unknown by communal farmers, although they milk their cows for human feeding. There are various factors affecting milk production and stage of lactation, breed, parity, season of calving, geographic region and management factors (nutrition, frequency of milking) are among the these factors (Walshe, 2002). It is important that milk produced by cows meets the human's nutrient requierements. Milk proteins are converted to various body proteins required by the body and these are high biological value proteins. According to Harper and Yoshimura (1993) the protein requirements by humans are shown in Table 2.1. There are various factors affecting milk composition in cows.

Table 2.1: Estimated protein dietary allowances for humans

Human age	g/ kg body weight day
1-3 mo	2.00
6 mo	1.50
1 yr	1.20
6 yr	1.00
Adult	0.75

Source: Harper and Yoshimura (1993).

2.4 Factors affecting milk production in communal areas

2.4.1 Breed

The Holstein cow has the highest volume of milk production and the highest in producing milkfat, protein and lactose (Ozrenk and Inci, 2008) but they are not kept in communal production systems. Communal farmers have Nguni and crossbreds and there is no information available indicating milk yield and quality in Nguni and crossbreds but reports state that milk yield in communal farming is low (Bester *et al*., 2003). Therefore, milk yield needs to be improved.

Crossbreeding of local stock with imported dairy breeds has been considered as the method for producing dairy cattle in many regions of the developing world. In East Africa, for example, after up to 30 years selection for milk production under good management, the indigenous Zebu produced more than 960 kg of milk per lactation (Jonsson *et al*., 1993). Consequently, the use of crossbred or newly developed tropical dairy breeds could be the solution to increasing milk production in communal areas. On-station studies on milk production indicated that Nguni cows produced about 1200 kg of milk over a lactation period of 298 days (Epstein, 1971). Therefore, a choice of a cattle breed producing high milk yield, and adapted in communal production systems would be a solution to improve milk yield in communal farming.

2.4.2 Water supply

Water has the most dramatic effect on reduction in milk yield (McDonald *et al*., 1995; 2002). Communal farmers practice farming in environments that are restricted on water and nutrients. This has to do with inability to access facilities for dam construction and other water reservoirs. In some communal areas, cattle have to travel long distance searching for water. These water sources can be far from where the cows will be milked. It becomes a very big problem if a cow can not get water because milk production and digestibility of feed takes place in the presence of water and milk itself has more than 80% water as its composition (Maree and Casey, 1993).

2.4.3 Feed supply

Any restriction in feed and water supply reduces milk production (McDonald *et al.*, 2002). Communal farmers lack funds to buy supplementary feed to ensure that there are sufficient feeds especially during the dry winter periods. Supplementary feeding rich in protein and energy increases milk production, however, few communal farmers can afford to provide supplementary feeding to their animals (Smith *et al*., 1996; Chimonyo *et al*., 2000; Watters, *et al*., 2008; Hazell, 2008). Feed supply in communal production systems can be improved by cultivating pastures that use less water. However, this is not so easy to communal farmers without proper training although it is practical. Communal farmers were never exposed to such exercises of pasture cultivation for the animals. This has been made more difficult by the fact that there are few research studies involving communal farmers and pasture cultivation in communal areas that would motivate communal farmers to cultivate pastures. Establishment of pasture is also expensive. In this way milk yields will be improved because cows will not travel long distances in searching for feed.

2.4.4 Milking intervals and milking frequency

Milkings in communal farming is done once per day and this contributes to low milk yield. Commercial farmers milk twice and even three times per day. Cows that are milked twice per day produce more milk than cows milked only once per day (Auldist and Prosser, 1998; Barber *et al.*, 2003; Stelwagen *et al*., 2007). Cows milked at unequal intervals produce less milk than those milked at equal intervals (Stelwagen *et al*., 2007).

Incomplete milking for several consecutive days is one of the factors that reduces milk yield and can permanently reduce the cow's milk yield for the entire lactation (Waterman, 1983; Bailey and Currin, 1999; Davis *et al*., 1999; Stelwagen, 2001). In communal farming, the effect of milking intervals and frequencies on milk yield and milk composition is unknown. Under communal production systems, milking more than once per day is not practical due to various reasons such as lack of management knowledge and infrastructure cost implications. In addition to this cows, spent the whole day grazing in rangelands which are distant from the homesteads. The other reason could be that milk production is low because the dam is allowed to be with the calf unlike at a commercial dairy farm.

2.4.5 Age and body weight of dam at calving

The amount of milk produced increases with advancing lactations (age), since an increase in body weight results in an enlargement of the digestive system and the mammary gland (Moore *et al.,* 1990; Ruiz-Sanchez *et al.,* 2007). Recurring pregnancies can increase milk production from first to the fifth lactation by 30% (McDonald *et al*., 1995). The increase in milk yield is usually highest for first lactation cow and declines as the cow gets older (Berry *et al*., 2003). However, the effect of parity and body size on milk production and mothering ability in Nguni and crossbred cows is scanty.

2.4.6 Stress

Stress factors such as work, parasitic infestations and disease challenge reduce milk yields. The use of cows for ploughing and other draught purposes also reduces fertility and, therefore, the frequency of lactation (Chimonyo, *etal* 2000). Although mastitis is the main disease that reduce milk yield in dairy cows under commercial dairy systems, its impact in communal production systems is not well understood (Keyyu *et al*., 2003

There is little/no literature or study conducted in Nguni and communal crossbreed indicating the effects of stress in these animals on milk production. It is known that Nguni cattle are hardy and are able to walk for long distances searching for food and water (Raats, 1996), but the effect of this in their milk yield is unknown.

2.5 Milk utilisation in communal areas

One of the major reasons for keeping cattle in the rural areas is for milk production (Dugmore *et al*., 2004). In many situations the household has to milk several cows to get only a few litres of milk. Milk production in the traditional systems where cows are kraaled at night is limited by lack of feed intake at night, apart from the poor availability of grazing on communal grazing areas. In certain households cattle are kraaled at night and released late in the morning and kraaled again before dark. Other constraints such as once per day milking versus twice a day also limit yields. Crossbreeding of local stock (to retain local environmental adaptation) with imported dairy breeds (for milk production) has been considered the method of choice for producing dairy cattle in many regions of the developing world (Jonsson *et al*., 1993; Rey *et al*., 1993; Dugmore *et al*., 2004). Milk utilisation in communal production systems is not well documented although communal people utilise milk. Milk in communal production systems is utilized in different forms. However, there are no documents that support the forms of milk utilization in communal production systems of the Eastern Cape. According to Mutukumira *et al*. (1996) milk is sold as fresh, naturally fermented or cultured milk. Fermented milk is mainly consumed with sadza “pap”, a local food, and with other cereal-based food products.

However, the demand for milk the world over is increasing in developing countries and is projected to increase by 75% for milk (Nicholson *et al.*, 2001; Muchenje *et al.*, 2007). Milk consumption in developing countries such as South Africa will increase by 3% per year (Davis, *et al*., 1999; Nicholson *et al*., 2001). It is the middle class that benefit most from this increased consumption of milk (Nicholson *et al*., 2001) because the communal farmers are generally poor and their milk production levels are low. There are various reasons that contribute to inability of communal farmers to produce sufficient milk such as inappropriate government policies that would assist communal farmers, institutions not responsive to the needs of smallholder producers, limited access to markets and limited management experience and applied knowledge. The inability of communal and smallholder farmers to produce sufficient milk can be addressed by taking into consideration factors such as the farming environment, social condition of the household, training and knowledge of livestock owners and the inherent adaptability of the animals (Sibanda, 1999, Dugmore *et al*., 2004). Milk produced in communal production systems is said to be low (Chinogaramombe *et al.*, 2008) but the milk is still to be shared between humans and the calves. This indicates that milk available for a calf is low and this could be one of the reasons for poor calf performance.

2.6 Calf performance indicators

The main indicators of calf performance are calf birth weight, growth rate, weaning weight and calf mortality.

2.6.1 Birth weight

Calf birth weight is an important calf performance indicator to be known as it determines profitability of the enterprise. Commercial farmers are aware of calf birth weight and its importance. The birth weight of calves is closely associated with dystocia (Maree & Casey, 1993; Sibanda, 1999; Rentfrow *et al.*, 2004). The incidence of dystocia can be reduced by producing calves of lower birth weight relative to a given size of cow. Calving difficulties result in reduced calf performance, delayed oestrus and, in some cases, loss of the calf and/or dam (Maree and Casey, 1993; Rentfrow *et al*., 2004) and reduce productivity (Maree and Casey, 1993; Rentfrow *et al*., 2004). On the other hand, birth weight below 7-8% of the dam weight is not acceptable because this can lead to increased calf mortality due to reduced vigour (Wymann *et al.*, 2005).

Calf birth weight depends on breed, sex and is positively related to gestation length, the age of a dam and the level of nutrition (McDonald *et al.*, 1995; Sibanda, 1999). Birth weight determines how much milk the calf will consume (Rentfrow *et al.*, 2004). The bigger the calf, the more milk the cow has to produce and this meaning a bigger calf to be weaned. The relative birth weight (birth weight/cow weight at parturition) varies between 7% and 8% (McDonald *et al.*, 2002; Rentfrow *et al*., 2004). Male calves normally have higher birth weight than female calves (Pedersen and Madsen, 1998). This relationship between Nguni dam and crossbreds and their calf birth weight is not known.

2.6.2 Growth rate

Growth rate is an important characteristic in livestock production. For dairy cattle to be efficient and sustainable calves should grow fast so that newly born calves will reach maturity early. The pre-weaning growth rate for Nguni calves, under controlled conditions, range from 0.63 to 0.70 kg (Maree and Casey, 1993; Winks *et al*., 1978; Scholtz *et al*. 2000; National Department of Agriculture, 2006). Growth rate of communal Nguni and crossbred is unknown and therefore, weaning weights will remain unpredictable. Growth rate and weaning weight are associated with breed and nutrition (McDonald, 2002).

2.6.3 Weaning weight

The weaning weight depends on the weaning method practiced by the farmer. The weaning weight depends on several factors such as the age and size of a dam and sex of a calf. For example, male calves are generally heavier than female calves at weaning (National Department of Agriculture, 2000). Commercial farmers use different methods to wean calves such as separation of calves from dams by allocating a spare camp to weaned calves. Weaning is also done by using nose weaning plates. Calves with a metal plate cannot suckle. However, in communal production systems other weaning methods except for natural weaning are rear because the separation method which is another method used by commercial farmers need infrastructures such as fencing of the grazing area.

The birth season, breed type, sex of the calf and the age of the dam have effect on the weaning weight of calves. For example, calves born early in the summer in New Zealand were significantly superior to calves born later in summer and male calves outperformed female calves (Winks *et al.*, 1978). Male calves were 8-9 per cent heavier than female calves at 180 days. Pre-calving weight of the cow was positively correlated with calf growth rate and 180 day weight. Calf gains were inversely related to cow gains from birth to weaning (Winks *et al*., 1978). Calf birth weight was significantly correlated with calf growth rate at 180 days (Winks *et al.*, 1978). Breeds such as Shorthorn, Sahiwal or Brahman, Bonsmara and

Hereford have calves that are heavier at weaning (Winks *et al.*, 1978; Maree and Casey, 1993; McDonald *et al.*, 1995). However, under controlled environment at a research station Nguni calves at weaning had approximately 175 kg.

To attain a high weaning weight, calves have to get enough feed. Supplementary feeding can have more effect on weaning weight if the correct feed ingredients are added in the feed (Winks *et al*., 1978). According to Walker *et al.* (1982); (1986) correct supplementary feed must have high protein content and less fat contents. However, the effects of supplementary feeding on growth rate and weaning weight in pure Nguni and their crossbred calves are unknown.

Factors such as body weight of the dam, nutrition, environmental stress, gastrointestinal parasites and other non-genetic factors (Lyimo *et al.,* 2004) affect calf performance. These factors should be characterised and their impact on calf performance be quantified to enhance milk and beef production from the communal production systems. A high prevalence of gastrointestinal parasites and diseases seriously affect calf performance. Gastrointestinal parasites that cause diarrhoea, feeding on digested calf nutrients affect the calves by reducing feed conversion efficiency and this leads to retarded growth (Sanh *et al*., 1995). Affected calves are likely to be weak and might die before weaning. It is crucial to identify these gastrointestinal parasites so that effective prevention and control strategies are developed. No information is currently available on the prevalence of these parasites in Nguni and crossbred calves in communal production systems.

The severity of lactation stress in cows can affect the performance of a calf of that particular cow. The performance of a calf of a young cow that is in its first lactation stage will be mostly affected than a calf of an old cow. This is because a young cow will experience more lactation stress than an old cow; hence calf performance of a first time calving cow will be more affected than old cows (Sanh *et al.*, 1995). First time calving cows are still growing and need more feed for their body growth, maintenance and has to also produce milk (Roy, 1980). This cow lose too much of its body reserves (McDonald *et al.*, 1995). For these reasons a cow that is in lactation for the first time experiences more lactation stress and this will affect the growth rate and weaning weight of its calf (Maree and Casey, 1993; McDonald *et al.*, 1995; Sanh *et al*., 1995; Scholtz *et al.*, 2000). Therefore, to improve calf performance in communal production systems there should be strategies implied to reduce these lactation stresses in cows. There is little or no information that currently available on the prevalence of these parasites in calves in communal production systems.

Gastrointestinal parasites that are most common in calves include *Oesophagostomum radiatum, Haemonchus similes, Trichostrongylus axei, Strongyles, Strongyloides, Coccidia, Haemonchus placei, Moniezia, Cooperia punctata, Bunostomum phlebotomum, Trichuris globulosa, Trichostrongylus colubriformis* and *Cooperia pectinata* (Dreyer *et al.,* 1999; Keyyu *et al.,* 2003). Calves are likely to have higher worm burdens than mature animals. The higher worm burden occur at the end of the rainy or early dry season, while the lowest burden normally occur at the end of the dry or early rain season (Keyyu *et al.*, 2003; Rond *et al.,* 2005). Anthelmintic treatments in the late rainy or early dry season and early rainy season are recommended to prevent outbreaks of helminthosis during the dry season and to reduce carryover of infection into the next rainy season. An additional treatment in the wet season is advisable in immature cattle, but may not be needed for mature cattle owing to the availability of plenty of mature, good quality pasture (Keyyu *et al*., 2003).

Factors such as slopes, wetlands, rain, dryland and irrigated pastures or natural veld, grazing regimes, animal age, animal physiological status and body condition increase chances for gastrointestinal parasite loads in that animal (Maree and Casey, 1993). High rainfall during the summer and autumn provide favourable conditions for the multiplication of gastrointestinal parasites in commercial farming (McDonald *et al*., 2002) but the extent of this in communal production systems is unknown and gastrointestinal parasite most common in communal production systems are unknown.

Wireworm infestations (*Haemonchus spp*) are rife in all provinces of South Africa including Eastern Cape Province (Swai *et al*., 2006). Gastrointestinal parasites such as nodular worm (*Oesophagostomum spp)*, bankrupt worms (*Trichostrongylus* and *Cooperia spp*) are more common in the Eastern Cape Province (Maree and Casey, 1993). Lungworm (*Dictyoceulus spp*) and hookworm (*Bunostomum spp*) are also prevalent in the Eastern Cape and KwaZulu Natal Province. The brown stomach worm (*Oestertas spp*) and long necked bankrupt worm (*Nematodirus spp*) are mostly found throughout the Eastern Cape Province up to the Karoo Regions. Tapeworm such as *Moniezia spp* is common and affects calves in the Eastern Cape Province and Free State Province (Maree and Casey, 1993; Swai *et al*., 2006; Ruiz-Sanchez *et al*., 2007).

Most of the communal farmers are unaware about the prevalence of gastro-intestinal parasites and it is possible to find cattle that have never been dosed but are surviving. It is important that communal farmers understand the prevalence of these gastrointestinal parasites in Nguni cattle and their crossbred calves so that they can take necessary preventative precautions.

Gastrointestinal parasites affect the quality, quantity and potential marketable yield of livestock products (Rond *et al.*, 2005; Wymann *et al*., 2007). Weight loss in animals reduces milk and meat production and increase calf mortality (Kannan *et al.*, 2000). All animal species are susceptible to gastrointestinal parasites but susceptibility differs according to breed type and animal age (Keyyu *et al*., 2003; Swai *et al*., 2006).

2.6.4 Nutritionally-related blood metabolites

Nutritionally-related blood metabolites indicate the extent of metabolism of energy, proteins and other nutrients and hence, the nutritional status of cattle (Mondal *et al*., 2005). Examples of such metabolites include glucose, cholesterol, non-esterified fatty acids, protein, urea, creatinine, albumin, globulin, minerals, liver enzymes and haematology. Several factors, such as physiological status of an animal, breed, nutrition, season and age affect levels of blood metabolites (Ndlovu *et al*, 2007). A decrease in anaemia in livestock could be related to haematophagic parasites (Parra *et al*., 1999). A prolonged decrease in glucose level in calves up until puberty stage can seriously reduce fertility in those calves during the breeding period (Pysera and Opalka, 2000).

The total protein (TP) concentration represents all proteins dissolved in blood plasma or serum (Sakkinen, 2001). Albumin, which is synthesised in the liver, is responsible for the colloid-osmotic pressure that inhibits leakage of blood plasma from capillaries into tissues (Kaneko, 1997). Protein deficiency impairs both humoral and cell mediated immunity, thus predisposing an animal to diseases (Titgemeyer *et al*., 2001). Total protein and albumin concentrations indicate the nutritional condition in domestic ruminants (Kaneko, 1997) due to their stability in blood. Low levels of albumin and TP in plasma are interpreted as protein deficiency and undernutrition. Information on blood metabolites in Nguni and crossbred calves managed under communal production systems is not available.

2.6.5 Calf mortality

Calf mortality is a serious indication of productivity levels in both dairy and beef cattle. Dystocia and perinatal mortality to a lesser extent are found to be more frequent in heifers than in cows **(**Berger *et al*., 1992; NERPO, 2007). Perinatal mortality is common in calves that were born with very low birth mass that is lower than 20 kg. Gastrointestinal parasites are associated with calf mortality (Ganaba *et al.*, 2002) by causing calf diarrhoea. Some of the calves die as a result of infection by *Babesia bigemina* which is casused by *Cowdria ruminantium* (Ganaba *et al.,* 2002, Marufu *et al.,* 2009). The most critical time for calf death occurs in summer due to heart-water, gall-sickness and blackleg which are all cattle diseases (Mashoko *et al*., 2007).

Weather factors such as extreme high temperatures in summer and low temperatures in winter are other factors associated with an increased risk of calf mortality. Calves born during the periods of extreme temperatures have a higher risk of mortality than those born on more temperate days. Periods of increased risk of death are often associated with large temperature fluctuations irrespective of the absolute temperature. Nonmeteorological factors specific to individual farms also appear to influence daily calf mortality rates (Otterby and Linn, 1981). There is a limited knowledge on factors causing mortality in calves in communal production systems. Therefore, factors that cause calf mortality need to be investigated and necessary steps should be taken to avoid such deaths because calf death affects the farmer’s return from livestock production.

In the Limpopo Province of South Africa, estimates of calf mortality rates are as high as 60% per annum and these rates increase significantly during multi-year droughts (Moyo, 1996; 2003). During drought in Kenya, Ethiopia and Zimbabwe, stock losses were between 30 and 98%. There is a significant difference in mortality rate between cows with calves, dry cows, oxen and bulls (Barret *et al*., 2003). Calf mortality rate is highest, followed by cows that have recently calved. Traditional response to drought by communal farmers is to move their animals to relatives who have access to grazing (Sweet, 1998). Due to land demarcations cattle movement is not allowed.

2.7 Summary

Nguni and crossbred cattle are the cattle mostly kept by communal farmers. These cattle have characteristics of being adapted to harsh communal environmental conditions such as inadequate and poor quality due to erratic rainfall and high incident of droughts. Crossbreds have been developed from the Nguni breed through random crossing with different breeds. Milk is one of the products the communal farmers obtain from their animals. It is also a source of feed or nutrients for the calf. Milk yield and composition are affected by factors such as breed, feed supply, frequency of milking, age and stress. It is this milk that supplies the calf with nutrients for good performance. Calf performances are affected by different factors such as the breed, nutrition and prevalence of internal parasites. The impact of these factors on milk production and calf performance under communal production systems are, however, unclear. The objective of this study was to evaluate milk production and calf performance in Nguni and crossbred cattle grazing in communal rangelands.

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CHAPTER 3: Milk production and calf rearing practices in the smallholder areas in the Eastern Cape Province of South Africa

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Abstract

Farmer perceptions on milk production and calf rearing practices on communal rangelands in the smallholder areas of the Eastern Cape Province, South Africa were evaluated on a total of 218 cattle farmers using structured questionnaires, semi-structured interviews with key informants and personal observations. Nearly 70% of the households in the small-scale areas milked twice a day compared to 60% in the communal areas. About 62% of the interviewees weaned calves between 6 and 12 months of age. Milk yield/cow/day (7.5 ± 0.5 litres), fresh milk consumption/household/day (3.2 ± 0.5 litres) and sales/household/day (3.1 ± 1.1itres) were highest in the sourveld, small-scale farms ($P<0.05$). Sour milk consumption/household/day (2.6 ± 0.2 litres) and sales/household/day (0.8 ± 0.2 litres) were significantly high in communal farms in the sourveld. It was concluded that calf rearing practices were poor and milk yield, consumption and sales were generally low and varied with production system and rangeland type. Further research is required to improve calf management practices, cow nutrition, milk yield and quality and how milk production can be used as a tool for rural development in the smallholder areas of South Africa.

Key words: Communal areas, Indigenous cattle, Milk yield, Veld type, Suckling.

3.1 Introduction

Generally, demand for animal products such as beef and milk in South Africa is rising (Delali *at al.,* 2006). For example, milk import costs increased from US$ 92 859 000 in 2003 to US$ 132 411 000 in 2006 (NDA, 2008). In South Africa, the dairy sector produces about 2.7 million litres of fresh milk per annum from 0.79 million cows (NDA, 2008). These statistics however, exclude milk off-take from the smallholder sector. Prinsloo and Keller (2000) reported that milk produced in the smallholder areas is mainly for home consumption and sales to neighbours. There are no records, however, for the amount of milk produced in the smallholder sector, and its contribution to the household and national economies is largely unknown. Improvement of the smallholder dairy production is a possibility to increase food security and income for resource-poor farmers (Kabirizi *et al*., 2004; Somda *et al*., 2005; Ngongoni *et al*., 2007a).

In the smallholder sector, milk is largely obtained from indigenous cattle and their crosses with the exotic beef breeds (Moyo, 1996; Delali *et al*., 2006; Mapiye *et al*., 2007a; Nqeno, 2008). Utilisation of recognised dairy breeds, such as Holstein, Jersey, Guernsey and Ayrshire under the smallholder sector is not common. These breeds do not produce to their full genetic potential and have high mortality rates under low management conditions (Ngongoni *et al*., 2006; Muchenje *et al*., 2007). Imported breeds lack adaptation to harsh environments, such as high prevalence of gastro-intestinal parasites, ticks and tick-borne diseases and low plane of nutrition (Moyo, 1996; Bester *et al*., 2003). Selection and improvement of a moderate yielding dairy animal that is adapted to the harsh local environment of the smallholder farmer is, thus imperative.

The indigenous Nguni breed's adaptation to local agro-ecological conditions makes it attractive to smallholder farmers in South Africa. Nguni cattle are tolerant to nematodes (Smith *et al*., 1996; Ndlovu *et al*., 2007), ticks, tick-borne diseases (Norval *et al*., 1996; Muchenje *et al*., 2008), have high feed utilisation efficiency at low feeding levels and the ability to select high quality diets when grazing course forages on rangelands (Collins-Luswati, 2000). Such adaptation traits could assist to reduce costs of inputs, such as drugs and feed supplements for the smallholder dairy farmers. Information on Nguni cattle's milk production and calf performance in the smallholder areas is limited, making it difficult to evaluate the role of dairying in improving the welfare of the poor in communal areas of South Africa.

Calf performance and productivity is crucial for efficient milk production and in increasing income levels among the resource-poor through cattle sales. Development of strategies to reduce calf mortality and increase weaning weights is pertinent. There has been little, if any effort made to select and improve Nguni cattle herds for milk production in the smallholder areas. To design sustainable improvement programmes, it is crucial to evaluate the current production levels, milk consumption patterns, constraints to milk production and the value of the milk to smallholder farmers. Evaluation of the potential for milk production and calf performance on communal rangelands is of equal importance. The objective of this study was to determine farmer perceptions on milk production and calf rearing practices on communal rangelands in the smallholder areas of the Eastern Cape Province of South Africa.

3.2 Materials and Methods

3.2.1 Study areas and selection of farmers

Data were collected from 18 communities located in five district municipalities of the Eastern Cape namely; Alfred Nzo, Amathole, Cacadu, Chris Hani and Ukhahlamba. The communities were selected using stratified random sampling based on the production system (Table 1). There were, thus, small-scale farms and communal areas. Small-scale farms that were owned by communities that benefited from land restitution were chosen from each district municipality. Land restitution is a government-initiated programme of redistributing commercial agricultural land to benefit previously disadvantaged local black farmers. Farmers from both the sweet- and sourveld were interviewed. In the sour rangelands, forages have low nutritive value and are largely unpalatable during the dry season compared to the sweet rangelands, where forages remain palatable and nutritious throughout the year (Ellery *et al.*, 1995; Botsime, 2006). Table 3.1 shows the rainfall, temperature, altitudinal, edaphic attributes and sample size for the surveyed communities. Selection of farmers was based on cattle ownership and willingness to participate in the study.

3.2.2 Data collection

A total of 218 smallholder cattle farmers were interviewed using pre-tested structured questionnaires written in local language (Xhosa) between June and July 2007 (See Appendix 2). The interviews were conducted in the Xhosa vernacular by trained enumerators for 25 to 30 minutes per questionnaire. The questionnaire captured household demography; cattle herd sizes, composition and management, calf rearing practices and milk production aspects. Personal observations and interviews with key informants (Department of Agriculture officials, commodity group chairpersons, local politicians, traditional leaders and livestock-related

Table 3.1: **Mean annual rainfall and temperature, altitudinal and edaphic attributes for the surveyed communities**

Farm type	Community	Veld type	Respondents	Rainfall (mm)	Mean annual Temperature (^oC)	Altitude (m)	Soil type
Communal	Dyamala	Sweet	6	300-500	16	500-550	Loam
	Dyamdyam	Sweet	11	800-1000	20	200-300	Sandy
	Ityali	Sweet	12	450-600	16	500-550	Loam
	Kwamasele	Sweet	26	450-600	16	400-600	Loam
	Kwezana	Sweet	6	450-600	16	500-550	Loam
	Mahobe	Sour	9	650-1000	14	600-1400	Sandy
	Magwiji	Sweet	15	400-600	10	1400-2000	Sandy
	Melani	Sweet	14	450-600	16	500-550	Loam
	Msobubvu	Sweet	6	450-600	16	500-550	Loam
	Ncera	Sweet	13	450-600	16	500-550	Loam
	Ntselamanzi	Sweet	16	450-600	16	500-550	Loam
	Saphanduku	Sour	10	650-1000	14	600-1400	Sandy
	Tiwane	Sour	13	650-1000	12	600-1400	Sandy
	Upper Mnxe	Sour	18	650-1000	12	600-1400	Sandy
Small-scale	Caba-mdeni	Sour	13	600-800	12	1250-2000	Sandy-Loam
	Hex river	Sour	11	450-700	14	1350-1450	Sandy
	Masizame	Sweet	12	450-600	16	400-600	Loam
	Perkshoek	Sweet	7	300-450	20	100-200	Sandy-Loam

non-governmental organisations) were also made on milk production issues and calf rearing methods.

3.2.3 Statistical analyses

Associations between farm type (small-scale and communal) and veld type (sweetveld and sourveld) with milk production parameters and calf rearing practices measures were computed using chi-square tests (SAS, 2003). Correlations among milk yield, herd size, household size, land size, number of lactating cows, milk consumption and milk sales were determined using PROC CORR of SAS (2003). The Generalized Linear Model (GLM) procedure of SAS (2003) was used to analyse the effect of household characteristics, veld type, farm type and their interactions on herd size and composition, milk yield and consumption and sales. Pair-wise comparisons of the least square means were performed using the PDIFF procedure (SAS, 2003).

3.3 Results

3.3.1 Livestock species and cattle herd composition

There was a significant interaction between veld type and farm type for cattle, goat, sheep, chickens and pigs herd/flock sizes (Table 3.2). Cattle herd sizes in the small-scale farms in the sourveld were significantly high (Table 3.2). Goat flocks were large ($P<0.05$) in the small-scale farms in the sweetveld. Sheep flock sizes were significantly high in the communal areas in the sweetveld. Chicken flocks and pig herds were large ($P<0.05$) in the communal and small-scale farms in the sourveld (Table 3.2).

Crossbred of Nguni and exotic beef breeds (70% of the respondents) and Nguni (50%) breeds were most common in the surveyed areas. Generally, small-scale farms in the

Table 3.2: Least square means (± standard error of means) of herd/flock sizes and cattle herd composition based on veld type and farm type

	Sweetveld		Sourveld	
Livestock species (numbers/household)	Communal (n=125)	Small-scale (n=19)	Communal (n=50)	Small-scale (n=24)
Cattle	8.7 ± 3.44^{a}	12.6 ± 4.23^{ab}	13.1 ± 3.73^{ab}	15.5 ± 3.90^{b}
Goats	5.4 ± 7.32^{a}	25.0 ± 9.10^{c}	16.7 ± 7.93^{b}	15.3 ± 8.42^{b}
Sheep	4.7 ± 13.61^{a}	3.3 ± 17.00^{a}	24.2 ± 14.83^{c}	11.5 ± 15.62^{b}
Chickens	1.7 ± 4.12^{a}	3.0 ± 5.13^{ab}	7.7 ± 4.50^{b}	8.3 ± 4.73^{b}
Pigs	0.9 ± 1.13^{ab}	0.3 ± 1.40^{a}	1.8 ± 1.22^{b}	1.1 ± 1.33^{ab}
Herd composition (numbers/household)				
Calves	0.1 ± 0.21^{a}	0.2 ± 0.10^{a}	0.2 ± 0.11^{a}	0.8 ± 0.21^{b}
Heifers	2.51 ± 0.80^{a}	3.0 ± 0.90^{b}	2.4 ± 0.64^{a}	3.3 ± 0.92^{b}
Steers	1.7 ± 1.14^{a}	3.4 ± 1.30^{b}	2.0 ± 1.13^{a}	3.5 ± 1.22^{b}
Bulls	1.0 ± 0.92^{a}	1.9 ± 1.12^{a}	1.6 ± 1.03^{a}	2.9 ± 1.03^{b}
Reproductive cows	3.6 ± 1.42^{a}	4.9 ± 1.73^{a}	4.7 ± 1.52^{a}	6.9 ± 1.22^{b}
Lactating cows	0.2 ± 0.57^{a}	0.6 ± 0.71^{a}	0.8 ± 0.63^{a}	1.2 ± 0.73^{b}

^{a,b,c} Values with different superscripts within a row are significantly different (P<0.05) sourveld had the largest ($P<0.05$) number of calves, steers, heifers, cows and bulls (Table 3.2). The number of lactating cows was also high in the small-scale farms in the sourveld ($P<0.05$). Ratio of lactating cows to reproductively active cows in the herd was 1: 4 across production systems and veld types. Level of education and occupation had a significant influence on cattle herd sizes. Farmers with tertiary qualifications and those with informal employment had large cattle herd sizes ($P<0.05$; Table 3.3).

3.3.2 Cow productivity and management

Age at puberty, age at first calving, calving interval and length of productive life were not associated with veld type and farm type ($P>0.05$). About 44 and 38% of the respondents reported that heifers reached puberty at 24 and 36 months, respectively. The majority (68%) of the interviewees reported that the age at first calving for their cows was between 36 and 49 months. Out of the 218 farmers enumerated, 70% reported that calving intervals were between 12 and 24 months. Generally, poor nutrition (66% of the respondents), diseases and parasites (24%) and breed (10%) were the major causes of delayed sexual maturity and long calving intervals in the study areas. Most cows had productive life of between 10 and 15 years (77% of the respondents) and produced between 6 and 10 calves (82%).

Table 3.3: Least squares means (± standard error of means) of cattle herd size based on education levels and occupation status of the communal farmers (n=218).

	Cattle herd size (numbers/household)
Education levels	
No formal education	8.7 ± 7.21[a]
Informal education	7.7 ± 3.42[a]
Grade 1-7	7.4 ± 3.10[a]
Grade 8-12	9.7 ± 3.53[a]
Tertiary	24.5 ± 4.74[b]
Principal occupation	
Unemployed	12.4 ± 3.63[b]
Formal	6.2 ± 2.32[a]
Informal	17.6 ± 3.43[c]

[a,b,c] Values with different superscripts within the column are significantly different ($P<0.05$)

Lactation period and calving season were significantly associated with veld type. Sourveld areas had more respondents who reported lactation periods of between 151 and 300 days for their cows compared to sweetveld ($P<0.05$; Table 3.4). Most cows calved in the hot-wet season in the sweetveld compared to sourveld ($P<0.05$; Table 3.4). Lactation period and calving season were not significantly associated with farm type.

Cow abortion problems were significantly associated with veld type, with more respondents in the sweetveld experiencing higher incidences of abortions compared to sourveld (45 versus 27%; $P<0.05$). Cow abortion problems were not associated with farm type ($P>0.05$). Cow abortions were attributed to diseases (48% of the respondents), poor nutrition (34%) and old age (18%). Cows experienced problems of retained placenta (27% responses), dystocia (17%), mastitis (15%), agalactia (6%) and metritis (3%) soon after calving and 32% did not experience any calving problems. The proportions of farmers who observed and assisted their cows during calving were not significantly associated with farm type. However, there was an association between veld type and the proportion of farmers who observed and assisted their cows during calving ($P<0.05$). Sixty-six percent of the respondents in the sourveld assisted their cows during calving compared to 40% in the sweetveld. Out of those farmers who did not observe their animals during calving, 55 and 80% in the sweetveld and sourveld, respectively, attended to their cows within 24 hours of calving. All the respondents reported feed shortages and loss of animal condition, especially during cool-dry and hot-dry seasons. Veld type and farm type was significantly associated with the proportion of the farmers who provided supplementary feeding to their cattle. Seventy percent of the interviewees in the sourveld, small-scale farmers provided supplements to their cattle compared to 22% in the sweetveld, communal farmers ($P<0.05$). Crop residues (75% of the respondents) and hay (20%) were the main supplements used by farmers. Over 75% of the respondents

Table 3.4: Calving seasons and lactation period of cows as reported by the farmers (%) in the sweetveld and sourveld areas

	Sweetveld (n=144)	**Sourveld** (n=74)
Lactation period (days)		
<150	35	11
151- 300	52	72
301-540	8	14
>540	5	3
Season		
Hot-dry	8	42
Hot-wet	80	50
Cool-dry	6	5
All year round	6	3

supplemented animals once a day during the cool-dry and hot dry seasons, across production systems and vegetation types. Farmers preferred giving extra feed to cows first, then calves, heifers, steers, oxen and bulls, in that order, across farm types and veld types. Farmers reported that they supplemented cows to improve milk yield and calves to improve growth.

3.3.3 Calf rearing practices

Most of the farmers (73%) preferred to have female calves. Over 90% of the respondents reported that their calves were born healthy and 75% did not report calf mortality as a major constraint. Nearly 90% of the respondents were aware of the importance of colostrum for the calves. Farmers reported that colostrum is highly nutritious to calves (39%), boost calf immunity (34%) and both highly nutritious and boost calf immunity (27%). About 18 and 22% of the households did not milk colostrum and kept the calf with its dam, respectively, to ensure that the calf gets enough milk from its dam and 60% did nothing. When the calf lost its dam soon after birth, 55% of the farmers bought milk for the calf, 32% gave it milk from other cows in-milk within the herd and 13% did nothing.

Age at weaning was not significantly associated with farm type and veld type. About 18% of the respondents weaned calves between 0 and 5 months of age, 62% between 6 and 12 months and 20% over 12 months. There was no association between weaning methods and veld type. Weaning method was significantly associated with farm type. The majority of farmers in the communal areas used the natural method to wean calves whilst those in the small-scale used the separation method ($P<0.05$ (Table 3.5). To separate the calves from the dams, farmers move the cows temporarily (for 7-21 days) to distant grazing areas whilst calves are grazed near to homesteads and kraaled at night. Alternatively, home-made metal

Table 3.5: Times of first milking after calving, milking frequency and weaning methods as reported by respondents (%) in the communal and small-scale areas

	Communal (n=175)	**Small-scale** (n=43)
Time of first milking after calving (weeks)		
<1	30	20
1-2	35	60
>3	8	2
Do not milk	27	18
Milking frequency		
Once	15	20
Twice	60	70
Do not milk	25	10
Weaning method		
Natural	45	35
Separation	15	43
Metal plate	40	22

nose plates are fitted to calves for up to 21 days at the age of 6-12 months. More than 90% of the respondents did not dehorn their calves. Sixty percent of the farmers had no reasons for not dehorning, 20% wanted the calves to protect themselves during fighting, 15% did not know how to dehorn and 5% did not have the appropriate equipment. Over 85% of the households kraaled calves at night for about 12 to 15 hours. Most of the kraals (65%) were built of untreated wood and fence, without roofs.

3.3.4 Milk production

Milk was ranked as the third most important reason for keeping cattle, after cash and ceremonies. The type of cattle breeds kept by farmers was not associated with farm type and veld type ($P>0.05$). About 30 and 50% of the farmers milked Nguni and crossbred cows and 20% used both breeds. Most of the households (72%) milked during the hot-wet season (November to February). Times of first milking after calving and milking frequency were significantly associated with farm type. There were more farmers in the small-scale farming areas who started to milk their cows between the first and second week of calving than those in the communal areas ($P<0.05$; Table 3.5). Most of the farmers in the small-scale farming areas milked their cows twice a day (between 0800 and 0900 hours and 1430 and 1500 hours) compared to those in the communal areas (Table 3.5). Over 65% of the households allowed calves to suckle for ½ to 1 ½ minutes to induce milk let down before milking the cow manually. Thereafter, the calf was released together with its dam and enclosed separately at sunset. In cases where the calf was not allowed to suckle, it was fed with milk from its dam or other cows, and fed supplements.

Milk off-take was shared between family consumption and sales to neighbours. It was consumed as fresh in tea (64% of the respondents), as sour milk as a relish with semi-solid boiled mealie-meal (55%), and whey was used as food for pets (8%). Only 10 and 6% of the households sold milk as fresh and sour, respectively. Average prices for fresh and sour milk were US$ 2.0 and US$ 1.60 per litre, respectively. Milk prices were not associated with farm type and veld type ($P>0.05$).

On average, the farmers milked 4.2 litres/cow/day. Over half of the respondents cited small herd sizes and low milk yield (35%) as reasons for low milk sales. There was a significant interaction between veld type and farm type for milk yield, fresh and sour milk consumption and fresh and sour milk sales (Table 3.6). Daily milk yield/cow and fresh milk consumption/day and sales/day were significantly high in the sourveld, small-scale farms (Table 3.6). Daily sour milk consumption and sales were high in the communal farms in the sourveld ($P<0.05$).

Milk yield was highly correlated with number of lactating cows, milk consumption and milk sales ($P<0.01$; Table 3.7). Herd size, land size and household size were positively correlated with milk yield ($P<0.05$; Table 3.7). Respondents used the following criteria to evaluate milk quality; colour (60%), smell (18%), water content (12%) and taste (10%). Most of the respondents (94%) reported that the milk produced by their animals was of good quality. All the respondents reported a serious lack of milking facilities and infrastructure.

Table 3.6: **Least square means (± standard error of means) of milk yield (litres/day), milk consumption (litres/day/household) and milk sales (litres/day/household) based on veld type and farm type**

Milk production	**Sweetveld**		**Sourveld**	
	Communal (n=125)	Small-scale (n=19)	Communal (n=50)	Small-scale (n=24)
Milk yield per cow	3.0 ± 0.52^{a}	6.0 ± 0.41^{c}	4.5 ± 0.21^{b}	7.5 ± 0.52^{d}
Fresh milk consumption	0.8 ± 0.22^{a}	2.0 ± 0.43^{a}	1.2 ± 0.43^{a}	3.2 ± 0.52^{b}
Sour milk consumption	1.5 ± 0.22^{a}	1.7 ± 0.63^{ab}	2.6 ± 0.24^{b}	2.3 ± 0.73^{ab}
Fresh milk sales	0.2 ± 0.12^{a}	1.8 ± 0.31^{c}	1.2 ± 0.23^{b}	3.1 ± 1.10^{d}
Sour milk sales	0.2 ± 0.10^{a}	0.1 ± 0.41^{a}	0.8 ± 0.20^{b}	0.4 ± 0.41^{ab}

^{a,b,c,d} Values with different superscripts within a row are significantly different (P<0.05)

Table 3.7: Correlations between milk yield, consumption and sales with herd size, land size and household size

	Milk yield	Lactating cows	Herd size	Milk consumption	Milk sales	Land size
Lactating cows	0.80**					
Herd size	0.25*	0.50**				
Milk consumption	0.62**	0.17	0.18			
Milk sales	0.76**	0.22	0.28*	0.31*		
Land size	0.40*	0.29*	0.30*	0.11	0.12	
Household size	0.35*	0.20	0.13	0.33*	0.17	0.15

Significantly correlated at *P <0.05; **P<0.01

3.4 Discussion

The observation that cattle herd sizes were bigger in the small-scale farms in the sourveld could be attributed to feed availability and farmer resources ownership. Sourveld areas receive moderate to high rainfall (600-800mm per annum) that promote excess herbage growth during the hot-wet season (Ellery *et al.*, 1995), which in turn, could be conserved as hay for dry season supplementary feeding by small-scale farmers (Simela *et al*., 2006). A strong relationship is expected to exist between feed availability, milk production and cattle populations (Ezanno, 2005). Animals with higher levels of protein and/or energy are better able to produce more milk than under-nourished animals (Bebe *et al*., 2003; Ezanno, 2005). Small-scale farmers' use of technology for feed conservation and purchase of external feed inputs is moderate compared to communal farmers who are resource-limited (Ainslie *et al*., 2002; Mapiye *et al*., 2007b). Large cattle herd sizes observed for educated and informally employed respondents have implications for adoption of smallholder dairy production technologies. In order to increase dairy production technologies adoption of smallholder, research and development should target informally employed people who have time and resources, and educated people who have knowledge to manage dairy production.

Cattle herd structure has implications for milk production, because dairy cows make up part of the reproductive herd. The large number of cows and heifers might indicate that farmers prefer retaining female animals in the herd because they derive extra benefits such as milk and calves from them compared to castrated males which are often sold to meet immediate household cash needs (Musemwa *et al*., 2008). However, the observed ratio of lactating cows to reproductive cows can be attributed to low cow management and productivity levels, and low bull numbers and poor bull fertility (Nqeno *et al*., 2009). Cow productivity and bull fertility for the smallholder herds warrant investigation.

Cow productivity was low as reflected by delayed age at puberty (24 and 36 months) and at first calving (36-48 months). This is partly due to environmental factors, including nutrition, diseases and parasites (Abayawansa *et al*., 1994; Abeygunawardena and Dematawatewa, 2004; Nqeno *et al.*, 2009). Estimates of age at puberty in *Bos indicus* cattle in the tropics and subtropics range between 16 and 40 months compared to 12-24 months for *Bos taurus* x *Bos indicus* crossbred or purebred Taurine cattle (Galina and Arthur, 1989; Mukasa-Mugerwa 1989). In agreement with findings of this study, Martin *et al*. (1975), Galina and Arthur (1989), Abeygunawardena and Dematawewa (2004) and Ngongoni *et al*. (2006), the age at first calving of *B. indicus* cattle ranges from 23 to 60 months, with an average estimate of 44 months. Age at puberty and first calving marks the beginning of a cow's productive life and are closely related to generation interval and, therefore, influences response to selection (Mukasa-Mugerwa, 1989). The calving intervals of 24-48 months reported by the farmers are long when compared to 12-36 months that Ngongoni *et al*. (2006) reported. Schoeman (1989) also observed shorter inter-calf intervals of 12-24 months for indigenous cattle in South Africa.

Cows in the surveyed areas had long productive lives of 10-15 years and produced large numbers of calves. Schoeman (1989) reported that indigenous cows in the smallholder areas of South Africa have long productive life (10-15 years) and produce more than 10 calves. Mukasa-Mugerwa (1989) reported that the useful life of Zebu cattle ranges from 4.5 to 8.5 years, during which they produce three to five calves. Even though Zebu cattle tend to reach sexual maturity late, their productive life and that of their crosses tends to be longer than that of taurine cattle (Mukasa-Mugerwa, 1989). If animals with long productive life are also highly productive, it can be advantageous to keep them in the herd as long as possible. This might, however, increase the generation interval and thus reduce the response to selection. The trade-off between immediate productivity and herd improvement must, therefore, be carefully considered.

Lactation periods of 151-300 days found in this study are similar to 150-240 days reported for Nguni and cows by Moyo (1996). These lactation periods are shorter than 250-305 days recommended for recognised dairy breeds (Ngongoni *et al*., 2006). Long lactation lengths increase calving intervals, thereby leading to reduced cow productivity. The larger proportion of farmers who reported lactation lengths of 151-300 days in the sourveld than in the sweetveld can be ascribed to the availability of nutrition. Cows in the sourveld have access to a higher plane of nutrition during lactation compared those in the sweetveld (Botsime, 2006).

The finding, stating that most cows calved in the hot-wet and hot-dry seasons agreed with Abayawansa *et al*. (1994) and Pedersen and Madsen (1998). This corresponds to improved nutritional conditions during the subsequent rainy season to meet cow nutrient requirements for maintenance, growth, reproduction and lactation (Abayawansa *et al*., 1994; Abeygunawardena and Dematawatewa, 2004). The disparity in calving season reports given by respondents in the sweet and sourvelds can be ascribed to different rainfall patterns between the two veld types. In the sourvelds, effective rainfall is received earlier (in mid November) compared to the sweetveld, where effective rainfall is received late (in mid December) (Ellery *et al.*, 1995; Botsime, 2006).

The greater propotion of respondents who experienced cow abortion problems in the sweetveld compared to those in the sourveld could be attributed to poor rangeland management practices which reduce the feed resource base for the cattle (Berger *et al.*, 1992). Under-nourished animals have weak immunity and are more susceptible to diseases and parasites than well conditioned animals (Ezanno, 2005). The problems of retained placenta and difficult calving reported in this study could be a reflection of inadequate pre-partum nutrition (Ganaba *et al*., 2002; Ngongoni *et al*., 2007a).

The reported feed shortages and loss of animal condition, particularly during the dry season and the low cow productivity warrant research on alternative supplementary feeding strategies for cows. In this study, the farmers gave more attention to cow supplementation compared to other classes of cattle. The potential for crop residues (such as stover straws and hulls) that is available should be fully exploited by offering them to cows together with salt urea-molasses blocks or treat them with ammonia before feeding. Utilisation of feed supplementation strategies which include use of crop by-products (that include milling by-products and oilseed cakes), and improved herbaceous and browse trees deserve investigation (Kabirizi *et al*., 2004; Mapiye *et al*., 2007b; Ngongoni *et al*., 2007b). Research on indigenous browse trees (leaves, pods and fruits), which are low-cost supplements that also provide fencing posts, fuel wood and shade for animals should be prioritised.

Farmers' preference for female calves can be attributed to their future reproductive and milk production roles. Weaning ages and methods in this study are similar to earlier reports by Pedersen and Madsen (1998). The natural weaning method practised by most of the communal farmers delays postpartum ovarian activity and reduces reproductive efficiency (Ngongoni *et al*., 2006; Nqeno *et al.*, 2009). Farmers should practice early weaning using the home-made nose plate. This reduces calf weaning stress compared to the separation method, lowers the pressure on the cow and allows it to quickly regain lost weight, and shortens the calving interval (Pedersen and Madsen, 1998).

Since the farmers' priority for cash through beef sales was higher than that for milk, it is important to develop smallholder dairy production to a level where farmers can easily derive benefits through milk sales. As long as farmers derive immediate and continuous supply on cash from milk, smallholder milk production can be a sustainable source of livelihoods for resource-poor farmers (Ngongoni *et al*., 2006). The fact that the majority of the farmers milked their cows in the hot wet season implies that the quantity of milk extracted for human consumption and sales varies between seasons. Thus, the seasonality of milk production can prevent farmers from earning a stable income throughout the year. Although the hot-wet season remains the best period for increased milk production, it is also the period of low prices (Somda *et al*., 2005; Musemwa *et al*., 2008).

Similar to the findings of this study, Das *et al*. (1999) reported that traditional milking of Zebu cows was based on twice a day suckling of calves, and later, when grazing with their dams, calves suckled their dams throughout the day. Suckling just before and during milking is known to be a major stimulus for lactation milk yield in Zebu and crossbred cows (Das *et al*., 1999; Yilma, 2006). Suckling exploits the maximum milk potential of the cows through the consumption by the calf of the residual milk, achieves high milk yield at milking, good calf growth, low mastitis incidence and results in low calf mortality (Mejia *et al*., 1998; Yilma *et al*., 2006). The fact that there were more farmers milking twice in the small-scale areas could be also be due to provision of supplementary feeds during the milking season compared to the communal areas.

The use of crossbred and indigenous cattle in the smallholder milk production areas was also reported by Moyo (1996), Ngongoni *et al*. (2006) and Yilma (2006). An average milk yield of about 4.0 litres/per day for indigenous cows and their crosses correspond to 2-4 litres/day obtained by Moyo (1996), Ngongoni *et al*. (2006), but is lower than 10-15 litres produced by exotic breeds in the same studies. Milk production traits of indigenous cattle can be improved through different methods which include selection within the existing population and cross-breeding with exotic breeds (Moyo, 1996; Muchenje *et al.*, 2007). Selection within the existing population has advantages of ensuring the development of animals which are able to adapt well to the existing feeding and management system (Cunningham and Syrstad, 1987). Consequently, it is necessary to improve the genetic potential of indigenous cattle by selection within populations, but it takes a long time to attain adequate genetic progress. When carrying out breed improvement, it is important to note that indigenous cattle are multi-purpose cattle.

The higher milk yield in cows in the sourveld than sweetveld indicates that smallholder milk producers are heterogeneous in their resource ownership and utilisation. The positive correlations observed between milk yield, milk consumption and milk sales confirm earlier reports by Kabirizi *et al*. (2004) and Ngongoni *et al*. (2007a) that increasing milk production improves household food security and income levels of the smallholder farmers. The observation that milk yield was positively correlated with land size and household size agrees with previous reports (Hanyani-Mlambo *et al*., 1998; Ngongoni *et al*., 2007b). Pedo-climatic factors (rainfall, temperature and soil fertility), land size, labour and capital indirectly determine feed availability, milk yield, milk consumption and milk sales (Hanyani-Mlambo *et al*., 1998; Somda *et al*., 2005; Ngongoni *et al*., 2007b). To invest in new technologies whose returns occur over a number of years, such as dairy production, resource-poor farmers located in low-medium rainfall areas need adequate labour force, access to land, improved animal genetic resources and more importantly capital to sustain these resources. Thus, resource-poor farmers should be financially supported and their access to credit and information improved. Since small-scale farmers have resources, they may need little technical support. Smallholder dairy production research and development should, therefore, be re-orientated toward producing appropriate technologies for farmers with diverse resource endowments and located in different agro-ecological zones.

High consumption and sales of sour milk in the sourveld, communal farms can be attributed to high temperatures prevalent in the sourveld during the hot-wet season (Ellery *et al.,* 1995) and lack of proper milk preservation facilities in the communal areas. In the absence of adequate milk processing and handling facilities, the risk of losing part of the milk off-take is high, because dairy products are highly perishable. Improvement of processing and handling facilities and market access is therefore, crucial.

3.5 Conclusions

It was concluded that, calf rearing practices were poor and milk yield, consumption and sales were generally low and varied with production system and rangeland type. It was suggested that milk production could be improved through the provision of supplementary feeds and selection of milk production traits within indigenous cattle populations. Further research is required to improve calf management practices, cow nutrition, milk yield and quality across seasons, breeds and agro-ecological zones in the smallholder areas of South Africa. Birth weight, growth rate and weaning weaning of Nguni and crossbred calf under communal production also need to be investigated.

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CHAPTER 4: Calf performance and prevalence of gastrointestinal parasites in Nguni and local crossbred calves under communal production systems in Eastern Cape Province of South Africa

(Submitted to Tropical Animal Health and Production)

Abstract

This study was designed to determine birth weights, average daily gain (ADG), weaning weights and the prevalence of gastrointestinal parasites in Nguni and crossbred calves raised on communal rangelands in the Eastern Cape, South Africa. Breed had significant effect on birth weight, ADG and weaning weights ($P<0.05$). Birth weight, ADG and weaning weights were greater in Nguni calves than crossbred calves. In both breeds, male calves were heavier at birth and at weaning than female calves. Weaning weight of the Nguni male (142.1 kg) calves was higher ($P<0.05$) than that of crossbred (123.6 kg) calves. *Strongyles*, *Strongyloides* and total worm count loads were lower ($P<0.05$) in calves younger than two months old, and increased as the age of calf increased. *Strongyles* egg counts in Nguni were higher (26.0 egg loads) than those in crossbred (18.9 egg loads) in their first month of age but were lower ($P<0.05$) in Nguni (38.5 egg loads) than in crossbred (83.3 egg loads) at the age of six months. *Strongyloides* egg loads were lower ($P<0.05$) in Nguni than in crossbred calves throughout the study period. Crossbred calves had higher ($P<0.05$) *Coccidia* egg loads than Nguni calves at one month old but at six month old Nguni had higher ($P<0.05$) *Coccidia* egg loads than crossbreds. It was concluded that Nguni calves had higher birth weight and pre-weaning growth rates and lower gastro-intestinal parasite egg loads than crossbred calves.

Key words: Birth weight, *Strongyles*, *Strongyloides*, weaning weight.

4.1 Introduction

The most suitable farming system practiced in the Eastern Cape Province of South Africa is livestock production and the most dominant enterprise being cattle production (Marufu *et al*., 2009). The majority of existing cattle breeds in these communal production systems are crossbreds and Nguni (Bester *et al*., 2003). There is little information known about calf performance in cattle kept by communal farmers and this needs to be investigated. Crossbreds were produced from crossing Nguni cows with imported breeds. Some of the breeds that were used in crossbreeding are largely beef breeds, such as Angus, Bonsmara and Brahman and to a lesser extent, dairy breeds (Bester *et al*., 2003). For sustainable, productive and efficient cattle production, cows kept under communal production systems should produce calves that would survive in the harsh communal environmental conditions. The calves of the communal cows need to have good calf performance and less prevalence to gastrointestinal pararasites. Communal farmers solely depend on calves to increase their herd sizes. Despite the importance of calves in cattle farming, calf mortality in the communal areas, for example exceed 30-35% compared to 5-10% under commercial production systems (Louvandini *et al*., 2006). Communal farmers are however, not aware of the losses they experience due to poor calf performance. Few, if any, information is available on calf performance under communal production systems. For example, birth weight and weaning weight of calves in communal production systems is unknown. Such information is crucial in developing possible strategies and ways of preventing peri- and post-parturient diseases and disorders, such as dystocia among other conditions.

Pre-weaning and weaning weights are some of the calf performance indicators that are not well understood by farmers (Chapter 3), although they determine sustainability and profitability of cattle production in the communal production systems. The pre-weaning and weaning weight can be affected by various factors and among these are gastrointestinal parasite infestations, particularly nematodes (Blezinger, 2008). In communal production systems susceptibility of calves to gastrointestinal parasites and its effect on calf performance has not been determined. The objectives of the current study were to compare the growth performance of Nguni and crossbred calves and to estimate the prevalence of gastrointestinal parasites in Nguni and crossbred calves under communal rangeland production systems. The hypotheses to be tested were that there were no significant differences existing in growth performance and gastrointestinal parasite loads in Nguni and crossbred cattle on communal rangelands.

4.2 Materials and Methods

4.2.1 Study site

The study was conducted at Hillview Farm in Seymour, a sub-municipality of Nkonkobe Municipality in the Amathole district of the Eastern Cape Province of South Africa. Pregnant cows serviced by communal bulls were randomly selected from three communities and were kept on the same veld with the Nguni cattle donated by the University of Fort Hare. All of these cows were under a communal production system management. The study site is located in the Valley Bushveld of the Eastern Cape (Acocks, 1975; Acocks, 1988; Beckerling, *et al.*, 1995). The dominant grass species are *Panicum maximum*, *Themeda triandra, Digitaria eriantha*, *Aristida congesta* and *Cynodon dactylon.* In the valleys, the main bush species is the *Acacia karroo*, whilst the mountainous areas are dominated by *Olea africana, Ptaeroxylon obliquum* and *Portulacaria afra.* The farm size is 650 ha. The area receives an average rainfall of 480 mm per year, and is mostly received in summer. The average maximum temperature and minimum temperature during the research period was 29.38 - 14.33 ^{0}C respectively. The average diurnal temperature is 30^{o}C.

4.2.2 Study animals

Forty calves (20 Nguni and 20 crossbred calves) were monitored from September 2007 to March 2008 and another thirty two calves (16 Nguni calves and 16 crossbred calves) born in September 2008 were monitored until March 2009. The calves were randomly selected from Rwantsana community and each calf was identified using ear-tags. All the calves were dipped once per month and no other medication was provided. Half of the calves monitored were males from each breed. The measurements were done over six months. The calves were solely dependant on dam's milk and rangeland for feed and no supplementary feeding was provided. All animals were getting water from the windmill. The calves were always with their dams and the farm was managed in a communal way of farming. Grazing capacity and stocking rates were not considered and the camps were not properly fenced to practice grazing management such as rotational grazing system and rotational resting.

4.2.3 Measurements

4.2.3.1 Body weights

Calf birth weights were determined by weighing each calf using a cattle's digital weighing scale from Border Scales (South Africa) over two years. The calves were weighed at 0800h once per month for six months. The average daily gain (ADG) was calculated as weight gained over a month divided by numbers of days for that month. Weaning weight was the weight of the calves at six months old.

4.2.3.2 Gastrointestinal parasites

Faecal samples were collected form the rectum of each calf. The faecal samples were placed in a cooler box containing ice blocks immediately after collection and thereafter were stored in a refrigerator at temperature between 4-8^{o}C. A technique for parasite assays and identification in faecal samples was used (See Appendix 3). Faecal egg counts were determined by the modified McMaster technique with saturated solution of sodium chloride as the floating medium (Soulsby, 1982) (See Appendix 4). Four grams of faeces were mixed in 56 ml of saturated solution of sodium chloride. The number of nematode eggs per gram of faeces was obtained by multiplying the total number of eggs counted in the two chambers of the McMaster slide by the dilution factor of 50 (Whitlock, 1948). The McMaster technique detects 50 or more eggs per gram of faeces. Details on the McMaster technique used are given in Appendix 4. Nematode egg types were determined using the sedimentation technique and identified using keys developed earlier by various authors (Soulsby, 1982; Uhlinger, 1991; Foreyt, 2001).

4.2.4 Statistical analyses

The egg counts data were checked for normality using Proc Univariate of SAS (2003) and was found to be normally distributed. Data were analysed using GLM procedures of SAS (2003).

The model used was:

$Y_{ijklm} = \mu + M_i + B_j + S_k + Y_l + (MxB)_{ij} + (MxS)_{jk} + (BxS)_{ik} + E_{ijklm}$, where:

Y_{ijklm} = birth weight or ADG or weaning weight or egg counts;

μ = constant mean common to all observations;

M_i = effect of age (months);

B_j = effect of breed (Nguni, crossbred);

S_k = effect of sex (male, female);

Y_l = effect of year of birth;

$(MxB)_{ij}$ = interaction between age of growth and breed;

$(MxS)_{ik}$ = interaction between age of growth and sex;

$(BxS)_{jk}$ = interaction between breed and sex; and

E_{ijk} = residual error assumed to be normally and independently distributed with mean 0 and variance equal to δ^2.

The PDIFF option of SAS (2003) was used to compare least square means.

4.3 Results

4.3.1 Birth weight

Breed and sex had effects on birth weight (P<0.05). Nguni calves were heavier at birth than crossbred calves (Table 4.1). In both genotypes, the birth weight of male calves was higher than that of females (P<0.05). In both genotypes, calves born in 2007 had larger birth weights than those of 2008, particularly the Nguni male calves (P<0.05) (Table 4.2).

4.3.2 Average daily gain and weaning weight

There were significant differences (P<0.05) between Nguni and crossbred calves on ADG. The ADG of Nguni calves were higher than that of the crossbred calves (Table 4.2). Sex had a significant effect on ADG, with male calves having higher ADG than female calves in both breeds. As shown in Table 4.2, year had no significant effect on ADG in Nguni calves. Crossbred calves born in 2008 had higher ADG than those born in 2007 (Table 4.2).

Table 4.1: Least square means (± standard error) for birth weight, average daily gain and weaning weight of Nguni and crossbred cattle based on sex

Parameter	Nguni		Crossbred	
	Males	**Females**	**Males**	**Females**
Birth weight (kg)	31.0 ± 0.60[c]	28.6 ± 0.64[b]	27.2 ± 0.50[b]	26.2 ± 0.65[a]
Average daily gain (kg/day)	0.63 ± 0.009[d]	0.60 ± 0.009[c]	0.53 ± 0.009[b]	0.48 ± 0.009[a]
Weaning weight (kg)	142.1 ± 1.62[d]	136.1 ± 1.69[c]	123.6 ± 1.60[b]	115.3 ± 1.75[a]

[abcd] Values with different superscripts within arow are different ($P<0.05$).

Table 4.2: Least square means (± standard error) for birth weight, average daily gain (ADG) and weaning weight of Nguni and crossbred cattle based on year of calving

	Year			
Parameter	**2007-2008**		**2008-2009**	
	Nguni	Crossbreds	Nguni	Crossbreds
Birth weight (kg)	32.2 ± 0.50^{b}	27.1 ± 0.56^{a}	26.3 ± 0.77^{a}	26.6 ± 0.68^{a}
ADG (kg/day)	0.60 ± 0.008^{c}	0.49 ± 0.009^{a}	0.62 ± 0.012^{c}	0.52 ± 0.016^{b}
Weaning weight (kg)	137.0 ± 1.45^{c}	116.7 ± 1.55^{a}	140.1 ± 2.156^{d}	122.8 ± 1.89^{b}

^{abcd} Values with different superscripts within a row are different (P<0.01).

Age had significant effect on ADG in both calf genotypes (P<0.05). At one month old, both calf genotypes had similar ADG but from two months old up to six months old Nguni calves had higher ADG than crossbreds (Table 4.3). Nguni calves had higher weaning weight than crossbred calves (P<0.05; Table 4.1). Weaning weight was significantly influenced by sex. Male calves had higher weaning weights than female calves (Table 4.1). There were also significant interactions between year and calf genotype of weaning weights (P<0.05).

4.3.3 Factors affecting *Strongyle* egg loads

There were significant differences between breed on *Strongyle* egg loads (P<0.05). Crossbred calves had higher *Strongyles* egg loads than Nguni calves (Figure 4.1). In crossbred calves, *Strongyle* egg loads increased as the age of the calves increased (Figure 4.1). Year and sex did not affect *Strongyle* egg loads. Age had significant effect on *Strongyles* loads (P<0.05). In both genotypes, the *Strongyle* egg loads were lower when calves were one month old and were higher at the age of five and six months. In Nguni calves, *Strongyle* loads decreased when calves were three and four months old and slightly increased at five and six months old. With the exception at one month of age the *Strongyle* egg loads were lower in crossbreds than in Nguni but after one month up to six months old there were more *Strongyle* egg loads in crossbreds than in Nguni (Figure 4.1). There were significant interactions between age and genotype on *Strongyle* egg loads (P<0.01).

Table 4.3: Least square means (± standard error) of average daily gain (ADG) (kg/day) of Nguni and crossbred calves based on age

Calf age (months)	Nguni	Crossbred
1	0.5 ± 0.04	0.5 ± 0.04
2	0.7 ± 0.04[b]	0.5 ± 0.04[a]
3	0.7 ± 0.04[b]	0.6 ± 0.04[a]
4	0.6 ± 0.04[b]	0.5 ± 0.04[a]
5	0.7 ± 0.04[b]	0.5 ± 0.04[a]
6	0.7 ± 0.04[b]	0.6 ± 0.04[a]

[ab] Values with different superscripts within a row are different (P<0.01).

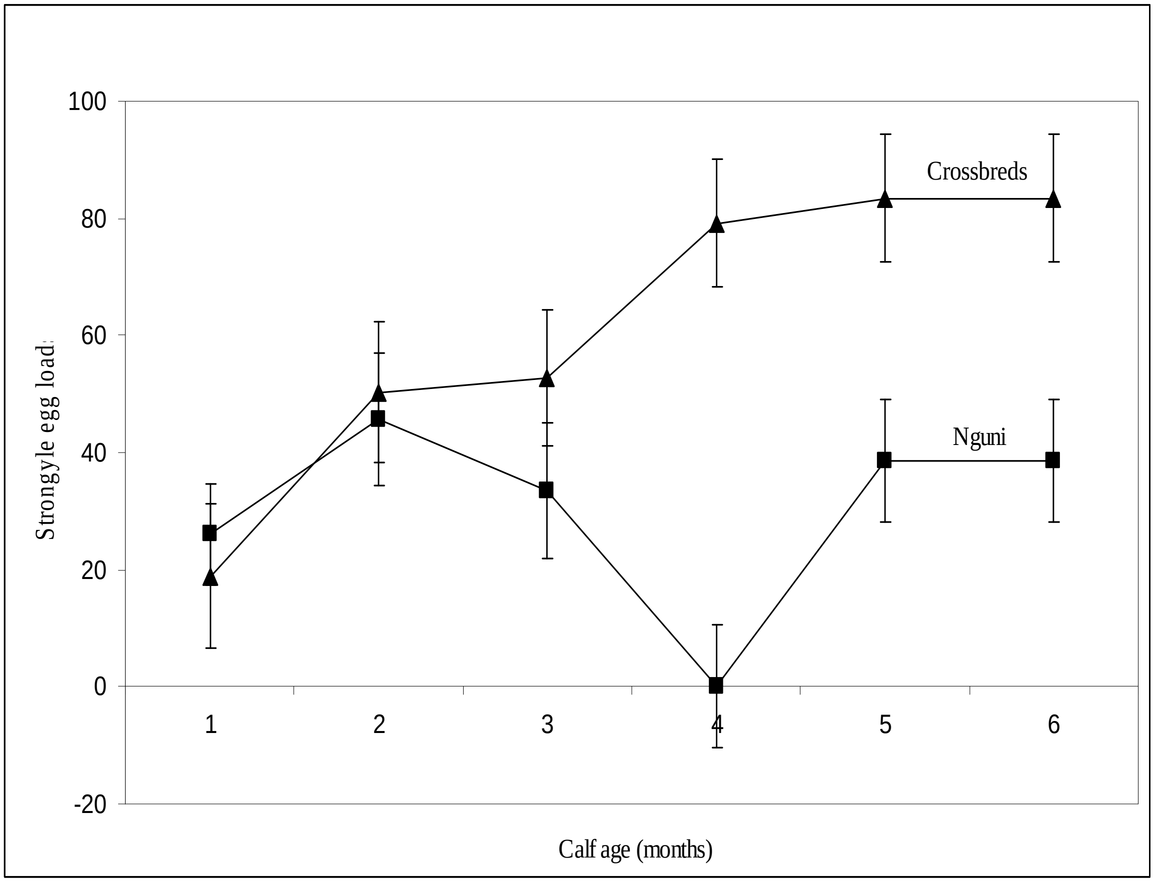

Figure 4.1: Least square means (± standard error) of *Strongyle* egg loads based on breed and age

4.3.4 Factors affecting *Strongyloides* egg loads

Breed had significant effect on *Strongyloides* egg loads (P<0.05). Crossbred calves had higher *Strongyloides* egg loads than Nguni calves throughout the study period (Figure 4.2). Age had a significant effect on *Strongyloides* egg loads (P<0.05). In both breeds *Strongyloides* egg loads increased up to three months old and thereafter there was a decrease in egg loads. In Nguni calves the loads were maintained at the same level at five months and six months old (Figure 4.2). There were significant interactions between breed and age of calf on *Strongyloides* egg loads (P<0.05). In both calf breeds *Strongyloides* egg loads were lower at one month old and increased as the calf age increased up to three months old. The age of three months was the peak period where *Strongyloides* egg loads were highest in both breeds. The *Strongyloides* egg loads decreased in both breeds as the age progresses from three months up to six months.

4.3.5 Factors affecting *Coccidia* loads

Breed had highly significant effect on *Coccidia* egg loads (P<0.05). Crossbred calves had higher *Coccidia* loads than Nguni calves in the first two months (Table 4.4). Age had significant effect on *Coccidia* egg loads (P<0.05). From one to two months old crossbred animals had higher *Coccidia* egg loads than Nguni calves. At the age of three, five and six months old crossbreds had lower *Coccidia* egg loads than in the Nguni. At four months old the *Coccidia* egg loads were higher in crossbreds than in Nguni calves (Table 4.4). On average, crossbred had higher prevalence of *Coccidia* egg loads than Nguni over the six month period. There were also significant interactions between age and breed on *Coccidia* egg loads (P<0.05).

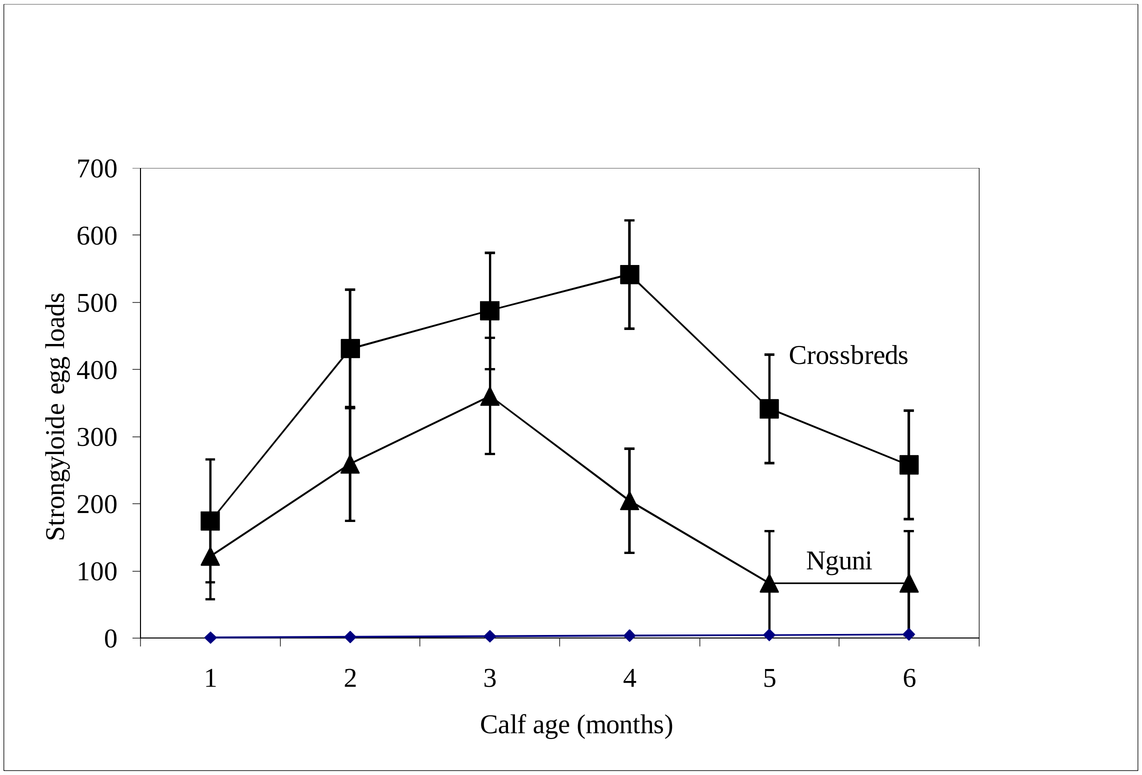

Figure 4.2: Least square means (± standard error) of *Strongyloides egg* loads in Nguni and crossbred cattle based on age of the calves

Table 4.4: Least square means (± standard error) of *Coccidia* egg loads in Nguni and crossbred calves based on age of the calves

Age (months)	Nguni	Crossbred
1	149.1 ± 56.12^{a3}	570.6 ± 80.14^{b5}
2	145.3 ± 74.22^{a3}	663.2 ± 77.88^{b6}
3	75. 5 ± 76.03^{b2}	59.2 ± 76.08^{a1}
4	0.7 ± 68.20^{a1}	75.0 ± 70.97^{b2}
5	285.3 ± 68.20^{b4}	83.3 ± 70.97^{a3}
6	285.3 ± 68.20^{b4}	91.7 ± 70.97^{a4}

^{ab}Within a breed, values with different superscripts indicate differences between breeds ($P<0.01$).

^{1234}Within age group, values with different superscripts indicate differences between different ages ($P<0.01$).

4.3.6 Factors affecting *Moniezia* egg loads

There were highly significant differences between breeds on *Moniezia* egg loads (P<0.01). With the exception of the third and fourth month, Nguni calves had higher *Moniezia* eggs than the crossbred calves (Table 4.5). Age had significant effect on *Moniezia* egg loads *(*P<0.05). In Nguni calves, higher *Moniezia* egg loads were observed when calves were one month old and decreased at the age of two months. At the age of three and four months old there were no *Moniezia* eggs identified in Nguni but *Moniezia* eggs increased at the age of five and six months (Table 4.5). In crossbreds, there were no *Moniezia* eggs identified at the age of one and two months. At three and four months old crossbred calves had fewer *Moniezia* eggs identified and there were no *Moniezia* eggs identified at five and six months old in crossbred calves (Table 4.5). There were no significant interactions between age and breed on *Moniezia* eggs. There were significant differences between breed on other roundworm eggs (P<0.05).

4.3.7 Factors affecting total worm count loads

There were significant differences between breed on total worm count loads (P<0.05). Nguni calves had higher total worm count loads than crossbred calves (Table 4.6). However, both breeds had higher total worm count loads throughout the study period. Age had significant effect on total worm count loads. Total parasite worm count loads were higher in Nguni in their first two months and decreased when they were three months and increased at five and six months old (Table 4.6). Crossbred calves had lower total parasite worm count loads at one month old but increased at two months to three months old. From four months to six months old there was a decrease in total worm count loads (Table 4.6). There were significant interactions between months and breeds on total worm count loads (P<0.05).

Table 4.5: Least square means (± standard error) of *Moniezia* egg loads in Nguni and crossbred calves based on age of calves

Age (months)	Nguni	Crossbred
1	609.4 ± 145.50[b4]	0 ± 207.81[a]
2	219.4 ± 192.46[b2]	0 ± 201.95[a]
3	0 ± 197.16[a1]	2.41 ± 197.30[a]
4	0 ± 184.03[a1]	2.67 ± 176.85[a]
5	390.5 ± 176.85[b3]	0.00 ± 184.03[a]
6	390.4 ± 176.85[b3]	0.00 ± 184.03[a]

[ab]Within a breed, values with different superscripts indicate differences at growing stage (P<0.01).

[1234]Within age group, values with different superscripts indicate differences at growing stage (P<0.01).

Table 4.6: Least square means (± standard error) of total worm counts in Nguni and crossbred cattle based on age of calves

Age (months)	Nguni	Crossbred
1	1491.9 ± 192.65^{b5}	210.4 ± 275.08^{a1}
2	1374.0 ± 254.76^{b4}	1026.0 ± 267.33^{a3}
3	1016.9 ± 260.99^{a3}	1637.8 ± 261.17^{b5}
4	542.9 ± 234.10^{a1}	1254.2 ± 243.60^{b4}
5	$1438 .3 \pm 234.10^{b2}$	838.3 ± 243.60^{a2}
6	1438.3 ± 234.10^{b2}	688.3 ± 243.60^{a2}

^{ab}Within a breed, values with different superscripts indicate differences at growing stage (P<0.05).

^{1234}Within age group, values with different superscripts indicate differences at growing stage (P<0.05).

4.4 Discussion

The Nguni calves were observed to have higher average daily gain and weaning weight than crossbred calves. This could indicate that the former are more adapted to the local environmental conditions. Growth rate in Nguni calves was associated with the good mothering abilities of the Nguni cows in terms of higher quality milk production and this is in accordance with the report of Raats (1997). This is supported by Poland *et al.* (2003) in their report, which states that Nguni cows have good mothering ability and could be used as dams for crossbred calves with larger beef breeds. The low growth rate observed in crossbred calves could be due to higher gastrointestinal parasite loads. These findings agree with the report of Appleby *et al*. (2001), Belem *et al*. (2005) and Coop and Kyriazakis (1999) stating that gastro-intestinal parasites compete with the calf for nutrients. Similarly, Nginyi *et al*. (2001) and Emery *et al*. (2008) furthermore supported our findings by reporting that gastrointestinal nematodes of livestock compete for or take nutrients away from the animal as well as cause extensive damage to the digestive tract.

It was reported that gastrointestinal parasites have negative effect on animal growth and production (Datta *et al*., 1998; Louvandini *et al*., 2006; Regassa *et al*., 2006). The harsh environmental factors in communal areas can also limit calf performance because cows walk long distances with calves in search of feed. Similary, Veissier and le Neindre (1989); Haley *et al*. (2005) reported that cows and calves spend more time walking, while spending less time eating and resting (Veissier and le Neindre, 1989, Gottardo *et al*., 2002). The effect of walking long distances in search of feed on calf performance in the communal areas has not been determined.

In both breeds, males had higher birth weight than female calves. This is in accordance to a natural phenomenon stating that in all animal species male animals have higher birth weights than females (Craig, 1988). However, Nguni male calves had higher birth weights than crossbred male calves and the lower birth weight in crossbred calves contributed to their lower weaning weights (Maree and Casey, 1993). In addition to lower birth weight, adaptability in the environment can also be a contributing factor. Comerford *et al*. (1987) reported that lower birth weights tended to be the limiting factor on survival of these calves. A lower birth weight in calves can be due to various reasons such as genetic factors related to the bull size and the dam size; and the nutritional status of the veld where the cow was grazing while still on gestation especially during the third trimester (Lykins *et al*., 2000; Koivula *et al*., 2009).

The birth weight of Nguni calves was not more than 7-8% of their dam's body weights which is the recommended standard for birth weight. Although the crossbred cows were mated to a bull that had an unknown history as far as dystocia is concerned there were no incidences of dystocia identified during the study period in these cows. The observed ADG values of these calves were not different from those of Nguni calves under commercial production systems as reported by Winks *et al.* (1978) stating that an ADG of between 0.63-0.70kg in Nguni calves were recorded.

The finding that male calves had higher ADG than female calves is in accordance to that reported of Winks *et al*. (1978) and Grøndahl *et al.* (2007). Age of calf had significant effect on ADG and this was associated with an increase in body weight of the calves (Haley *et al.*, 2005). The rate of increase was associated with nutritional status of the veld as well as dams milk production. Milk production can be measured in terms of quantity and quality.

According to Moyo *et al*., 1996 and Maichomo *et al*., 2004) calves that are not getting enough feed experience retarded growth.

The observation showing that at weaning, Nguni had higher weaning weight than crossbreds can also be ascribed to the hardiness of the Nguni cattle and their adaptability in communal environments (Raats, 1997). In both breeds, males had higher weaning weights than females and this is in concocordance with Winks *et al*. (1978) and Maree and Casey (1993). The higher weaning weight in Nguni calves can also be ascribed to the higher birth weight of Nguni calves and their adaptability to the environment.

The observations that calves born in 2007 had lower weaning weights than calves born in 2008 could be attributed to differences in rainfall and feed availability. The monthly weather report indicated that rains were higher in 2008 than in 2007; hence weaning weights in 2008 were higher than in 2007 and this was in line with the nutritional status of the veld. However, weaning weights of the Nguni calves in this study were lower than those observed under controlled environment (Winks *et al*., 1978; Carvalheira *et al*., 1995). A report by Winks *et al*. (1978) states that at a research station Nguni average weaning weights were 175.00kg weight whereas in this study weaning weights were 137kg and 140.1kg. The lower weaning weight in the current study could be associated with harsh environmental conditions such as higher gastrointestinal parasite loads and nutrition related problems. This agrees with the report of Raats (1997), which states that under communal farming, animals had to survive harsh environmental conditions.

Our findings indicating lower weaning weights in calves born with lower birth weight are in accordance to the report of Maree and Casey (1993) stating that excessive light birth weight can affect calf performance. Cow parity affects calf growth rate because milk yield is positively correlated with parity (Maree and Casey, 1993). This is more important because calves entirely depend on milk as a source of food in their early days of live (Heinrichs *et al*., 2005, Swai *et al.*, 2005). At this stage grass materials are inedible to the calf as its rumen is still underdeveloped and there are no rumen microbes for fibre digestion like in mature ruminant animals (McDonald *et al.*, 1995; 2002). In addition, first time calving cows experience lactation stresses and a cow loose its body reserves and this could affect calf growth (Sweet *et al*., 1998; Pirlo *et al*., 2000; Nilforooshan and Edriss, 2004). Calves whose dam is on its first parity can be more affected than calves whose dams are used to calving stress.

Calves in this study had higher egg loads and different types of gastrointestinal parasite species. These include species such as *Strongyles*, *Strongyloides*, *Coccidia*, *Moniezia* and other round worms. As reported by Belem *et al.* (2005); Wymann *et al*. (2006); (2008), young growing animals are more susceptible to gastrointestinal parasites. Although these gastrointestinal parasite species were identified in both calf breeds, the abundance of each parasite species was different from calf to calf and from breed to breed and this was supported by (Maree and Casey, 1993; Abebe, 2001; Keyyu *et al.*, 2003).

The observed results showing an increase in gastrointestinal parasite loads as the age of the calves increased is in accordance with the report of Maree and Casey (1993); Keyyu *et al.* (2003); Wynman *et al*. (2005); (2007). In this study crossbred calves had higher prevalence of gastrointestinal parasites than the Nguni calves and this was associated with breed differences. This also agrees with the findings of N’Dao *et al.*, 1995; Wymann *et al.* (2006; 2008) stating that there were breed differences on susceptibility to gastrointestinal parasites.

The hypotheses stating e no significant differences exist in growth performance and prevalence of gastrointestinal parasite loads are not supported by the results.

There were gastrointestinal parasites higher egg loads in these calves because they were owned by communal farmers who have little knowledge and resources in relation to gastrointestinal parasites and for this reason the calves were not dosed against gastrointestinal parasites. Crossbred calves had higher prevalent of gastrointestinal parasites and this was associated with breed differences. Crossbreds are not indigenous breeds in South Africa although they have Nguni genotype and it is for this reason that they were less adapted in communal environment than the Nguni.

4.5 Conclusions

It can be concluded that the lower calf performance reported by farmers in chapter 3 was associated with crossbred cattle which are the dominating type in the communities which participated in the study. In this chapter, Nguni calves proved to be well adapted to communal production systems and this was shown by higher birth weight, growth rate and weaning weights of Nguni calves compared to crossbred calves. However, each calf breed was susceptible to certain gastrointestinal parasite species. Nguni calves had higher *Moniezia* egg loads than crossbred calves and crossbred calves had higher *Strongyle*, *Strongyloides* and *Coccidia* egg loads than Nguni calves.

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CHAPTER 5: Concentration of nutritionally-related blood metabolites and mineral profiles of Nguni and crossbred calves kept under communal production systems

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Abstract

Blood samples were collected from 10 Nguni and 10 crossbred calves to compare total protein (TP), albumin, globulin, the ratio of albumin to globulin (A/G) concentrations and globulin ratio; glucose, cholesterol and non-esterified fatty acids (NEFA) between Nguni and crossbred calves under a communal production system in South Africa. Calcium, magnesium and phosphorus concentrations as mineral related blood metabolites were also evaluated. Blood samples to be analysed for other metabolites were collected via jugular veni-puncture into red top vacutainer tubes with no anticoagulant, while blood to be analysed for NEFA was collected using the vacutainer tubes containing ethylene diaminetetracetic acid (EDTA). Crossbred calves had higher (P<0.05) TP levels at one month old (73.8 g/1) than Nguni calves (67.1g and the TP levels increased with age in Nguni calves. At weaning, Nguni calves had higher (P<0.05) TP/l) levels (98.1g/l than crossbred calves (71.3g/l). Nguni calves had higher (P<0.05) NEFA levels than crossbred calves at weaning. Genotype and sex had no significant effect on calcium levels. Age of calf had significant effects on calcium levels (P<0.05), with calcium levels decreasing with age. The adaptability of the Nguni to the environment more than crossbred calves showed that they are the best cattle to be kept by poorly resourced communal farmers.

Key words: Calf age, non-esterified fatty acids, total protein, albumin: globulin, minerals

5.1 Introduction

For an animal to survive in an environment it needs to be adapted in the environment by being able to feed on available feed and able to produce immunity systems that would protect it against any infections. Calf performance indicators can not be the only method to effectively determine calf performance in communal production systems. Use of blood metabolites is effective in identifying nutritional, health status and adaptability to the environment of animals (Thye *et al.*, 2008). Accurate determination of nutritional and health status of animals is invaluable in modern animal agriculture (Ndlovu, *et al*., 2007; 2009). Strengärde *et al*. (2008) reported that metabolites can be used to indirectly indicate the nutritional quality of forages. Protein-related blood metabolites include total protein, globulin and albumin, while glucose, cholesterol and non-esterified fatty acids (NEFA) indicate the energy status of an animal**.** Blood metabolites are good indicators of animal performance (Whitaker *et al.*, 1999) and should be used to complement records on body weights, average daily gain and feed conversion efficiencies (Najarnezhad *et al*., 2009; Ndlovu *et al*., 2007). The levels of these metabolites in beef calves are hardly documented.

In Southern Africa, there are few reports on the assessment of calf performance under communal production systems. This is despite the fact that calf wastages in communal areas are high (Nqeno *et al*., 2009) and their growth performance is largely ignored (Mapiye *et al*., 2009). Farmers tend to focus on mature animals that provide tangible products, such as draught power, milk and cash through sales. The role of calves, which form the foundation of cattle production, is largely ignored, yet calf growth is closely related to slaughter weight and meat quality (Muchenje *et al.*, 2009). In South Africa, where there is a current thrust towards repopulating communal areas with the indigenous Nguni cattle, efforts have been made to evaluate the growth rate of cattle (Muchenje *et al*., 2008), tick resistance (Marufu *et al.*, 2009), blood metabolites (Ndlovu *et al*., 2007; Mapiye *et al*., 2009) and reproduction performance (Nqeno *et al*., 2009). Similar efforts to improve calf performance are glaringly lacking. Understanding the nutritional status of the calves under the communal production systems is, therefore crucial.

The objective of the current study was to determine concentrations of nutritionally-related blood metabolites and mineral profiles in calves under communal rangelands in the Eastern Cape Province of South Afeica. The null hypothesis tested was that there were no differences in the concentrations of nutritionally-related blood metabolites between Nguni and crossbred calves kept under communal rangelands.

5.2. Materials and Methods

5.2.1 Study site

The study site was described in section 4.2.1.

5.2.2 Experimental animals

A total of 20 calves (10 Nguni and 10 crossbred) were randomly selected and were eartagged. In each breed, there were five male and five female calves. The calves were born in December 2008.

5.2.3 Blood collection

Blood samples were collected from these calves once per month from one to six months old. Blood was collected via the jugular veni-puncture into red top vacutainer tubes with no anticoagulant for the analysis of other metabolites except for NEFA. Blood to be analysed for NEFA was collected using the vacutainer tubes containing ethylene diaminetetracetic acid

(EDTA). The blood was collected at 0800h, before the calves had access to milk or grazing. For the determination of glucose, blood was collected into Vacutainer® blood tubes containing sodium fluoride to arrest glycolysis. The blood was kept in a cooler box at about 4^oC. At the laboratory the blood was centrifuged for 10 minutes at 1000 x g for 10 minutes within 2 hours of collection. Serum was stored in tubes in a deep freeze at -20^oC pending analysis (For details, see Appendix 5).

5.2.4 Laboratory analyses

Non-esterified fatty acids were analysed using commercially available kits (Siemens, South Africa) and a Chexcks machine (Next/Vetex Alfa Wasseman Analyser, Woerden, Netherlands). Serum samples were analysed spectrophotometrically for total protein (TP) (Wechselbaum, 1946), albumin (Doumas, 1972), inorganic phosphorus (Young, 1990), NEFA (De Villiers *et al*., 1977), calcium (Cali *et al*., 1972) and magnesium (Tietz, 1976). Globulin concentrations were computed as a difference between TP and albumin, whilst albumin/globulin (A/G ratio) was obtained by dividing the albumin value by the globulin concentration. Enzymatic methods were used for glucose (Gochman and Schmitc, 1972) and cholesterol (Allain *et al*., 1974) analyses (See Apendix 4).

5.2.5 Statistical analyses

Data were analysed using GLM procedure of SAS (2003) for repeated measures. For protein, energy and mineral related metabolite levels, the model used was:

$Y_{ijkl} = \mu + M_i + B_j + S_k + (M \times B)_{ij} + (M \times S)_{ik} + (B \times S)_{jk} + E_{ijkl}$, where:

Y_{ijkl} = TP, albumin, globulin, A/B ratio; glucose, cholesterol, NEFA, Calcium, Magnesium, Phosphorus, Iron;

μ = overall mean common to all observations;

M_i = effect of age (months) (i=1-6);

B_j = effect of breed (j=Nguni and crossbred);

S_k =effect of sex of calf (k=male, female);

$(M \times B)_{ij}$ = interaction between age and breed;

$(M \times S)_{ik}$ = interaction between age and sex;

$(B \times S)_{jk}$ = interaction between breed; and sex;

E_{ijk} = residual error assumed to be normally and independently distributed with mean 0 and variance equal to δ^2.

The PDIFF statement was used to compare the least square means.

5.3 Results

5.3.1 Protein-related metabolites

There were interactions between breed and calf age on total blood protein levels ($P<0.05$). At one-month old crossbred calves had higher ($P<0.05$) total protein than Nguni calves (Table 5.1). At six months, Nguni calves had higher TP levels ($P<0.05$) than crossbred calves. About 50% of Nguni calves and 53.5% of the crossbred calves had TP levels within the normal range (Table 5.2). The term normal ranges or normal levels in all metabolites in this study means the calves had the levels of metabolite expected in healthy calves.

Breed and sex had no significant effect on albumin levels. Age had no significant effect on albumin levels. About 43% of Nguni calves and 78% of the crossbred calves were within the normal albumin range (Table 5.3). Six-month old crossbred calves had higher ($P<0.05$) globulin levels than Nguni calves (Table 5.1). About 43% of Nguni calves and 77% of the crossbred calves were with the normal range of globulin (Table 5.3).

Table 5.1: Least square means for protein related metabolite levels (g/l) in Nguni and crossbred calves

	Protein related metabolites (g/l)							
	Total protein		Albumin		Globulin		A/G[1]	
Calf age (months)	Nguni	Cross[2]	Nguni	Cross	Nguni	Cross	Nguni	Cross
1	67.1[a]	73.8[b]	32.0	33.9	35.1[a]	48.1[a]	0.9[a]	0.8[a]
2	72.9[a]	77.9[b]	32.4	35.6	40.5[a]	49.9[b]	0.9[a]	0.8[a]
3	73.1[a]	73.7[a]	25.6	30.7	43.1[a]	43.0[a]	0.8[a]	0.7[a]
4	73.6[ab]	72.2[a]	32.4	33.9	44.2[a]	46.7[a]	0.8[a]	0.8[a]
5	73.6[a]	86.5[b]	32.4	31.6	44.3[a]	54.8[ab]	0.8[b]	0.6[a]
6	98.1[b]	71.3[a]	34.9	32.2	39.0[a]	63.3[b]	0.6[a]	0.8[b]
SE	5.687	4.545	2.528	2.048	6.350	5.255	0.325	0.061

[ab]Values with different superscripts for each metabolite at a specific calf age are different ($P<0.05$).

[1] A/G: albumin: globulin ratio.

[2] Cross: crossbred (non-descript) calves

Table 5.2: Proportion of calves that were below, normal and above normal range of total protein

Breed	Age of calf (months)	Calves with normal, above and below range total protein (%)		
		Below normal[1]	Normal	Above normal
Crossbred	1	10.0	70.0	20.0
Nguni	1	16.7	50.0	33.3
Crossbred	2	7.7	30.8	61.5
Nguni	2	16.7	50.0	33.3
Crossbred	3	18.2	54.6	27.2
Nguni	3	22.2	55.6	22.2
Crossbred	4	16.7	66.6	16.7
Nguni	4	25.0	50.0	25.0
Crossbred	5	0.0	25.0	75.0
Nguni	5	25.0	50.0	25.0
Crossbred	6	0.0	87.5	12.5
Nguni	6	0.0	44.4	55.6

[1] Normal TP levels in calves range from 65 to 78 (g/l) (Karapehlivan *et al.*, 2006)

Table 5.3: Proportion of calves that were below, normal and above normal range of globulin in Nguni and crossbred calves

Breed	Age of calf (months)	Globulin ranges for calves (%)		
		Below normal	Normal	Above normal
Crossbred	1	0.0	40.0	60.0
Nguni	1	0.0	87.5	12.5
Crossbred	2	0.0	23.1	76.9
Nguni	2	16.7	33.3	50.0
Crossbred	3	0.0	63.6	36.4
Nguni	3	11.1	44.4	44.4
Crossbred	4	0.0	66.7	33.3
Nguni	4	12.5	50.0	37.5
Crossbred	5	0.0	0.0	100
Nguni	5	12.5	37.5	50.0
Crossbred	6	0.0	75.0	25.0
Nguni	6	0.0	11.1	88.9

A normal calf's globulin ranges between 28 and 42 g/l (Karapehlivan *et al.*, 2006).

Sex of calf had no effect on globulin levels. At five months, the ratio of albumin to globulin (A/G) was higher ($P<0.05$) in Nguni than crossbred calves. In contrast, crossbred calves had higher ($P<0.05$) A/G ratios at weaning than Nguni calves. Sex had no effect on A/G ratio ($P>0.05$). About 66.7% of the Nguni calves and 33.3% of the crossbred calves had A/G levels that were below the normal range ratio (Table 5.4).

5.3.2 Energy-related metabolites

Nguni calves had higher ($P<0.05$) glucose levels at 1, 4 and 5 months compared to crossbred calves (Table 5.5). Sex had no effect on glucose concentrations $P>0.05$). About 63 and 75% of Nguni and crossbred calves had glucose levels that were on the normal range respectively. Age of calf, breed and sex had no significant effects on cholesterol concentration.

About 69% of Nguni calves and 64.3% of the crossbred calves had normal levels of cholesterol respectively. Nguni calves had higher NEFA levels than crossbred calves at all age groups except in month 2 and 5 (Table 5.5). Nguni females had the highest NEFA levels than other calves (Figure 5.1). Table 5.6 shows the proportions of calves in the expected normal ranges.

5.3.3 Mineral profiles

Genotype and sex had no effect on calcium levels ($P>0.05$). The age of calf had significant effects on calcium levels ($P<0.05$). All calves had lower ($P<0.05$) calcium concentrations at weaning than before four months of age (Table 5.7). Genotype, age of calf and sex had no significant effects on magnesium and phosphorous concentration in both calf breeds (Table 5.7). About 83 and 86% of Nguni and crossbred calves respectively had magnesium levels that were within the normal range.

Table 5.4: Percentage of calves that were below and normal range of albumin: globulin ratios

Breed	Calf's age (months)	Albumin: globulin ranges (100%)	
		Below normal	Normal
Crossbred	1	70.0	30.0
Nguni	1	37.5	62.5
Crossbred	2	69.2	30.8
Nguni	2	66.7	33.3
Crossbred	3	81.8	18.4
Nguni	3	66.7	33.3
Crossbred	4	66.2	30.8
Nguni	4	62.5	37.5
Crossbred	5	100.0	0.0
Nguni	5	62.5	37.5
Crossbred	6	75.0	25.0
Nguni	6	100.0	0.0

A normal calf's A/G ranges between 28.00-42.00 and 0.9-1.4 (g/l) (König *et al*., 2009).

Table 5.5: Least square means for energy related metabolite levels in Nguni and crossbred calves (g/l)

Energy related metabolites(g/l)						
	Glucose		Cholesterol		Non-esterified fatty acids	
Calf's age (months)	Nguni	Crossbred	Nguni	Crossbred	Nguni	Crossbred
1	4.7[b]	2.1[a]	3.2	3.4	0.4[b]	0.2[a]
2	3.8[a]	2.1[a]	3.6	3.7	0.3[a]	0.2[a]
3	3.0[a]	4.0[b]	3.2	4.0	0.6[b]	0.3[a]
4	3.9[b]	1.9[a]	3.4	3.37	0.6[b]	0.4[a]
5	3.9[b]	1.1[a]	3.2	3.6	0.5[b]	0.4[b]
6	3.8[a]	3.3[a]	3.7	3.6	0.6[b]	0.3[a]
SE	0.83	0.83	2.44	1.81	0.07	0.06

[ab]Values with different superscripts for each metabolite at a specific calf age are different ($P<0.05$).

A normal calf's glucose and cholesterol ranges between 3.10-4.70 and 1.30-3.80g/l respectively (Klein *et al*., 2002).

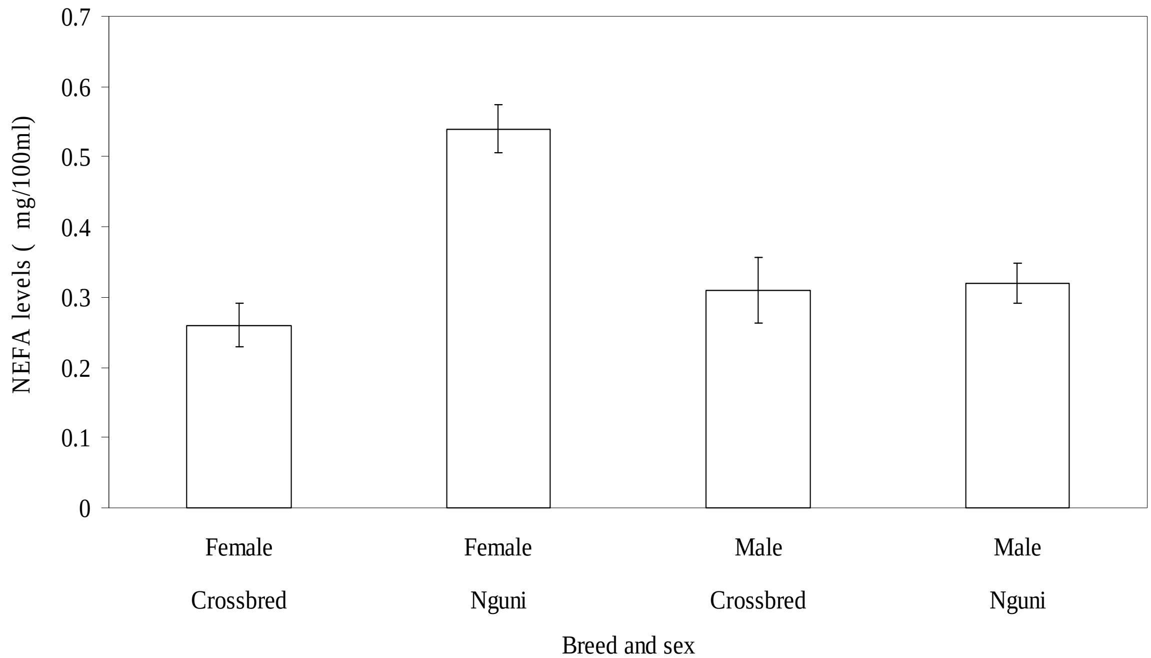

Figure 5.1: Effects of breed and sex on non-esterified fatty acid concentrations

Table 5.6: Proportion of calves that were below, normal and above normal range of glucose

Breed	Calf age (months)	Glucose ranges (100%)		
		Below normal	Normal	Above normal
Crossbred	1	80.0	0.0	20.0
Nguni	1	0.0	12.5	87.5
Crossbred	2	76.9	15.4	7.7
Nguni	2	100.0	0.0	0.0
Crossbred	3	36.4	36.4	27.3
Nguni	3	55.6	11.1	33.3
Crossbred	4	83.3	0.0	16.7
Nguni	4	62.5	0.0	37.5
Crossbred	5	100.0	0.0	0.0
Nguni	5	50.0	25	25
Crossbred	6	87.5	12.5	0.0
Nguni	6	88.9	11.1	0.0

Table 5.7: Least square means for calcium, magnesium and phosphorous concentration in Nguni and crossbred calves

	Mineral related metabolites (mol/l)					
	Calcium		Magnesium		Phosphorus	
Calf's age (months)	Nguni	Crossbred	Nguni	Crossbred	Nguni	Crossbred
1	2.4 ± 0.06^{b}	2.5 ± 0.07^{b}	0.92±0.541	0.94±0.468	3.05±0.306	3.15±0.320
2	2.4 ± 0.06^{b}	2.5 ± 0.06^{b}	1.00±0.453	1.07±0.412	3.19±0.365	3.32±0.303
3	2.4 ± 0.06^{b}	2.5 ± 0.08^{b}	1.66±0.594	0.98±0.448	3.55±0.401	3.56±0.409
4	2.4 ± 0.08^{b}	2.4 ± 0.11^{b}	1.65±0.791	0.98±0.604	3.52±0.535	3.59±0.278
5	2.2 ± 0.07^{a}	2.1 ± 0.11^{a}	1.65±0.791	0.97±0.541	3.52±0.535	3.63±0.365
6	2.2 ± 0.07^{a}	2.1 ± 0.07^{a}	1.02±0.523	0.92±0.523	3.77±0.354	3.65±0.354

^{abc} Values with different superscript indicate differences (P<0.05).

A normal calf's calcium, magnesium and phosphorus ranges between 2.00-2.90, 0.60-1.20 and 1.2-2.30 (mol/l), respectively (Tietz, 1993).

5.4 Discussion

The findings in our study of higher TP levels in crossbred animals in the first few months after birth and higher TP levels in Nguni at six months old were associated with breed differences and this agrees with the findings of earlier studies (Ahmad *et al*., 2004; Kapale *et al*., 2008; Mohri *et al*., 2007). The athours stated that variations in TP levels could also be due to breed differences and environmental effects. In addition, nutrition having higher protein concentration plays an important role to increase TP (El-Azab, 1993; Ahmad *et al*., 2004). The findings of higher TP levels in Nguni calves than in crossbred were associated also with the ability to adapt to the local environment. At this stage Nguni calves were able to efficiently utilise the available feed resources more than the crossbred calves and to synthesise proteins (Sürmeli and Hamdi, 2009). These findings were suggesting that Nguni calves were getting adequate nutrients including proteins from milk as well as from the veld. The milk consumption levels by calves were, however, not estimated in this study.

Our findings showing that, Nguni calves had lower TP levels at one month old and higher at six months old agrees with Kapela *et al*. (2008) who reported that TP increases with age. The Nguni calves were able to extract proteins from the available feed source in the environment better than crossbreds. Total protein may be decreased due to malnutrition, malabsorption (Kapela *et al.*, 2008) and inadequate iron intake (Adam *et al*., 1993; Bisalla *et al.*, 2007). Total protein may drop due to chronic infection, adrenal cortical hypofunction, liver dysfunction and dehydration (Guenter, 1997; Kapela *et al.,* 2008; König *et al*., 2009); therefore from this statement a drop in TP levels was associated with some sickness. Calves did not show any sicknesses and no sickness testing was carried as it was not part of this study. The finding showing that TP levels in the first and second months were higher in the crossbred than Nguni calves were indicating that there are genotypic differences that manifest themselves at an early stage. The overall results indicate that there were no nutritional problems experienced by the calves in our study.

In both breeds, globulin levels were within the normal range although crossbred calves had higher globulin levels than Nguni. Whitaker *et al.* (1999) associated higher globulin levels with some illness and inflammatory diseases. Globulin protects animals against infectious diseases (van Dam *et al.*, 1998; Bisalla *et al.*, 2007; Marufu *et al.*, 2009) and thus globulin production increase in the presence of infections. To support these Ogunsanmi *et al.*, (1994) reported that globulin levels in the body indicate the level of immunity systems. Otto *et al*. (2000) associated higher globulin levels in animals with higher prevelance of parasites and pathogens. Higher globulin levels in crossbreds were associated with the presence of disease in these calves (Marufu *et al*., 2009) although this was not identified during the study period. The differences in the levels of globulin between Nguni and crossbred calves were also associated with breed differences and this is in agreement with Shrikhande *et al.* (2008). The observed similarity in the globulin levels between male and female calves within the same breed were in accordance with the report of O'Kelly (1991); Kapela *et al*. (2008). Lack of variation in albumin levels between the two calf breeds suggested that the calves in our study were in a good health status and this means more investigation is required to test the status of albumin and globulin/albumin levels that could be associated with a disease. Our findings reporting a drop in albumin values with an increase in globulin levels concurs with the findings by Whitaker *et al.* (1999). According to Jeremy and Kaslow (2009) low albumin levels indicate poor health. In our study, age had no effect on albumin levels. Shrikhande *et al*. (2008) associated changes in globulin levels with seasonal variations and this also agrees with our findings.

Normal range of A/G ratios in calves is between 0.9 and 1.4 (Tietz, 1993; König *et al*., 2009). Kapela *et al.* (2008) also reported A/G ratios of 0.54 in calves. In this study about 66.7% of the Nguni calves and 33.3% of the crossbred calves had A/G ratio levels below the normal range which may be an indication of sickness that might be in calves, although there was no disease testing conducted to determine any disease that might be present in calves during the study period. This also supports the need for further investigation. That A/G ratio was less than one concurs with the findings by König *et al*. (2009) whereby the athours explained that this might indicate presence of disease infections. The A/G ratio in Nguni calves slightly decreased with age, yet in crossbred calves this pattern was not clearly defined as in Nguni calves. This is contrary to Kapela *et al.* (2008) who reported that the expectation is that the ratio should increase with age.

Normal glucose levels in calves should be within 3.10 and 4.70 g/l (Klein *et al*., 2002). In the current study, the glucose levels in Nguni calves were between 2.80 and 4.70 while in crossbred calves, glucose levels ranged from 2.10 to 4.00 g/l. Thus, many crossbred calves had glucose concentrations that were lower than the normal levels and many Nguni calves had glucose concentrations that were within the normal levels. This may suggest that the crossbred calves experienced energy stress during the study period. These findings are in agreement with a report by Mudron *et al*. (2005); Osborne *et al*. (2007) reporting that low glucose concentration indicates limited energy supply. The major sources of glucose for calves were forage materials and the dam's milk. Our results disagree with the earlier reports of Arai *et al*. (2006); Otto *et al.* (2000) stating that blood glucose levels tends to decrease with age. Although it was not part of this study, these authors also reported higher glucose levels in calves than in mature animals. In our findings the glucose concentration levels in Nguni and crossbreds calves did not show constant pattern of increasing with age. The lower glucose levels at weaning stage, particularly in crosssbred calves, may be indicating that crossbreds were less adapted to the environment. Crossbred calves were less able to extract glucose from the forage materials compared to Nguni calves. This could be due to inability to utlise certain plant species that are regarded as feed stuff by Nguni. This is supported by Raats (1996) who reported that Nguni can feed on feed material such as *Pteronia ancana* that are regarded by other animals as non-feed stuff.

Cholesterol levels in calves increased with age in both breeds. Strengärde *et al*. (2008) reported that low cholesterol levels indicate lower dry matter intake. On the other hand, consumption of polyunsaturated fatty acids (PUFA) usually causes a lower blood cholesterol levels in animals than does the consumption of a more saturated fat (Rice and Kennedy, 1988; Muturi *et al*., 2005). According to Kamimura *et al.* (2006) a decrease in cholesterol concentrations is a sign of diarrhoea and malnutrition in animals. The observations indicating a slight increase in cholesterol concentrations with age agrees with Moody *et al*. (1992), who associated a change in blood cholesterol levels with dam's milk cholesterol concentrations. As calves approach weaning, milk production and consumption decrease, thereby lowering blood cholesterol levels in the calves. It is likely that an increase in cholesterol levels was due to consumption of forage material containing saturated fat as reported earlier (Kamimura *et al*., 2006).

Non-esterified fatty acid levels in the animal's body are good indicators of feed intake (Fox *et al*., 1991; Dewhurst *et al*., 2006; Kamimura *et al.*, 2006). Kamimura *et al*. (2006) extended this by reporting that a decrease in NEFA indicates diarrhoea and malnutrition in calves. The observation that NEFA concentrations in both calf breeds were within the normal ranges indicates that there were no feed shortages although the calves were in communal areas. Thus

NEFA are considered a biomarker of negative energy balance, where the supply of glucose is insufficient to meet energy needs (Stokol and Nydam, 2005). Negative energy balance can be detrimental because it predisposes animals to hepatic lipidosis and ketosis. When energy is insufficient, stored fatty acids in the body will be rapidly mobilized in the form of NEFA in an attempt to meet energy demands (Kamimura *et al.*, 2006). Our findings showed that Nguni had more NEFA than crossbreds. This indicates that Nguni calves had more reserved energy than crossbreds and, which might suggest better adaptability of the Nguni to communal area production systems (Muchenje *et al*., 2008; Mapiye *et al*., 2009).

Calcium and phosphorus are the major minerals required for bone growth and therefore, pregnant cows need to have a sufficient source of these minerals to give birth to calves that have strong bones (McDonald *et al*., 2002). For communal grazing the only source of minerals are rangelands. According to our findings rangelands had sufficient calcium levels for the calves. Our findings indicating higher calcium levels during the early months of age of the calves and decreased with age were associated with higher calcium levels from the feed source of the dams while they were pregnant leading to calves born with sufficient calcium in their bones. The higher calcium levels reported during early lactation and decreased subsequent as the lactation progressed can also be associated with sufficient calcium in milk produced by the dams. Normal calcium levels in calves range between 2.0 and 2.9 mmol/l. These findings indicate that no calcium deficiencies were experienced. Although it was not relevant or appropriate since it was not part of study, Balakrishnan and Balagopal, 1994; Otto *et al*. (2000), reported that young animals have lower calcium levels than mature animals, thus this needs further investigation.

Magnesium levels in Nguni and crossbred calves in the current study were normal, indicating adequate source of magnesium for the calves either from the feed or from the milk. This is because milk is an adequate source of magnesium for young calves (Dakka and Abdel-All (1992); Maas, 2007). This indicates that if the magnesium concentrations in dam milk are high, the blood magnesium will be higher also. This might be the reason why in our study magnesium levels in calves were maintained at constant levels and there were no breed differences between Nguni and crossbred on magnesium concentrations. On the other hand, a decrease in magnesium concentration is observed in animals that are naturally infected with *Theileria annulata* (Beighle, 1999; Saber *et al*., 2008) Gonul *et al*., 2009). Serum magnesium concentration was, however, not significantly affected in the present study. The present study also did not show any significant differences between the two calf breeds on phosphorus levels. This indicates that both calf breeds had sufficient source of phosphorus. These findings are in accordance with the report of Dou *et al.* (2003) stating that phosphorus concentrations in diet samples matched closely with phosphorus concentrations in the body.

5.5. Conclusions

The lower prevalence of gastrointestinal parasites (Chapter 4) in Nguni and adequate nutrients including proteins and glucose levels than crossbreds in their blood was an indication of adaptability of the Nguni to the communal production system environment more than crossbred calves. Furthermore, adaptation was emphasised by observation that at weaning Nguni calves had higher glucose levels than crossbreds suggesting that they were able to extract glucose from the available feed source in the environment in the study area. The adaptive characteristics to harsh enivironmental conditions of the Nguni led us to a conclusion that Nguni calves were the best cattle suitable for communal production systems.

5.6 References

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CHAPTER 6: Milk utilisation patterns in the low-input production systems in South Africa

(Submitted to Tropical Animal Health and Production)

Abstract

Although milk plays a vital role in food security, poverty alleviation and is nutritious there is little, if any, information available on how it is utilised in communal areas in South Africa. The objective of the study was to determine milk utilisation patterns in different smallholder farming systems in the Eastern Cape Province of South Africa. Data were collected through the administration of recording sheets to 130 randomly selected households in Alice, Fort Beaufort and Queenstown districts in the Eastern Cape. Amounts of milk produced per household ranged from nine to 21 litres per household per day. Milk consumption per household was similar among the three districts. There was, however, double the amount of milk consumed in the early than in late lactation ($P<0.05$). Milk in the communal areas was largely utilised as raw fresh milk and as sour milk. Fresh milk was mostly used in tea/coffee or to make porridge for children. Sour milk was mixed with a stiff porridge made from maize meal. Fort Beaufort (10.2 ± 1.37l/day) had the highest sour milk sales whilst Queenstown had the highest fresh milk sales (9.7 ± 5.57l/day). The average price of fresh milk was highest in Alice (R6.00/l) and lowest in Queenstown (R3.00/l). It was concluded that quantities of milk consumed or sold as fresh or sour were generally low and varied across smallholder farming systems.

Key words: Farmers, consumption, fresh milk, sour milk, prices

6.1. Introduction

Milk as a source of nutrients for the calf and our findings in chapter 5, indicated that prior to weaning calves had higher nutrients in their blood as indicated by blood metabolites. These nutrient levels decreased with age of calves. This information is important to be known by cattle farmers in the Eastern Cape Province of South Africa as it has the largest cattle numbers (NDA, 2008). This will help to ensure that calves get sufficient milk. Despite that milk production being one of the major reasons for keeping cattle in the communal areas Chimonyo *et al*. (2000); Mapiye *et al*.; (2009) and (Nqeno 2009) there is little information on its utilisation.

Besides reducing malnutrition, especially among infants milk is a source of income to the resource-poor (Tapson 1991). The regular monthly monetary earnings from the sale of milk and milk products have favorable effects on the cash flow charts of rural households (Ngongoni *et al.,* 2006). Several reports have indicated that communal farmers prefer using imported dairy breeds for milk production (Ngongoni *et al*., 2006; Muchenje *et al*., 2007). Given the high capital investments required to maintain large-framed dairy breeds such as Friesian, most communal farmers cannot afford maintaining them sustainably (Ngongoni *et al*., 2006). The University of Fort Hare and the Department of Agriculture in the Eastern Cape are in the process of reintroducing Nguni cattle into communal areas. As beef-type animals, these cattle are well known for low milk yield (Mapiye *et al*., 2007) although they are milked in the communal production systems. Recent researches on Nguni cattle have been focused on disease and parasites resistance (Marufu *et al*., 2009), reproductive performance (Nqeno *et al*., 2009) and beef production (Muchenje *et al*., 2008; Mapiye *et al*., 2009). Milk production and utilisation patterns in the communal areas are, however, not well understood (Mapekula *et al*., 2009). Understanding milk production and utilisation patterns in communal areas assists in designing sustainable programmes to reduce poverty and improve food security in communal areas. Falvey and Chantalakhana (2001) encouraged the production of milk by communal farmers because of the importance of milk. Different communal areas have access to different infrastructures, facilities and services, which might influence the milk utilisation patterns (Mutukumira, 1995; Mutukumira *et al.*, 1996). It is likely that milk utilisation patterns depend on the amounts of milk produced, production system, household sizes, cattle herd size, vegetation types, proximity to markets and cultural beliefs. The objective of the current study was to determine the milk utilisation patterns in different smallholder farming systems in the Eastern Cape Province of South Africa. The hypothesis tested was that milk production and utilisation patterns do not vary with production system.

6.2. Materials and Methods

6.2.1 Description of study sites

The study was conducted around Alice, Fort Beaufort and Queenstown areas in the Eastern Cape, South Africa. These communities were selected based on their differences in facilities and production system. In Alice, there is a newly introduced large-scale pasture-based dairy system, where neighbouring communal farmers have access to information on feeding management, milking technologies and appropriate cow management practices. Communities in Fort Beaufort are surrounded by many large-scale citrus farms where the bulk of the communal farmers get part-time farm employment, particularly during harvesting of oranges. Communities in Queenstown are beneficiaries of the land reform programme, where the farmers are allocated fairly large pieces of farmland to utilise as co-operatives. The cattle in these communities are kept communally. These communities were selected on the basis of willingness to participate in the research exercise, with assistance from the local extension officers from the Department of Agriculture. Selection of farmers was based on cattle ownership and willingness of farmers to participate. Only households with at least one cow were used in the study. In Alice, data were collected from Childara, Ngcamgeni and Debe Nek communities, whilst in Balfour, Seymour, Rwantsana, Katberg and Hillview Farm communities participated from around the Fort Beaufort area. Hertzog and Water-Hot communities represented the emerging commercial farms in Queenstown.

In general, all the communities are located in the sweetveld. All the communities receive rainfall during summer. The average winter temperatures are between 10-19^{0}C and the average summer temperatures are between 18 and 32^{0}C. Cattle in all the communities entirely relied on rangelands. In all the communities, continuous grazing systems were practised (Trollope *et al.*, 1989).

6.2.2 Data collection

Data were collected from a total of 130 households using milk recording sheets. The data were collected in early lactation (January) and late lactation (June). The questions were written in English and translated into Xhosa vernacular by trained enumerators. The recording sheet captured information on farmers' socio-economic profile, breed of cow, milk production and utilisation patterns per household and milk prices. The households were categorised into two; small (less than six members) and large (six members or more) (See Appendix 5).

6.2.3 Statistical analyses

Data were analysed using GLM procedures of SAS (2003). The model used was:

$Y_{ijklm} = \mu + B_i + C_j + D_k + F_l + E_{ijklm}$,

Where:

Y_{ijklm} = total milk yield, fresh and sour milk for sale or consumption;

μ = constant mean common to all observations;

B_i = effect of districts,

C_j= effect of stage of lactation,

D_k = effect of gender of head of household (male, female)

F_l = effect of household size (large, small)

E_{ijk} = residual error assumed to be normally and independently distributed with mean 0 and variance equal to δ^2.

Chi-square (PROC FREQ procedure) tests were used to determine the association between gender roles in milking and district. Tests for association were also performed for milk uses in different regions. Pearson's correlation coefficients were computed among milk yield, milk consumption, sales and prices.

6.3. Results

6.3.1 Milk production and gender participation

Region/district significantly affected both the total number of lactating cows and total milk yield ($P<0.05$). Farmers in Fort Beaufort had the highest milk yield and number of lactating cows while Alice had the lowest (Table 6.1). There was greater milk yield by cows in early lactatation than in late lactation in all the three districts. Non-descript crossbred cows were the dominant breeds kept and few Nguni cows were also used for milk production, particularly in Alice. The Department of Agriculture reported that the crossbred cows were largely crosses of Jersey and Brahman bulls with local Nguni cows. Gender and household size had no effect on total milk yield.

Table 6.1: Effects of location/district on milk yield and milk disposed patterns at different stages of lactation

Parameter	District		
	Fort Beaufort	Queenstown	Alice
		Early lactation	
Herd size	3.8 ± 1.21[c]	2.6 ± 1.34[a]	2.3 ± 1.88[a]
Number of lactating cows	2.1 ± 0.23[c]	1.6 ± 0.17[b]	0.8 ± 0.14[a]
Total milk yield/household/day	20.9 ± 10.74[c]	12.7 ± 7.56[b]	8.6 ± 4.54[a]
Fresh milk sales/day (litres)	7.7 ± 3.59[b]	9.7 ± 5.57[c]	3.0 ± 0.01[a]
Sour milk sales/day (litres)	10.2 ± 1.37[b]	2.6 ± 0.99[c]	3.6 ± 0.72[a]
Milk consumed/day (litres)	3.0 ± 1.12	0.4 ± 0.39	2.0 ± 0.45
		Late lactation	
Herd size	3.8 ± 1.21[c]	2.6 ± 1.34[a]	2.3 ± 1.88[a]
Number of lactating cows	0.1 ± 0.15[c]	0.0 ± 0.17[b]	0.1 ± 0.14[a]
Total milk yield/household/day	1.2 ± 1.74[c]	0.7 ± 7.56[b]	0.1 ± 4.54[a]
Milk consumed/day (litres)	1.2 ± 1.00	0.2 ± 0.99	0.1 ± 0.02

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

The bulk of the cows were dry by June; with the farmers reporting that days in milk last for between 100 and 120 days. There was an association between district and the gender of the person who performs over 90% of the milking duties ($P<0.05$). Male youths were the most dominant milking persons in all the communities, followed by adult males (Table 6.2). In Alice, more male youths were involved in milking than in the other two regions. Adult females were not active in milking cows, although there was significantly higher adult female involvement in Queenstown. In Alice there were no female youths who were involved in milking cows (Table 6.2). There was no significant association between gender and involvement in milking across stages of lactation.

6.3.2 Milk consumption patterns

As shown in Table 6.1, milk consumption per household was similar among the three districts ($P>0.05$). There was, however, double the amount of milk consumed in early than in late lactation. There were no significant associations in the ways in which fresh milk was utilised in communal areas ($P<0.05$). In all the three regions, fresh milk was used in tea and/coffee or to make porridge for human consumption (Table 6.3). There was a significant difference in the proportion of households using fresh milk to feed pets; with Fort Beaufort having the fewest households. About 12.5% of the households in Alice fed piglets on fresh cow milk. In Alice, about 4% of the households gave fresh milk to their neighbours. There was no milk provided to piglets and neighbours in Queenstown (Table 6.3). Table 6.3 also shows the utilisation of sour or naturally fermented milk in Alice, Fort Beaufort and Queenstown. Sour milk was prepared by souring fresh milk in conventional milk churns at ambient temperatures for periods of between 24 and 48 hours. The curd was then carefully scooped out using a perforated metallic plate, leaving the whey in the churn.

Table 6.2: Participation of different genders in the milking of cows (%)

Gender	Alice	Fort Beaufort	Queenstown	Significance
Adult males	30.1	45.6	28.6	*
Male youths	61.6	48.4	52.3	*
Female youths	0.0	4.7	10.3	**
Adult females	0.1	3.4	4.8	*

* Significant different between regions at P<0.05

** Significant different between regions at P<0.01

Table 6.3: Uses of fresh and sour milk in the smallholder areas of Alice, Fort Beaufort and Queenstown in early lactation

Product	**Alice**	**Fort Beaufort**	**Queenstown**
		Fresh milk (%)	
Tea and/coffee	100.0	100.0	100.0
Porridge	48.8	77.1	75.6
Pets (cats and dogs)	11.2	2.3	9.2
Piglets	12.5	0.1	0.0
Neighbours	3.8	1.2	0.0
		Sour milk (%)	
Preparing *umpokoqo*[a]	86.1	85.3	80.1
Pets (cats and dogs)	2.0	3.2	3.7
Piglets	15.2	14.2	12.1
Bread	10.5	12.4	15.1

[a] Mixture of sour milk and stiff porridge.

About 86, 85 and 80% of the households in Alice, Fort Beaufort and Queenstown, respectively mixed sour milk with “pap” a boiled semi-solid maize meal product to produce “*umpokoqo”*, one of the staple foods for the Xhosa people. A small proportion of households mixed sour milk with bread to develop a mixture of food traditionally referred to as “*umvubo wesonka”* (P<0.05). In some few cases in Alice and Queenstown, sour milk was also mixed with rice. In late lactation, all the small amounts of milk produced were used for human consumption, and was utilised as fresh milk. Both household size and gender of head of household had no effect on milk consumption. Where milk was limited in quantity, priority was given to children.

6.3.3 Milk sales and prices

Larger size households were selling more sour milk than smaller households. Region had significant effect on sour milk sales and prices (P<0.05). Fort Beaufort had the highest sour milk sales compared to other regions (Figure 6.1). Region had significant effect on quantity of fresh milk sold (P<0.05), with Queenstown having the highest fresh milk sales. No milk sales occurred during the late lactation in all the communities. All the milk was sold locally to neighbours or other community members.

Household size and gender had no effect on fresh milk sales (P>0.05). Households with large families, however, had higher sour milk sales than small households (P<0.05; Table 6.4). Male-headed households also had higher sour milk sales than female-headed ones. Table 6.5 shows that adult females were largely involved in selling milk. No youths were involved in the sale of either fresh or sour milk in all the districts. In Alice, an equal proportion of males and females sold the milk, while in Fort Beaufort and Queenstown, females were

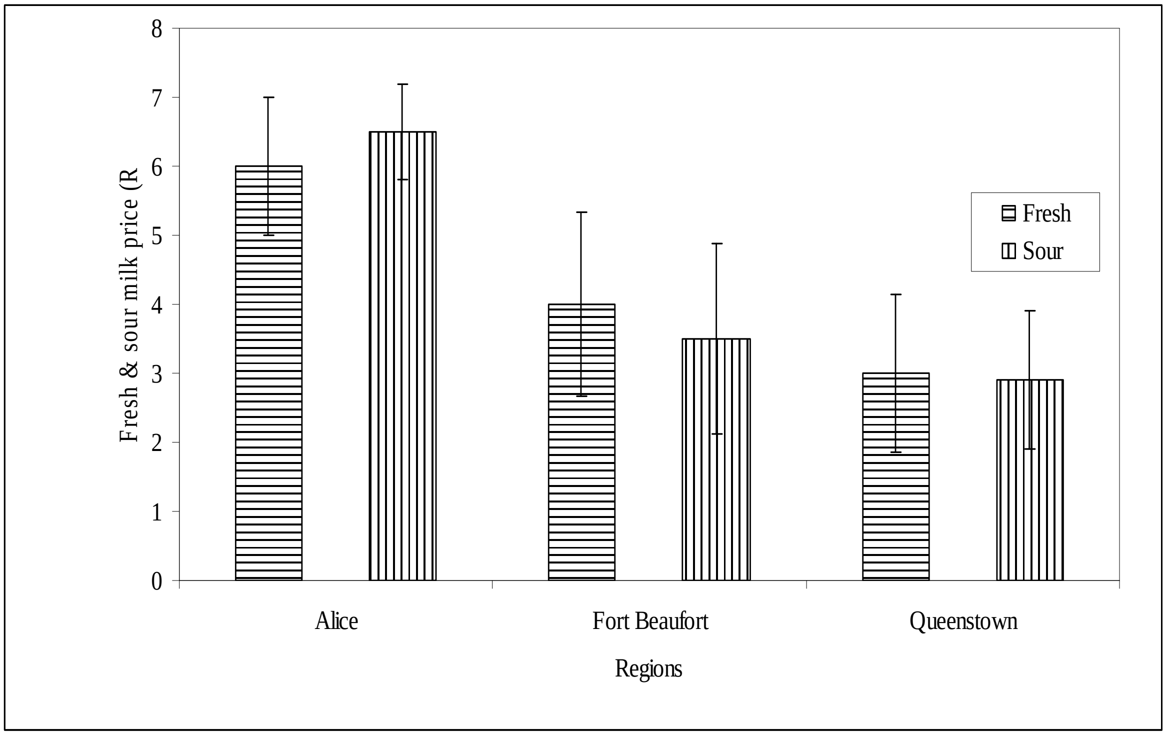

Figure 6.1: Prices of fresh and sour milk in Alice, Fort Beaufort and Queenstown regions

Table 6.4: Least square means for sour and fresh milk sold/day (litres) according to the household size and gender

Parameter	Household size		Gender of head of household	
	Large	Small	Female	Male
Sour milk sales	5.8 ± 5.15^{a}	2.0 ± 2.83^{b}	5.4 ± 6.87	5.7 ± 5.34
Fresh milk sales	5.0 ± 4.47	6.0 ± 0.01	3.6 ± 3.20	5.7 ± 4.74

^{a,b} Values with different superscripts with a row are significant different ($P<0.05$).

Table 6.5: Family members who sold milk (%)

Region	Adult female	Adult male	Significance
Alice	50.0	50.0	NS
Fort Beaufort	85.7	14.3	**
Queenstown	92.9	7.1	***

NS: Non significant (P>0.05)

** P<0.01

*** P<0.001

predominantly involved in the selling of milk ($P<0.05$). Region had significant effect on the prices of both fresh and sour milk ($P<0.05$).

The average price of fresh milk was highest in Alice and lowest in Queenstown (Figure 6.1). Although the price of fresh milk was not statistically different within each region, sour milk tended to be higher than fresh milk in Alice. Generally, milk prices were twice as expensive in Alice as the other two regions. Based on total milk yield and prices, each household earned an average of R 62, 48, R53, 00 and R44, 00 from both fresh and sour milk per day in Fort Beaufort, Queenstown and Alice, respectively.

6.3.4 Correlation coefficients among total yield, consumption, sales and prices of milk in the three districts in the Eastern Cape during early lactation

In Alice, total milk yield was positively correlated with consumption ($P<0.01$) and sales ($P<0.05$; Table 6.6). Milk consumption in Alice and Queenstown was negatively correlated ($P<0.05$) with sales (Table 6.6). There was a positive correlation between yield and sales in Fort Beaufort. Milk prices in Fort Beaufort and Queenstown were positively correlated with consumption and sales (Table 6.6).

6.3.5 Reasons for selling milk

Table 6.7 shows the reasons for selling milk by the respondents. The majority of the households in Queenstown (85 %) indicated that the income from milk was largely for the purchase of household food items. The proportion was significantly higher than for Alice and Fort Beaufort ($P<0.05$). The other purposes for dairying were to pay for school fees and medical bills, as well as to purchase veterinary drugs. The households that did not sell milk reported that the milk was inadequate even for household consumption, while about 15% in

Table 6.6: Pearson's correlation coefficients among total milk yield, consumption, sales and prices in three Districts in the early lactation

	Alice		
	Consumption	Sales	Prices
Total yield	0.63**	0.45*	0.15
Consumption		-0.28*	0.34*
Sales			0.16
	Fort Beaufort		
Total yield	0.26*	0.53*	0.25
Consumption		-0.12	0.26*
Sales			0.36*
	Queenstown		
Total yield	0.35*	0.56**	0.53*
Consumption		-0.25*	0.17
Sales			0.64**

* P<0.05. ** P<0.01

Table 6.7: Reasons (in %) for selling and not selling milk

Reason	Districts		
	Alice	**Fort Beaufort**	**Queenstown**
	Reasons for milk sales		
Purchase household food items	31.8	41.0	84.6
School fees payment	12.9	20.2	7.7
Purchase veterinary drugs	17.5	31.0	7.7
Medical treatment	37.8	7.8	0.0
	Reasons for not selling milk		
Low amount of milk to sell	86.4	57.8	25.0
Cultural belief	4.6	16.6	0.0
Share milk with neighbours	9.1	15.6	15.0

Queenstown argued that they got more satisfaction from sharing the milk with neighbours rather than selling it.

6.3.6 Suggestions to increase milk yield

Table 6.8 indicates suggestions to increase milk yield in different regions as reported by farmers. Sixty percent of the farmers in Alice reported that they need more cows to increase milk yield. Feed availability, appropriate breeds, and technical assistance were some of the suggestions made by farmers in all the regions.

6.4. Discussion

The observation that milk yield in communal production systems was low compared to commercial yields agrees with literature (Mejai e*t al.*, 1998; Shackleton *et al*., 1999; Delali *et al*., 2006). Similarly, in South Africa Trial and Gregory (1981); Prinsloo and Keller (2002) reported low milk yields in communal areas of between 7.6 and 10.6 1itres per household**.** Similar findings about low milk yields have been reported in the communal areas of Zimbabwe, where milk yield was less than 10kg/day (Ngongoni *et al*., 2006; Muchenje *et al*., 2007; Chinogaramombe *et al*., 2008). The observed differences between regions on milk yield could be attributed to difference in lactating cow numbers, management, nutrtition and agro-ecological factors. Besides having the highest number of lactating cows, the higher average earnings received per day by farmers in Fort Beaufort might have motivated them to produce more milk than other districts. This is further supported by the positive correlations between milk yield and sales observed in Fort Beaufort.

The observations indicating more sour milk available for sales by large households was attributed to that large households kept more cattle, and had more lactating cows than small

Table 6.8: Suggestions to increase milk yield in different regions (%)

Suggestion	Alice	Fort Beaufort	Queenstown
Increase cow numbers	60.0	12.1	8.7
Provision of technical assistance	6.9	6.9	8.7
Provision of dairy breeds	10.0	3.7	28.7
Establishment of milk collection centre	0.0	30.0	13.0
Provision of feed supplements	20.0	12.3	26.1
Desire crossbred cows	0.0	30.0	8.5

households. The highest producing district which was Fort Beaufort had the lowest correlation with consumption. This was attributed to that these farmers were closer to the city and tended to consider dairy farming as a business. The finding that milking was done mostly by men concurs with earlier reports (Bachmann, 1985; Mutukumira et al., 1996; Grobber et al., 2008), who reported that men are responsible for milking of cows, hiring of labourers and herding the cattle in communal production systems

The lower fresh milk sales observed in large households could indicate that most of the milk was sold as sour milk by household members. These results are supported by the negative correlations observed between milk consumption and milk sales. Since milk is a perishable good small-sized households sold excess milk to avoid wastage. The findings that milk in communal areas was utilised as fresh and sour and fresh milk was mainly used in tea/coffee or porridge and drunk fresh agrees with Mutukumira *et al.* (1996). The observation that sour milk was mainly consumed with a traditional semi-solid boiled maize meal agrees with earlier reports (Mupunga and Dube, 1993; Mutukumira *et al*., 1996). Similar to our findings, Grobber *et al.* (2008) reported that children were given preference to consume milk when it was in limited supply.

Farmers having higher milk yields were able to sell their milk either as fresh milk or as sour milk. These findings are supported by the observed correlations between milk yield and sales in all the three regions. The higher milk prices observed in Alice could be due to high demand triggered by low milk yields. The lower prices of fresh milk than sour milk were probably fixed to encourage consumers to buy fresh milk and that would help to empty their containers to allow milk space for the next milking session. Most farmers do not have transport or appropriate cooling facilities to preserve/store fresh milk, therefore they quickly dispose fresh milk at low prices to avoid contamination, wastage and milk is also a perishable product. The higher prices for sour milk could also be related to larger households that had more lactating cows. This attributed to more milk yield that becomes sour before consumed while still fresh and also due to lack of milk processing facilities. Chinogaramombe *et al*. (2008) reported that transport problem and lack of storage facilities in the smallholder areas are not conducive for highly perishable dairy products. Electrification and construction of milk storage facilities and roads, training farmers on processing and value-addition of milk could improve milk utilization and consequently rural livelihoods.

The finding that some community members, especially in Queenstown preferred donating than selling milk to neighbours was unexpected. Although farmers did not give specific reasons for donating milk, it might have been done to strengthen relationships, for socio-political security or for fame. In an interview, these farmers indicated that they wanted to produce more milk and wished to have dairy breeds such as Jersey or dairy crossbreeds. However, these farmers mentioned that they wished to be capacitated with management of the dairy breeds and supplementary feeding (Israel and Pearson, 2000). Ngongoni *et al.* (2007) and Muchenje *et al.* (2007) reported that crossing dairy breeds such as Jersey with indigenous cows can improve milk yield in communal areas. The findings that farmers need to be trained in dairy cattle managemet agrees with Du Toit Moolman and Burger (1992). Bebe *et al*. (2003); Beaulieu and Palmquist (1995) reported that animals need higher levels of proteins and energy feeds to produce more milk. Chikura (1994) reported that animal management was important to increase milk yield.

Some of these farmers were interested in increasing their cow numbers to develop their own smallholder dairy sector that would allow them to have milk throughout the year.

Unfortunately these farmers mentioned that, their animals lose body condition markedly during winter months. Pedersen and Madsen, 1998 reported that there are many constraints for milk production in communal areas. As a result milk production during and after winter drops and some cows stop producing milk. This is the main explanation for low milk consumption and absence of milk sales in the late lactation. Decline in milk production in winter, therefore, has negative impact on monthly food security and monetary earnings from the sale of milk and milk products in rural households. Holroyd *et al*., 2009 reported that the effects of pasture type and supplementary feeding on the milk yield proved to be helpful in Shorthorn and Brahman cross cows in the dry tropics. Steinfeld (1998); Israel and Pearson (2000) reported that there should be strategies to improve the effectiveness of supplementary feeding of cattle. Research on alternative supplementary feeds during winter is, therefore, imperative.

6.5. Conclusions

Milk that is intended for genetic expression of calf performance is also utilised by humans in communal production systems. Milk yield and quality produced by the communal cows is unknown. Most farmers either consumed milk or sold it as fresh or sour. Improvement of milk utilisation in the communal areas should, therefore, be accompanied by use of appropriate breeds and supplementary feeds, development of milk preservation facilities and transport network, training of farmers on dairy production, and milk processing and value-addition. Milk produced by communal cows is low and this needs to be improved. Milk utilisation patterns by communal people were identified and it is utilised in different ways.

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CHAPTER 7: Fatty acid, amino acid and mineral composition of milk from Nguni and local crossbred cows under low-input production systems in South Africa

(Submitted to Journal of Food Composition and Analysis)

Abstract

The study was designed to determine the fatty acid, amino acid and mineral composition of milk from Nguni and crossbred cows in the communal areas of the Eastern Cape Province of South Africa. Milk samples from eight Nguni and eight crossbred cows were collected monthly from January to June 2009. Nguni cows had higher ($P<0.05$) levels of amino acids than crossbred cows. Nguni had 0.15 and crossbreds had 0.09 (g/100ml) arginine levels in early lactation. Arginine levels decreased ($P<0.05$) as the lactation stage progressed in the Nguni cows. Crossbred cows had higher ($P<0.01$) levels of C18n1n9t in early lactation, which gradually decreased in mid lactation and were lowest in late lactation. There was an interaction between the stage of lactation and genotype on C18n1n9t, C18n1nC, C18n2n6C and C20n5n3 levels. Nguni milk had higher ($P<0.05$) levels of C18n1nC, calcium and magnesium, particularly during early and mid lactation. Phosphorus levels were higher ($P<0.05$) in early lactation and gradually decreased as the lactation stage progressed. In both genotypes, iron levels were lower ($P<0.05$) during early lactation stage and increased as lactation progressed. It can, therefore, be concluded that Nguni milk is richer in terms of fatty acids, amino acids and minerals and should be incorporated in dairy production to improve milk quality.

Key words: Cow genotype, poly-unsaturated fatty acids, essential amino acids lactation stage, rangelands.

7.1 Introduction

Nguni cattle, which are adapted to the harsh environmental conditions experienced in communal production systems of Southern Africa, have been considered inferior to exotic breeds in terms of both beef and milk production (Hofmeyr, 1994; Bester *et al*., 2003). Recently, there is evidence that Nguni are less susceptible to ticks (Muchenje *et al*., 2008) and tick-borne diseases (Marufu *et al*., 2009); nematodes (Xhomfulana *et al*., 2009), are better able to utilize rangeland resources (du Pleissis and Hoffman, 2004; Muchenje *et al*., 2008; Mapiye *et al*., 2009a) and produce high quality meat that outcompetes meat from established beef breeds (Muchenje *et al*., 2008). There are now efforts to replace the dominant non-descript crossbred cattle (largely crosses between exotic breeds with local cows) in communal areas with the adaptable Nguni breed (Mapiye *et al*., 2007; Mapiye *et al*., 2009b). Most efforts on cattle production are biased towards beef production and milk production is neglected or sidelined. Understanding milk production potential of these breeds is essential. Despite milk yield and quality being important to satisfy the nutrient requirements of both the calf and household members, the milk production potential of Nguni cattle has, however, received little, if any, attention.

The majority of existing cattle in communal areas of Eastern Cape of South Africa are crossbreds produced from crossing Nguni cows with imported breeds. Some of the breeds that were used in this indiscriminate crossbreeding are largely beef breeds, such as Angus, Bonsmara and Brahman, and, to a lesser extent, dairy breeds. They are, thus regarded as non-descript cattle or local crossbreds. Nguni is a pure indigenous beef breed that produces low milk yields (Bester *et al.,* 2003). The crossbred cows generally have larger frame sizes than Nguni cows (Mapiye *et al*., 2009a). The potential of the Nguni in commercial milk production is low. They, however, get milked in the low input mixed farming systems.

Besides determining the levels of total solids, proteins, fats and lactose in milk, the accurate value of milk to calves and humans require information on fatty acids, amino acids and minerals. To promote human health, it is essential to evaluate the levels of poly-unsaturated fatty acids (PUFA), and omega 3 fatty acids (Soyeurt *et al*., 2006). For calf growth, understanding the levels of amino acids, particularly the essential amino acids, is crucial so as to better formulate calf rations that maximize the growth of Nguni calves. Calves, like monogastric animals, require essential amino acids (McDonald *et al*., 2002). Davis *et al*. (1994) reported an increase in EAA levels after calving in Charolais cows. Information on the post-partum variations in milk amino acid levels in Nguni and non-descript crossbred cattle needs to be determined so as to accurately compare the value of their milk as a food for calves and humans.

Although milk is generally considered highly nutritious, it is crucial to determine the levels of fatty acids, especially when the milk is to be used for preparing food for infants. Pešek *et al*. (2005) reported that significant differences exist between breeds on saturated fatty acids (SFA) levels, such as C16:0, C18:0. In a separate study, Soyeurt and Gengler (2008) reported that Normande and Montbeliarde cattle breeds produced milk with higher C18:0 content, although the fat content was similar. Information on the levels of these fatty acids in Nguni and crossbred cattle is not available.

In most communal areas of Southern Africa, the soils and vegetation are deficient of minerals, particularly phosphorus. The values of these minerals in milk are, therefore, essential to ensure the proper formulation of feeds for calves and infants. Mineral requirements vary with seasons, stage of lactation, age and breed, among other factors. As such, the milk production potential of these breeds in communal production systems is largely unknown. Changes in the fatty acids, amino acids and mineral concentrations in milk from Nguni and crossbred cows are vital for feed and health management of calves and infants. Chapter 6, revealed that milk production and milk utilisation in communal areas was low because of various reasons that include cattle breeds, however although milk yield was low, milk quality is still unknown. The objective of this study was to determine the fatty acids, amino acid and mineral composition of milk from Nguni and crossbred cows. The hypothesis to be tested was that milk quality from Nguni and crossbreds cows is similar.

7.2 Materials and Methods

7.2.1 Study site

This study is fully described in section 4.2.1.

7.2.2 Experimental animals

Eight Nguni and eight crossbred cows, all in the second parity, were used in this study. All the cows grazed on rangeland and no supplementary feeding was provided. All the cows were kept in the same camp and were under the same management conditions. The cows were dipped once per month using Triatix and were vaccinated against anthrax and black quarter. The cows were dewormed using valbazen. All the cows used in this study had calved in December 2008.

7.2.3 Measurements

7.2.3.1 Determination of milk yield

The cows were hand-milked once per month in February, April and June 2009. The calves were separated from their dams at 1800h on the day prior to milk sample collection. Drinking water and shade were always available to calves. The cows were milked between 0700 and

0800h on the next morning. The cows were injected intramuscularly with phentocin and hand-milked immediately until all milk was withdrawn. The quantity of milk withdrawn from each cow was determinde using a graduated measuring cup. Milk samples were taken in February (early lactation), April (mid lactation) and June (late lactation) for amino acids, fatty acids and minerals analyses.

7.2.3.2 Determination of milk fat, protein and lactose levels

About 45 ml of milk were collected from each cow and placed in a plastic milk bottle containing Broad Spectrum Microtabs II® (D&F Control Systems Inc, Copenhagen, Denmark) a Bronopol-based milk preservative. The samples were analysed at the Agricultural Research Council Analytical Laboratory, Elsenburg for milk fat, milk protein, lactose and total solids, using CombiFoss™ (Copenhagen, Denmark) and MilkoScan™ (Copenhagen, Denmark). The samples were pre-heated at about 40ºC to evenly distribute fat globules in milk before analysis. The samples were thoroughly mixed to dissolve possible deposits of milk solids and a representative sample was withdrawn for analyses.

7.2.3.3 Determination of amino acid and fatty acid composition

Analyses for amino acids involved acid hydrolysis, pre-column derivitisation, and separation by high performance liquid chromatography (HPLC) and detection using a fluorescence detector as described by Einarsson *et al*. (1983). Lipids were extracted according to the method described by Einarsson *et al*. (1983). Preparation of fatty acids methyl esters (FAME) was done using the protocol described by Appelqvis (1968). The FAME analysis was carried out with a HP5890 series II gas chromatography (Hewlett Packard Co, Chicago, USA), fitted with a flame ionization detector and a capillary column DB-23 (Agilent Technologies, Chicago, USA) length 30 m. i.d. 0.25 mm, 0.25 µm film thickness. Column temperature was programmed at 2ºC/min from 40 to 220ºC. Injector and detector temperature were set at 250ºC. Identification of fatty acids was performed by comparing the obtained peaks with those of standard sample GLC-62 (Nu-Chek Prep, Copenhagen, Denmark). Peak areas were integrated using HIP ChemStation (Chicago, USA). The carrier gas was nitrogen. Saturated fatty (SFA), mono-unsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), CIS fatty acids (CISFA), omega 6 to omega 3 ratio and PUFA/MUFA ratios were computed.

7.2.3.4 Minerals

For the determination of calcium, magnesium, phosphorus, potassium and iron, 0.5 g of freeze-dried milk samples were digested with concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) at 200ºC using a Varian Liberty 200 machine. Concentrated nitric acid was added to a freeze-dried milk sample and heated (in an open glass digestion tube in heating block) to 120ºC (block temperature). After addition of 30% hydrogen peroxide (H_2O_2) and distilled water to the nitric acid the samples were digested for 20 minutes before cooling. All samples were digested in duplicate. An aliquot of the digest solution was used for the Inductively Coupled Plasma Optical Emission Spectrometric (ICP-OES) determination of these minerals. The wavelengths used for magnesium, calcium, phosphorus, potassium, sodium and iron were 383.826 nm, 422.673 nm and 317.933 nm, 213.618 nm and 769.896 nm, 589.592 nm and 259.940 nm, respectively. The instrument was set up and operated according to the recommended procedures (Zasoski and Burau, 1977; Chao-Yong and Schulte, 1985). Initially, one of the samples was analysed to determine the approximate level of all the elements, and this information was used to prepare a series of standard solutions to calibrate the instrument for accurate analysis of all the samples. These standards contained all the elements of interest in similar proportions to the samples. All four sample solutions (duplicate nitric acid only and duplicate perchloric + nitric acid digests) were analysed to obtain quadruplicate values for each sample for each element, and after rejection of possible outliers, the mean of the remaining values was calculated for each element per given sample.

7.2.4 Statistical analyses

Data were analysed using GLM procedures of SAS (2003). The model used was:

$Y_{ijk} = \mu + B_i + L_j + BL_{ij} + E_{ijk}$, where:

Y_{ijk}= response variable (milk yield, amino acid composition, fatty acid composition, mineral concentration)

μ = overall mean common to all observations;

B_i = effect of breed (i = Nguni, Crossbred);

L_j = effect of lactation stage (j = early, mid and late);

BL_{ij} = interaction between lactation stage and breed;

E_{ijk} = residual error assumed to be normally and independently distributed with mean 0 and variance equal to δ^2.

Least square means were separated using the PDIFF procedure (SAS, 2003).

7.3. Results

7.3.1 Milk yield

There were significant differences between genotypes on milk yield. Crossbred cows produced higher ($P<0.05$) milk yield than Nguni cows (Table 7.1). Lactation stage had a significant effect on milk yield, particularly in the crossbred cows. For Nguni cows, milk yield was similar throughout the lactation period.

Table 7.1: Least square means (± standard errors) of milk yield (litres/day) for Nguni and crossbred cows

	Milk yield (litres)	
Lactation stage	**Nguni**	**Crossbred**
Early	1.30 ± 0.369^{a}	3.35 ± 0.378^{b1}
Mid	1.76 ± 0.369^{a}	3.54 ± 0.378^{b1}
Late	1.28 ± 0.371^{a}	2.50 ± 0.417^{b2}

[ab] Values with different superscripts within row differ (P<0.05).

[1,2] Values with different superscripts within column differ (P<0.01).

Table 7.2: Least square means for milk protein, fat, lactose and total solids in Nguni and crossbred cows across stages of lactation

Component	Genotype	Stage of lactation			SE
		Early	**Mid**	**Late**	
Milk protein (%)	Nguni	3.32^{a}	3.96^{b}	4.58^{c}	0.296
	Crossbred	3.39^{a}	3.28^{a}	3.68^{a}	0.256
Milk fat (%)	Nguni	0.64^{a}	0.78^{a}	1.96^{b}	0.063
	Crossbred	3.15^{c}	3.43^{c}	3.73^{c}	0.055
Milk lactose (%)	Nguni	4.77^{c}	4.88^{c}	3.51^{a}	0.205
	Crossbred	4.48^{b}	4.87^{c}	4.87^{c}	0.176
Milk total solids (%)	Nguni	9.47^{a}	10.39^{a}	10.85^{a}	0.819
	Crossbreds	12.31^{b}	12.41^{b}	13.13^{b}	0.701

^{abc} Values with different superscript within column differ (P<0.05).

There was an interaction between lactation stage and genotype on milk yield. In crossbred cows, the cows had the highest ($P<0.05$) milk yield in the mid lactation and the lowest ($P<0.05$) in late lactation (Table 7.1). Overall, crossbred cows had higher ($P<0.05$) milk yield in all stages of lactation.

7.3.2 Milk protein, fat and lactose contents

There was an interaction between lactation stage and genotype on milk protein content. Milk protein content increased ($P<0.05$) with the lactation stage in Nguni cows (Table 7.2). Milk protein content in the crossbred cows was, however, similar throughout the lactation period. Nguni cows produced milk with highest protein levels in the late lactation period compared to crossbred cows in other lactation stages (Table 7.2). Significant interactions were observed between genotype and lactation stages on milk fat levels. Milk fat levels in Nguni cows were highest in late lactation stage. Milk fat levels were, however, consistently higher ($P<0.05$) in crossbred cows than Nguni, and did not vary with stage of lactation. Lactose levels were also affected ($P<0.05$) by breed, stage of lactation and the interaction between the two factors. In Nguni cows, lactose levels were lowest ($P<0.05$) in late lactation. Lactation stage had no ($P>0.05$) significant effects on total solids. Only the breed of cow influenced ($P<0.05$) total solids, with crossbred cows having more ($P<0.05$) total solids than Nguni cows (Table 7.2).

7.3.3 Amino acid composition

7.3.3.1 Essential amino acids

There was a significant interaction between stage of lactation and genotype on arginine levels. Milk from Nguni cows had higher ($P<0.05$) arginine levels in early and mid lactation periods compared to crossbred cows (Table 7.3).

Table 7.3: Least square means of essential amino acids in milk of Nguni and crossbred cows

Amino acid (g/100ml)	Genotype	Stage of lactation			SE
		Early	Mid	Late	
Arginine	Nguni	0.15^{b}	0.13^{b}	0.10^{a}	0.023
	Crossbred	0.09^{a}	0.10^{a}	0.10^{a}	0.025
Threonine	Nguni	0.15^{b}	0.17^{b}	0.21^{b}	0.011
	Crossbred	0.12^{a}	0.13^{a}	0.14^{a}	0.012
Methionine	Nguni	0.15^{b}	0.19^{b}	0.18^{b}	0.011
	Crossbred	0.05^{a}	0.05^{a}	0.06^{a}	0.011
Valine	Nguni	0.13^{a}	0.18^{b}	0.15^{ab}	0.013
	Crossbreds	0.13^{a}	0.14^{a}	0.14^{a}	0.014
Phenylalanine	Nguni	0.17^{b}	0.14^{ab}	0.13^{a}	0.015
	Crossbred	0.10^{a}	0.11^{a}	0.12^{a}	0.016
Isoleucine	Nguni	0.15^{b}	0.15^{b}	0.13^{a}	0.009
	Crossbred	0.12^{a}	0.12^{a}	0.12^{a}	0.009
Leucine	Nguni	0.22^{b}	0.23^{b}	0.19^{a}	0.016
	Crossbred	0.17^{a}	0.18^{a}	0.18^{a}	0.018
Histidine	Nguni	0.10^{b}	0.11^{b}	0.08^{a}	0.010
	Crossbred	0.07^{a}	0.07^{a}	0.07^{a}	0.012
Lysine	Nguni	0.20^{a}	0.22^{b}	0.26^{b}	0.009
	Crossbred	0.19^{a}	0.20^{a}	0.19^{a}	0.010

[ab] For each amino acid, values with different superscript differ (P<0.05).

Stage of lactation had no effect (P>0.05) on the levels of methionine and threonine. Milk from Nguni cows had, however, higher (P<0.05) levels of methionine and threonine than crossbred cows. Valine levels were highest in Nguni milk in mid lactation than in milk from crossbred cows. Phenylalanine, histidine, isoleucine and leucine levels in milk from Nguni cows were higher (P<0.05) in early and mid lactation periods compared to crossbreds (Table 7.3). There were, however, significant interactions between lactation stage and genotype for lysine levels. Nguni cows had higher (P<0.05) lysine levels in the mid and late lactation periods (Table 7.3).

7.3.3.2 Non-essential amino acids

Nguni cows had higher tyrosine, glycine and proline levels than crossbred cows (P<0.05; Table 7.4). In the early lactation stage, Nguni cows had higher (P<0.05) serine levels than crossbred cows, but in mid lactation crossbred cows had higher (P<0.05) serine levels than Nguni cows. Stage of lactation had a marked effect (P<0.05) on alanine levels in Nguni cows. Alanine levels were higher in milk of Nguni cows in the early to mid lactation periods compared to cross bred cows (or Crossbred cows had the lowest alanine levels in the early lactation compared to Nguni cows). Glutamic acid and Ho-Proline levels in Nguni and crossbred cows were similar throughout the lactation period.

7.3.4 Fatty acid composition

7.3.4.1 Saturated fatty acid composition

Table 7.5 shows the levels of saturated fatty acids in milk from Nguni and crossbred cows. Genotype had an effect on C12:0 fatty acids, with the Nguni cows having higher (P<0.05) levels than crossbred cows. There were no significant interactions between lactation stage and breed on C12:0 levels.

Table 7.4: Least square means for non-essential amino acids in milk of Nguni and crossbred cows

Amino acid (g/100ml)	Genotype	Stage of lactation			SE
		Early	**Mid**	**Late**	
Serine	Nguni	0.14[b]	0.12[a]	0.13[ab]	0.009
	Crossbred	0.11[a]	0.14[b]	0.13[ab]	0.009
Glutamic acid	Nguni	0.37	0.49	0.50	0.049
	Crossbred	0.40	0.41	0.41	0.041
Glycine	Nguni	0.06[b]	0.07[b]	0.07[b]	0.006
	Crossbred	0.04[a]	0.05[a]	0.05[a]	0.004
Alanine	Nguni	0.13[c]	0.20[c]	0.09[b]	0.011
	Crossbreds	0.06[a]	0.08[b]	0.08[b]	0.002
Tyrosine	Nguni	0.17[b]	0.15[b]	0.15[b]	0.019
	Crossbred	0.15[a]	0.09[a]	0.13[a]	0.021
Proline	Nguni	0.30[b]	0.28[b]	0.25[b]	0.032
	Crossbred	0.16[a]	0.21[a]	0.20[a]	0.035
Ho-Proline	Nguni	0.03	0.03	0.03	0.003
	Crossbred	0.01	0.01	0.03	0.003

[ab] Values with different superscripts for the same amino acid differ ($P<0.05$).

Table 7.5: Least square means of identified saturated fatty acids in milk of Nguni and crossbreds cows

Fatty acid (g/100ml)	Breed	Stage of lactation			SE
		Early	Mid	Late	
C8:0	Nguni	0.01	0.01	0.01	0.007
	Crossbred	0.01	0.02	0.01	0.007
C10:0	Nguni	0.06	0.03	0.02	0.019
	Crossbred	0.07	0.07	0.05	0.020
C12:0	Nguni	0.88^{c}	0.40^{b}	0.30^{b}	0.027
	Crossbred	0.11^{a}	0.85^{c}	0.78^{c}	0.027
C14:0	Nguni	0.31^{b}	0.16^{a}	0.11^{a}	0.121
	Crossbred	0.39^{b}	0.39^{b}	0.34^{b}	0.129
C15:0	Nguni	0.04	0.03	0.02	0.021
	Crossbred	0.06	0.07	0.06	0.023
C16:0	Nguni	0.89^{c}	0.55^{b}	0.18^{a}	0.358
	Crossbred	0.90^{c}	1.06^{c}	0.78^{b}	0.371
C17:0	Nguni	0.04	0.03	0.02	0.016
	Crossbred	0.04	0.06	0.04	0.017
C18:0	Nguni	0.35^{b}	0.29^{b}	0.15^{a}	0.169
	Crossbred	0.30^{b}	0.53^{c}	0.36^{b}	0.180
C20:0	Nguni	0.01	0.01	0.01	0.005
	Crossbred	0.01	0.02	0.01	0.005

^{abc} Values with different superscript for each fatty acid differ ($P<0.05$).

Milk from crossbred cows had higher (P<0.05) C14:0 levels than Nguni cows. There was no (P>0.05) interaction between lactation stage and breed on C14:0 levels. Nguni cows had lower (P<0.05) C16:0 and C18:0 fatty acids compared to crossbred cows. There was no effect of lactation stage and genotype on the other saturated fatty acids.

7.3.4.2 Unsaturated fatty acids

There was a significant interaction between the stage of lactation and genotype on the levels of C18n1n9t, C18n1nC, C18n2n6c and C20n5n3 (Table 7.6). Milk from crossbred cows had higher (P<0.05) levels of C18n1n9t in early lactation and decreased (P<0.05) as the stage of lactation progressed (P<0.05; Table 7.6). During early lactation, the levels of C18n1nC in Nguni milk were higher (P<0.05) than in late lactation (Table 7.6). In the mid and late lactation, crossbred cows had higher (P<0.05) C18n1nC levels than in early lactation (Table 7.6). Genotype had a significant effect on C18n1nC (P<0.05). Overall, milk from crossbred cows had higher (P<0.05) levels of C18n1nC than Nguni. The stage of lactation affected (P<0.05) C18n2n6C. In early lactation, the levels of C18n2n6C in Nguni and crossbred cows were higher (P<0.05) than in late stage of lactation (Table 7.6). Genotype had no effect on C18n2n6C. Nguni cows in early lactation had higher (P<0.05) levels of C20n5n3 than crossbred cows. Overall, there were no (P>0.05) differences between Nguni and crossbreds on C20n5n3 (Table 7.6). No (P>0.05) interactions existed between lactation stage and genotype on C20n5n3.

Table 7.6: Least square means for unsaturated fatty acids in milk from Nguni and crossbred cows

Fatty acid (g/100ml)	Breed	Stage of lactation			
		Early	Mid	Late	Standard error
C14nl	Nguni	0.02	001	0.02	0.008
	Crossbred	0.03	0.03	0.02	0.008
C15nl	Nguni	0.01	0.01	0.01	0.005
	Crossbred	0.01	0.02	0.02	0.006
C16nl	Nguni	0.04	0.03	0.02	0.030
	Crossbred	0.04	0.05	0.04	0.043
C17nl	Nguni	0.01	0.01	0.01	0.012
	Crossbred	0.10	0.02	0.02	0.014
		Monounsaturated fatty acids			
C18n1n9t	Nguni	0.02[a]	0.03[a]	0.01[a]	0.067
	Crossbred	0.16[c]	0.07[b]	0.02[a]	0.072
C18n1nc	Nguni	0.58[c]	0.50[b]	0.22[a]	0.228
	Crossbred	0.45[a]	0.79[c]	0.64[c]	0.242
C18n2n6c	Nguni	0.05[b]	0.03[a]	0.01[a]	0.014
	Crossbred	0.05[b]	0.04[b]	0.02[a]	0.015
		Trans fatty acids			
C18n3n3	Nguni	0.02	0.02	0.02	0.008
	Crossbred	0.02	0.02	0.02	0.008
C20n5n3	Nguni	0.03[b]	0.02[a]	0.02[a]	0.002
	Crossbred	0.02[a]	0.03[b]	0.02[a]	0.001

[abc] Values with different superscript for each fatty acid differ ($P<0.05$).

7.3.4.3 Fatty acid ratios

Lactation stage and genotype affected (P<0.05) saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA), cis-fatty acids (CISFA) and omega 3 (n3) to omega 6 (n6) ratio but not for polyunsaturated fatty acids (PUFA). Lactation stage had significant (P<0.05) effect on ratio of PUFA/MUFA. In early and late lactation, the PUFA/MUFA ratios in Nguni cows were higher (P<0.05) than in mid lactation (Table 7.7). In crossbred cows, there were no (P>0.05) differences in PUFA/MUFA ratios across the three stages of lactation. There were higher (P<0.05) levels of n3:n6 fatty acids ratio in Nguni cows than in crossbred cows across all stages of lactation, as shown in Table 7.7.

Genotype and lactation stage interaction for PUFA: SFA ratio was significant. Nguni cows had higher (p<0.05) levels of PUFA/SFA ratios in the early and mid lacation than crossbred cows. Nguni cows had higher (P<0.05) EPA levels in early lactation than crossbred cows (Table 7.7). In late lactation, the EPA was lower (P<0.05) in Nguni than in crossbreds.

7.3.5 Milk minerals

There was a significant interaction between genotype and stage of lactation on the levels of calcium in milk. In early and mid lactation, Nguni milk had higher (P<0.05) calcium levels than crossbred milk (Table 7.8). Magnesium levels were higher (P<0.05) in Nguni cows in the mid and late lactation compared to crossbred cows, (Table 7.8). Phosphorus levels were highest in milk from Nguni cows in the early lactation phase. Stage of lactation had no (P>0.05) effect on potassium levels (P>0.05). Crossbreds had higher (P<0.05) potassium levels than Nguni throughout the lactation period (Table 7.8).

Table 7.7: Fatty acid categories and ratios in milk of Nguni and crossbred cows

Fatty acid (g/100ml)	Genotype	Stage of lactation			
		Early	Mid	Late	SE
SFA	Nguni	1.85^{b}	1.17^{b}	0.72^{a}	0.649
	Crossbred	2.04^{b}	2.36^{c}	1.94^{b}	0.757
MUFA	Nguni	0.69^{a}	0.61^{a}	0.26^{a}	0.282
	Crossbred	0.71^{b}	0.95^{b}	0.77^{b}	0.268
PUFA	Nguni	0.09	0.08	0.03	0.028
	Crossbred	0.09	0.11	0.08	0.031
CISFA	Nguni	0.63^{b}	0.56^{b}	0.24^{a}	0.245
	Crossbred	0.64^{a}	0.83^{c}	0.68^{b}	0.243
Omega 3	Nguni	0.02	0.03	0.01	0.008
	Crossbred	0.02	0.03	0.02	0.008
Omega 6	Nguni	0.02	0.05	0.07	0.023
	Crossbred	0.07	0.08	0.07	0.024
Omega 9	Nguni	0.59^{b}	0.54^{b}	0.23^{a}	0.212
	Crossbred	0.60^{a}	0.80^{b}	0.65^{b}	0.230
PUFA/MUFA	Nguni	0.13^{b}	0.11^{a}	0.13^{b}	0.007
	Crossbred	0.11^{a}	0.11^{a}	0.11^{a}	0.008
PUFA/SFA	Nguni	0.049^{b}	0.068^{b}	0.042^{a}	0.004
	Crossbred	0.044^{a}	0.047^{a}	0.041^{a}	0.003
N6:n3	Nguni	0.35^{b}	0.46^{c}	0.45^{c}	0.019
	Crossbred	0.33^{a}	0.32^{b}	0.25^{a}	0.020
EPA	Nguni	0.03^{b}	0.02^{b}	0.01^{a}	0.001
	Crossbred	0.02^{a}	0.02^{b}	0.02^{b}	0.001

^{abc} Values with different superscript for a given fatty acid categories and ratio differ (P<0.05).

FA= Fatty acids, SFA= saturated fatty acids, MUFA= mono unsaturated fatty acids, PUFA= polyunsaturated fatty acids, CISFA= Cis-fatty acids (unsaturated fatty acids that have double bonds that are on the same side, PUFA/MUFA=polyunsaturated fatty acids: monounsaturated fatty acids, n3:n6= a ratio of omega to omega 6 fatty acids, EPA= Eicosapentenoic acid

Table 7.8: Least square means (± standard errors) of milk minerals in Nguni and crossbred cows

		Genotype	
Milk mineral (mg/100ml)	**Stage of lactation**	**Nguni**	**Crossbred**
Calcium	Early	119.02 ± 5.701^{b}	115.19 ± 6.176^{a}
	Mid	148.77 ± 5.701^{b}	126.88 ± 6.368^{a}
	Late	116.51 ± 5.701^{a}	107.95 ± 6.176^{a}
Phosphorus	Early	101.84 ± 6.559^{c}	95.06 ± 6.018^{b}
	Mid	86.79 ± 5.526^{a}	93.78 ± 6.270^{b}
	Late	82.81 ± 5.526^{a}	79.17 ± 6.018^{a}
Magnesium	Early	9.83 ± 0.795^{a}	9.86 ± 0.862^{a}
	Mid	12.97 ± 0.795^{b}	11.03 ± 0.888^{a}
	Late	14.04 ± 0.788^{b}	9.91 ± 0.862^{a}
Potassium	Early	130.06 ± 7.998^{a}	147.67 ± 8.664^{b}
	Mid	110.31 ± 7.998^{a}	156.87 ± 8.934^{b}
	Late	125.56 ± 7.998^{a}	135.92 ± 8.664^{b}
Iron	Early	6.89 ± 1.491^{a}	7.36 ± 1.618^{a}
	Mid	12.79 ± 1.493^{b}	9.52 ± 1.618^{a}
	Late	15.21 ± 1.493^{b}	11.79 ± 1.668^{b}

^{abc} Values with different superscript for a particular mineral are different ($P<0.05$).

Stage of lactation had significant effects on iron levels. In both genotypes, iron levels were lower ($P<0.05$) in early lactation stage and gradually increased ($P<0.05$) with lactation (Table 7.8). There were no ($P>0.05$) differences on iron levels between genotypes.

7.4. Discussion

The observed low milk yield in Nguni and crossbred cows in the communal production system concurs with literature (Ghazaleh *et al*., 2001; Dugmore, 2004; Mapiye *et al*., 2007; Muchenje *et al*., 2007). Although milk yield is low, and is inadequate to meet the various functions of milk in the communal areas, milk production is one of the major reasons for keeping cattle in rural areas (Ugarte, 1991; Jonsson *et al*., 1993; Smith, 1996; Mapiye *et al*., 2009b). These findings may indicate that there is a need to improve milk yield in both the Nguni and crossbred cows to adequately meet calf and human requirements. The amount of milk yield produced by a cow determines the amount of milk that would be available for calf and human consumption (Mapekula *et al*., 2009; Mapiye *et al*., 2009a).

The high levels of protein in milk produced by the Nguni cows indicate that these cows have the ability to convert feed to milk (Mikolayunas-Sandrock *et al*., 2009). This will ensure that calves get adequate nutrients they require from consuming the low amounts of milk that the Nguni cows produce. Milk protein content increases with an increase in protein content in the feed (Maree and Casey, 1993; McDonald *et al*., 2002), suggesting that milk protein in Nguni can potentially be increased by manipulating diets. Such appropriate feeds for use in communal production systems need to be developed.

The increase in milk fat from early lactation to weaning agrees with Harris and Bachman (2009), who observed that milk fat content is high at calving but falls drastically for 10 to 12 weeks. The potential milk fat content from an individual cow is determined genetically, as are protein and lactose (Gòmez-Cortes *et al.*, 2009; Harris and Bachman, 2009). The observed low fat content in milk from Nguni cows in the current study was unexpected and difficult to explain, and is likely to be genetic. Research should be focused on determining whether these low values could be easily influenced by nutrition. It is, therefore, pertinent to make further investigations from different locations. Whether the low values of fat are an advantage to the cow or the calf also requires further investigation. Certainly, low fat levels are advantageous for humans. The lactose content in Nguni and crossbred cows were similar to that of the well known dairy breeds (Harris and Bachman, 2009), despite that the Nguni and crossbred cows in this study were not given any supplementary feeds.

The findings in this study indicate that the Nguni and the crossbreed cows grazing in communal rangelands are able to provide the required amino acids to their calves and to humans. During the early lactation stage the amino acids were higher in milk and this was so because a calf at this stage feeds exclusively on milk hence, milk amino acids have to be higher in early lactation for the calf's growth and development (Harper and Yoshimura, 1993).

The observation that milk from Nguni cows had higher arginine levels compared with crossbred cows, which decreased as the stage of lactation progressed, agree with Buttery and D'Mello (1994). These authors reported that young animals have to get arginine because it is classified as a semi-essential or conditionally essential amino acid, depending on the developmental stage and health status of the individual. Initially calves depend on milk for arginine (Herper and Yoshimura, 1993). As the calves grow, their arginine requirement from milk decreases because this ca ne synthesised by rumen microbes. Arginine is extremely useful in enhancing the immune system in all animals and infants have to get arginine in their feed to meet their requirements (Buttery and D'Mello, 1994).

In both breeds, stage of lactation had no effect on the levels of methionine and threonine and this could indicate that the suppliyng feed was sufficient for the cows throughout lactation. The higher levels of methionine and threonine observed in Nguni milk might be an indication of adaptability to the environment. Methionine, lysine and threonine are the first limiting amino acid in most diets and so they are the representative of amino acids fed in nutrition (Buttery and D'Mello, 1994).

Phenylalanine, histidine, isoleucine and leucine levels in milk from Nguni cows significantly decreased from early to late lactation, but did not change for crossbred cows. A decrease in amino acid content of milk as the lactation stage progresses was attributed to the fact that as calves grow, they microbial populations increased to synthesis essential amino acids (McDonald *et al.*, 2002). Milk from Nguni cows had higher phenylalanine, histidine, isoleucine and leucine than that from crossbred. The increase in lysine content as the stage of lactation progressed could indicate the enhanced ability of Nguni cows to produce EAA for their calves.

Similar to results of this study, differences in fatty acid composition between Swedish dairy breeds have been documented ((Hemansen and Lund, 1990; Rege *et al.* (2004); Palmquist and Beaulieu, 1992; Lindmark-Mànsson, 2001; Näslund *et al.*, 2006) Results from this study could indicate that the Nguni has an ability to synthesise fatty acids from consumed feed materials available in the environment more than crossbreds. This is supported by Raats (2004) who reported that Nguni is adapted to low nutrient intake and it still manages to synthesise the desired fatty acids. Bovine fat contains certain fatty acids with odd number of carbons, such as pentadecanoic acid (15:0) and heptadecanoic acid (17:0) (Näslund *et al.*, 2006). These are synthesised by the bacterial flora in the rumen. The remaining 16:0 and the long-chain fatty acids originate from dietary lipids (Beaulieu and Palmquist, 1995; Lindmark-Mànsson, 2008) and lipolysis of adipose tissue (Lindmark-Mànsson, 2008). There are many factors associated with the variations in the amount and fatty acid composition of bovine milk lipids. They may be of animal origin such as related to genetics (breed and selection), stage of lactation, mastitis and ruminal fermentation, or they may be feed related factors, such as related to fibre and energy intake, dietary fats, seasonal and regional effects (Lindmark-Mànsson, 2008). Ye *et al.* (2009) reported that feeding feed reach in oil to animals reduced the proportion of both short-chain (C8:0 to C12:0) and medium-chain (C14: to C16:1) fatty acids and increased the proportion of long-chain (≥C18:0) fatty acids in milk. Cis-9, trans-11 conjugated linoleic acid (CLA) in milk fat increased if cows are fed feeds rich in linoleic acid such as soybean oil (SBO) and oil extruded soybeans (ESB).

Our current findings showed that saturated fatty acids percentage was dominating in the milk of both breeds of cows followed by polyunsaturated fatty acids. Similarly, Lindmark-Mànsson (2001), reported that the gross composition of milk fat in Swedish dairy milk was 69.4% saturated fatty acids and 30.6% unsaturated fatty acids. The milk of these cows was in line with the milk suitable for human consumption. A milk lipid composition favorable to human health would be about 30% SAT, 60 % MUFA and 10% PUFA (Hayes and Kosla, 1992; Soyeurt *et al*., 2006). The observed breed differences in unsaturated fatty acid content also agree with Soyeurt and Gengler (2008). The results indicating higher levels of n6:n3 ratio between 35-46% in Nguni; and 25-33% in crossbred showed that milk from both breeds is a health milk for humans and for calf rearing. This was also reported by Bauman *et al*. (1999); Simpoulos, 1999; Pariza *et al*. (2000).

The observation that PUFA/MUFA levels were higher during early lactation and late lactation stage agrees with Lindmark-Månson (2008). Findings of this study indicated an average of 4 and 6% levels of C10:0 for Nguni and crossbreds, respectively which were similar to those reported by Pešek *et al*. (2005). These authors reported that in Holstein cows the capric acid (C10:0) and stearic acid (C18:0) levels were 3.30 and 4.45% respectively, as compared to 2.69 and 2.61% for Czech Pied cows. Nguni cows had an average of 26% and crossbreds had an average of 40% levels of C18:0 which were higher than what was reported by Pešek *et al.* (2005). The milk fat of Czech Pied cows had higher content of oleic acid (C18:1) of 23.6% and Holstein had lower (C18:1) of 21.7%. These differences could be genetic.

Nguni cows had higher C18n1nC than crossbreds while the crossbreds had higher C18n1n9t than Nguni cows implies breed differences. Breed differences on C18n1nC had also been reported earlier (Gaunt, 1980; Grummer, 1991; Gibson, 1995; Baumgard *et al*., 2000). These findings suggest the ability of the Nguni and crossbred cows to convert consumed feed to desirable milk nutrients and adaptability to survive and produce in harsh communal environments.

Nguni cows had higher C12:0 levels than crossbred cows, while crossbreds had higher C14:0 than Nguni cows. These observations contradict those of Baumgard *et al*. (2000), who reported positive correlations between the fatty acids belonging to the same class of fatty acids, be it saturated, monounsaturated or polyunsaturated fatty acids.

Mineral nutrition is very important in human health. Diets rich in calcium or dairy products facilitated weight loss and fat loss in obese subjects and reduced weight and the regaining of fat in cows during re-feeding after dietary restriction (Gallego, *et al*., 2006). Dietary calcium has a slight but significantly beneficial effect on blood pressure. This was more pronounced if the calcium intake was based on milk products, which may be due to the high magnesium and potassium, and low sodium content (Scholz-Ahrens and Schrezenmeir, 2007). Milk minerals are also important for immune regulation. The previous report also stated that calcium and phosphorus percent, and total iron production has influence on calf growth. Humans can obtain calcium in the diet by various sources, but the most highly recommended source is dairy products. Dairy products are a source of calcium with high bioavailability (Gallego *et al*., 2006). Because of the essential role of iron and zinc in immune function, a more stable supply of those minerals might be important to the health of growing of the calves. These minerals are also important for immunity functions in humans. Potassium content of milk decreased across time, but that effect occurred primarily during the last few weeks of lactation (Gallego *et al*., 2006).

This study indicated that in early lactation and mid lactation most of the mineral levels were higher than in late lactation except for magnesium and iron. This was attributed to the fact that immediately after birth, the calf depends on cow’s milk for all its nutrient requirements. The findings that the concentrations of macro minerals, copper, iron and zinc were significantly higher during early than late lactation agrees with earlier reports (Gallego *et al*., 2006; Scholz-Ahrens and Schrezenmeir, 2007).

The observation that Nguni cows had higher minerals in their milk than crossbred cows is associated with the adaptability of the Nguni to the environment. It is highly probable that Nguni cows were be able to utilise consumed plant feeds better that the crossbreds (Muchenje *et al.*, 2008). Calcium, magnesium, iron and potassium levels in Nguni milk were higher than in crossbreds although crossbred had higher potassium than Nguni and that indicates the breed differences between communal cattle (Scholz-Ahrens and Schrezenmeir, 2007). The observation that Nguni cows had higher EPA levels in early lactation than crossbreds but the opposite was true in the lactation warrants further investigation. It is important to note that, from a calf nutrition perspective, the absolute amount of nutrients, not just the concentration, is important in situations where the calf consumes all the milk.

7.5 Conclusions

Our research findings in this chapter addressed the problems that were not addressed in chapter 6 showing milk yield produced by both Nguni and crossbred cows were low. However, milk quality was different between the two cattle breeds. Milk fat content in Nguni cows were lower than in crossbreds. Nguni cows had higher levels of essential amino acids than crossbreds throughout the study. Nguni cows also had higher levels of non-essential amino acids than crossbreds except for serine. Certain milk components in crossbred cows were higher ie SFA, MUFA and omega 9 fatty acids than in Nguni, while most of milk components in Nguni cows were higher than in crossbreds. Nguni is a cattle breed that is best suited for to communal production systems because it produces high quality milk, albeit in small amounts, under harsh communal environments. The cows have to be adapted to graze and digest poor quality forages. It can also be concluded that, although Nguni cows produce low milk yield, the Nguni cows produce higher quality milk. Nguni cattle are better able to cope with heat stress and require relatively less drinking water than crossbreds and other cattle breeds.

7.6. References

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CHAPTER 8: General discussion, conclusions and recommendations

8.1 General discussion

The study was designed to characterise milk production and calf performance in Nguni and crossbred calves raised on communal rangelands of South Africa. All the cattle were grazing on rangelands and were under the communal grazing systems and management. There was no supplementary feeding provided to these cattle. The main hypothesis tested was that milk production and calf performance of Nguni and crossbred (non-descript) cattle were the same.

In the first trial (Chapter 3), structured questionnares were administered to determine farmer perceptions on milk production and calf rearing. The farmers reported that milk yield, household milk consumptions and sales were low. Calf rearing practices were poor and milk yield, consumption and sales were generally low and varied with production system and rangeland type. The major constraints to calf rearing were the lack of appropriate housings for calves, poor nutrition and high prevalence of gastrointestinal parasites.

In Chapter 4, birth weight, average daily gain and weaning weight; and gastrointestinal parasite loads of Nguni and crossbred calves were compared. The hypothesis tested was that no differences existed between Nguni and crossbred calves on calf performance and gastrointestinal parasite loads. Calves were weighed for birth weight, monthly thereafter until weaning (six months). Faecal egg counts for gastrointestinal parasites were also quantified monthly. Crossbreds and Nguni calves had lower *Strongyles*, *Strongyloides* and total worm egg count loads at two months of age and below. However, these gastrointenal parasite egg loads increased as the age of calf increased. Nguni calves had higher *Strongyles* egg counts than crossbred calves in their first month of age, however, at the age of six months Nguni had lower egg loads than in crossbreds which indicate genotype differences (Wymann *et al.*, 2008). Nguni had lower *Strongyloides* egg loads than in crossbred calves throughout the experimental period. There was a constant increase in *Strongyloides* egg loads in both genotypes from one to three months in Nguni and from one to four months in crossbreds. *Coccidia* egg loads in crossbred calves were higher than in Nguni calves at one month old but at six month old Nguni had higher egg loads than crossbreds.

In Chapter 5, differences in blood total protein, globulin, albumin, ratio of globulin to albumin, glucose, cholesterol, non-esterified fatty acid and mineral concentrations between Nguni and crossbred calves were compared. The hypotheses tested were that blood metabolite concentrations in Nguni and crossbred calves grazing in the same environment did not differ significantly. Blood sample for metabolite concentrations were taken monthly over a six month period and analysed. Crossbreds had higher total protein at early age after birth than Nguni but at weaning Nguni had higher total protein than crossbreds. The ratio of albumin to globulin at five months old was higher in Nguni than in crossbred calves, but at weaning crossbreds had higher albumin to globulin ratios than Nguni calves. Nguni also had higher NEFA levels than crossbreds and this was indicating higher feed intake in Nguni calves than in crossbreds (Fox *et al.*, 2004).

In Chapter 6, milk utilisation patterns in communal areas were determined. The hypotheses to be tested were that, milk yield, milk consumptions were low and this was according to a report by Mutukumira (*et al.*, 1996) milk prices were different between the districts and milk utilisation patterns were different between regions. Milk recording sheets were administered to determine milk yields, milk prices and milk utilisation patterns. Fort Beaufort had the highest milk yield and number of lactating cows followed by Queenstown while Alice had the lowest. Farmers reported that days in milk last between 100 and 120 days. Male youths were the main persons responsible for milking in all communities, followed by adult males. Adult females were not actively involved in milking cows, but there were fewer females involved in cow milking in Queenstown and this was in agreement with a report by Carpenter (2000). In all the three regions, fresh milk was used in tea/coffee or to make porridge for human consumption and in certain districts fresh milk was also fed to pets and piglets. In Alice, some milk producing households gave fresh milk to their neighbours. Sour milk was utilised in the preparing of *umpokoqo*. Sour milk was also fed to pets and to piglets. District had a significant effect on milk price with Alice having highest milk prices. Sour milk prices were higher than fresh milk prices. Milk production in farmers that were selling milk was seen as a source of income for meeting the family needs according to report by (Mutukumira *et al*., 1996).

In Chapter 7, milk yield and milk quality of Nguni and crossbred cows were compared. The hypotheses tested were that, Nguni cows produce the same amount of milk as the crossbred cows and there were no differences in milk quality. Crossbred cows produced higher milk yield than Nguni. Milk yield in crossbreds was higher in mid lactation and lower in late lactation and this was attributed to differences between breeds (Fiss and Wilton, 1993). Nguni had higher milk quality than crossbreds. Nguni milk had higher arginine levels than crossbred in early and mid lactation periods and this was in agreement with a report by Ng-Kwai-Hang and Moxley (1988). Nguni milk had higher levels of valine than crossbred cows in mid lactation and Nguni milk generally had higher levels of methionine and threonine than crossbred cows milk. Phenylalanine, histidine, isoleucine and leucine levels in Nguni milk were higher in early and mid lactation periods than in crossbreds. Nguni milk also had higher tyrosine, glycine and proline levels compared to crossbred cows.

Nguni had higher levels of C12:0, C14:0, C16:0 and C18:0 fatty acids compared to crossbred cows. Crossbred milk had higher C18n1n9t and C18n1C levels than Nguni milk. Nguni cows had higher C20n5n3 than crossbred cows in early lactation. Nguni milk had higher PUFA/MUFA ratios than crossbreds in mid lactation period and also had higher n3:n6 fatty acids ratio throughout the lactation period. Crossbred milk had higher omega 9 fatty acid in mid and late lactation period compared to Nguni milk and also had higher CISFA than Nguni milk throughout the lactation period.

8.2 Conclusions

Calf rearing practices were poor in smallholder areas involved in this study. Milk yield, consumption and sales were low. Nguni calves were adapted to communal farming as indicated by higher birth weight, growth rate and weaning weight. Nguni calves were more susceptible to *Moniezia* species while crossbreds had higher *Strongyle*, *Strongyloides* and *Coccidia* egg loads. Energy, protein and mineral blood metabolites in animals that are totally dependant on rangelands as the only feed source need to be evaluated. Proteins, minerals and energy status of forage material that constitute feed of rangeland animals need to be evaluated. Most farmers in smallholder sectors in this study consumed milk or sold milk as fresh or sour. Alice had lowest number of lactating cows, milk yield and higher milk prices. Generaly, in all districts cow numbers were low and that contributed to the low milk yields and high milk prices. Milk yield in communal areas should be improved by using appropriate breeds, supplementary feeds and training of farmers on dairy production.

Nguni milk fat was lower compared to crossbred milk and Nguni milk had higher essential amino acid levels than crossbreds throughout the study. Crossbred cows had higher SFA, MUFA and omega 9 fatty acids, whereas Nguni cows had higher n3:n6 levels. PUFA/MUFA ratio was higher in Nguni cows than in crossbreds. Therefore, as a breed, Nguni cattle are better suitable for communal farming because of high quality milk production abilities under harsh communal environments.

8.3 Recommendations

Calf rearing practices in communal areas need to be improved. This could be achieved by capacitating farmers with calf rearing skills that would include nutritional requirements, welfare of calves such as provision of housing and monitoring of calf health. Milk production also needs to be improved because the milk produced in communal areas in certain households generates income to meet basic needs by providing facilities that support milk yield by communal farmers. Crosses of Nguni cows with dairy breeds can produce higher milk producing cows that would be adapted to harsh communal environmental conditions and this would increase milk yield. Nguni cattle are recommended to keeping by resourced communal farmers because of their ability to give birth without any dystocia cases, calves that have higher average daily gain, higher weaning weight and lower prevalence of gastrointestinal parasites. Nguni calves are able to extract required nutrients from available feed materials in the environment to satisfy their nutrient body requirements.

8.4 Further research

1. Methods of improving milk yield and milk quality in communal areas. Methods that would improve milk yield in communal areas will improve food security and creates wealth for the poor.
2. Comparison of birth weight, average daily gain, weaning weight and prevalence of gastrointestinal parasites in Nguni calves and imported breeds such as Bonsmara,

Hereford, Brahaman and Angus under communal rangelands grazing systems, which are established beef breeds.

3. Effect of supplementary feeding provision to Nguni and crossbred heifers from 3 weeks of age until puberty on milk yield and quality. This will help to understand the response of the Nguni and crossbreds to supplementary feeding on milk yield so that this can be practised if it is valuable to do so.
4. Comparison of blood, urine metabolite concentrations between Nguni and crossbred cows in the three lactation stages.
5. Faecal sample culturing for identification of other gastro-intestinal parasites in cattle kept under communal production systems.

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APPENDICES

Appendix 1: **Tropical Animal Health Production, 41:1475-1485 DOI 10.1007/sl 1250-009-9336-5**

Appendix 2: Survey questionnaire on milk production and calf rearing by smallholder farmers in the Eastern Cape Province

Qestionnaire number……… Enumerator name……………

Municipality name……….. Community name……………

Name of respondent……… Date…………………………

A. Household demographic information

1. Head of household

a. Sex: M F

b. Marital status: Married Single Divorced Widowed

c. Age <30 31-45 46-60 >60

d. Highest level of education: No formal education Grade1-7 Grade 8-12 Tertiary

2 What is your principal occupation?

3. What is your religion? Christianity Traditional Moslem Other (specify)

4. What is the size of your household? Adults: M….. F…..Children: M…….F………

5. How much land do you own (ha)?

6. How much land is arable (ha)?

7 How much land is used for grazing (ha)?

8. Is grazing communal? Yes No

9. What type of livestock species do you keep? (Rank 1 as the most important species)

Class	**Cattle**	**Goats**	**Sheep**	**Chickens**	**Other (specify)**

10. What are your sources of income? (Tick first column as appropriate and rank 1 as the most important source of income)

Source	**Amount raised**	**Rank**

B. Cattle herd composition and gender roles

1. What is the composition of your cattle herd?
   Calves (less than 7 months)….. Heifers….. Steers…. Cows….. Oxen….. Bulls…..
2. If you have lactating cows, how many are they?...
3. How did you acquire your cattle? Inherited? Given Bought Other (specify)….
4. Who is the owner of the cattle? Community Father Mother Children Other (specify)
5. Why do you keep cattle? (Tick one or more) (Rank 1 as the most common use)

Use	Rank	Use	Rank

6. What role (s) does each family member play in cattle production? (Tick one or more)

Role	**Adults**		**Children**		**Hired labour**
	Male	**Female**	**Boy**	**Girl**	

C. Cow productivity and calf rearing

1. At what age do your female animals reach puberty? <1yr 2yrs 3yrs 4yrs >5yrs
2. What is the average age at first calving for your cows? 1yr 2yrs 3yrs 4yrs >5yrs
3. If your heifers calve late, what are the reasons? (Rank 1 as the most important)

Reason	**Tick**	**Rank**
Nutrition		
Disease		
Inadequate		
Breed		
Other (specify)		

4. On average, what is the calving interval of your cows? 1yr 2yrs 3yrs 4yrs >5yrs
5. At what age do you cull your cows<5yrs 5-10yrs 10-15yrs >15yrs
6. On average how many calves does each cow produce in its life time? 1-3 4-6 7-9 >10
7. Do you experience abortion problems with your cows? Yes No
8. If yes, what are the causes? Nutrition Age Diseases Breed Other (Specify)
9. In which season do most of your cows calve down? Rainy season Winter Dry season
10. Do you observe your cows during calving? Yes No
11. If yes, how do you attend them?...
12. If no, after how long do you attend to your newly born calves? >24hrs 24-48hrs 8hrs
13. Which calving problems do your cows experience? Retained placenta Dystocia Metritis Mastitis Agalactia (no milk) Other (specify)
14. What do you do if your cow does not produce milk after calving?

……………………………………………………………………………………..

15. Are your calves born healthy? Yes No
16. If no, how do you attend them?

………………………………………………………………………………

17. What do you do to calves that have lost their mothers?............................
18. Do you know what colostrum is? Yes No
19. If yes, what is its importance?...

………………………………………………………………………………

20. How do you ensures that your calves get adequate colostrum?........................you

………………………………………………………………………………

21. If you milk your cows after calving, when do you start milking them? Do not milk <1wk   After 2wks After 4wks After 8wks Other (specify)……………………………
22. How many times do you milk your cows per day? Once Twice >Three times
23. How many times do you allow your calves to suckle per day? Do not suckle Once Twice Whole day Other (specify)…………………………………
24. If you allow your calves to suckle, at what time (s) do you release them to suckle? (Tick one or more) 0600-0900hrs   0900-12hrs 1200-1500hrs   >1500hrs
25. If the do not suckle, how do you feed them?....................................
26. What abnormalities do you normally experience in the newly born calves?...........
……………………………………………………………………………………..
27. How do you attend to the problems you have mentioned above?...........................
28. Do you experience early calf death problems? Yes   No
29. If yes, how do you attend to the problems you have mentioned above?.................
30. Which calf sex do you prefer? M   F
31. Give reasons for the preferred sex?..
……………………………………………………………………………………..
32. What is the average length of lactation period for your cows?
<6mo 6-12mo 12-18mo >18mo
33. At what age do you wean your calves? <3mo 3-6mo 6-9mo 9-12mo >12mo
34. What method do you use to wean your calves? Natural Separation Metal plate Other…..
35. What are the chances of calf survival to weaning stage? Low Moderate High Excellent
36. If you dehorn calves, which method do you use? Do not dehorn Hot iron Knife Other…….
37. If you do not dehorn, why?..
38. At what age do you dehorn your calves? <6mo 6-12 12-18 >18mo
39. What type of housing do you use for your calves? Kraal Stall Other
40. What Types of materials have been used for calf housing? (Tick one or more)
Untreated wood/bush   Treated wood   Fence   Iron sheets/asbestos   Other (specify)

D. MARKETING MANAGEMENT

1. On average how much milk does each cow produce per day?
2. If you consume milk, how much do you consume per day? Fresh…..Sour……Other
3. If you sell milk, how much do you sell per day? Fresh….Sour….Other
4. How do you price the milk? Fresh…………………..   Sour………….
5. How do you evaluate the quality of your milk? Color Water content Taste Other
6. What is the market for your milk? Neighbours Vendors Others (specify)……….

Appendix 3: Techniques for parasite assays and identification in faecal samples

Introduction

To diagnose gastro-intestinal parasites of ruminants, the parasites or their eggs/larvae must be recovered from the digestive tract of the animal or from faecal material. These are subsequently identified and quantified. This chapter presents diagnostic techniques within the reach of most laboratories to identify and quantify parasite infections from the examination of faecal material. The following are the main tasks involved in this process:

· Collection of faecal samples

· Separation of eggs/larvae from faecal material, and their concentration

· Microscopical examination of prepared specimens

· Preparation of faecal cultures

· Isolation and identification of larvae from cultures

Collection of faecal samples

Faecal samples for parasitological examination should be collected from the rectum of the animal. If rectal samples cannot be obtained, fresh faecal samples may be collected from the pasture. Several samples should be collected. Samples should be dispatched as soon as possible to a laboratory in suitable containers such as:

· screw cap bottles

· plastic containers with lids

· disposable plastic sleeves/gloves used for collecting the samples

· plastic bags

Each sample should be clearly labelled with animal identification, date and place of collection. Samples should be packed and dispatched in a cool box to avoid the eggs developing and hatching. If prolonged transport time to a laboratory is expected, the following may help to prevent the eggs developing and hatching.

(a) Filling the container to capacity or tightening the sleeve/glove as close to the faeces as possible. This is to exclude air from the container.

(b) Adding 3% formal in to the faeces (5-20 ml, depending on the volume of faeces). This is to preserve parasite eggs. (N.B Formalin-fixed faeces cannot be used for faecal cultures.) When samples are received in the laboratory they should immediately be stored in the refrigerator (4 °C) until they are processed. Samples can be kept in the refrigerator for up to *3* weeks without significant changes in the egg counts and the morphology of eggs.

Sedimentation technique (for trematode eggs)

Principle

The sedimentation technique is a qualitative method for detecting trematode eggs *(Paramphistomum)* in the faeces. Most trematode eggs are relatively large and heavy compared to nematode eggs. This technique concentrates them in sediments.

Application

This is a procedure to assess the presence of trematode infections. It is generally run only when such infections are suspected (from previous postmortem findings on other animals in the herd/flock area), and is not run routinely. The procedure can be used to detect liver fluke *(Fasciola)* and *Paramphistomum* eggs.

Equipment

· Beakers or plastic containers

· A tea strainer or cheesecloth

· Measuring cylinder

· Stirring device (fork, tongue blade)

· Test tubes

· Test tube rack

· Methylene blue

· Microslide, coverslips

· Balance or teaspoon

· Microscope

Procedure

(a) Weigh or measure approximately 3 g of faeces into Container 1.

(b) Pour 40-50 ml of tap water into Container 1.

(c) Mix (stir) thoroughly with a stirring device (fork, tongue blade).

(d) Filter the faecal suspension through a tea strainer or double-layer of cheesecloth into Container 2.

(e) Pour the filtered material into a test tube.

(f) Allow to sediment for 5 minutes.

(g) Remove (pipette, decant) the supernatant very carefully.

(h) Resuspend the sediment in 5 ml of water.

(i) Allow to sediment for 5 minutes.

(j) Discard (pipette, decant) the supernatant very carefully.

(k) Stain the sediment by adding one drop of methylene blue.

(l) Transfer the sediment to a microslide. Cover with a coverslip.

Appendix 4: McMaster counting technique (for nematodes)

Principle

The McMaster counting technique is a quantitative technique to determine the number of eggs present per gram of faeces (e.p.g.). A flotation fluid is used to separate eggs from faecal material in a counting chamber (McMaster) with two compartments. The technique described below will detect 50 or more e.p.g. of faeces.

Application

This technique can be used to provide a quantitative estimate of egg output for nematodes, cestodes and coccidia. Its use to quantify levels of infection is limited by the factors governing egg excretion.

Equipment

· Beakers or plastic containers

· Balance

· A tea strainer or cheesecloth

· Measuring cylinder

· Stirring device (fork, tongue depressor)

· Pasteur pipettes and (rubber) teats

· Flotation fluid (see the Appendix to this handbook for formulation)

· McMaster counting chamber*

· Microscope

Procedure

(a) Weigh 4 g of faeces and place into Container 1.

(b) Add 56 ml of flotation fluid.

(c) Mix (stir) the contents thoroughly with a stirring device (fork, tongue blade).

(d) Filter the faecal suspension through a tea strainer or a double-layer of cheesecloth into Container 2.

(e) While stirring the filtrate in Container 2, take a sub-sample with a Pasteur pipette.

(f) Fill both sides of the McMaster counting chamber with the sub-sample.

(g) Allow the counting chamber to stand for 5 minutes (this is important)

(h) Examine the sub-sample of the filtrate under a microscope at 10 x 10 magnification.

(i) Count all eggs and coccidia oocytes within the engraved area of both chambers.

(j) The number of eggs per gram of faeces can be calculated as follows: Add the egg counts of the two chambers together.

Multiply the total by 50. This gives the e.p.g. of faeces. (Example: 12 eggs seen in chamber 1 and 15 eggs seen in chamber 2 = (12 + 15) x 50 = 1350 e.p.g.)

(k) In the event that the McMaster is negative (no eggs seen), the filtrate in Container 2 can be used for the simple flotation method (section 3.2.2), steps f, g and h.

Appendix 5: Determination of blood metabolites

For the determination of total protein content, biuret reagent AE5-23 was allowed to complex with the peptide bonds of protein from the sample under alkaline condition to form a violet-coloured compound. Sodium potassium tartrate was used as an alkaline stabilizer, and potassium iodide was used to prevent autoreduction of the copper sulfate. The amount of the violet complex formed was proportional to the increase in absorbance when measured bichromatically at 544 nm/692 nm. For albumin, reagent AE5-2 was allowed to complex with the sample and the increase in absorbance which was measured bichromatically at 629 nm/692 nm, was proportional to the amount of albumin present in the sample.

The rate of increase in absorbance, monitored bichromatically at 408 nm/486 nm, was directly proportional to the alkaline phosphatase activity when the sample was allowed to react with reagent RX1002. For the determination of inorganic phosphate, reagent AE5-18 was allowed to react with the sample and at completion of the reaction, the absorbance of the sample reagent mixture was read bichromatically at 340 nm/378 nm. The difference between these two absorbance values was proportional to the amount of phosphorus present in the sample. For the determination of calcium, Arsenazo was used, whilst xylidyl blue in an alkaline medium was used for the determination of magnesium. The colour intensities were read off bichromatically and were proportional to the amount of the mineral present in the sample.

Glucose was analysed using the method described by Gochman and Schmitz (1972) where reagent NAE2-27 was used after enzymatic oxidation in the presence of glucose oxidase. The blood values were categorized into below, normal and above normal range considering the reference values as presented in Table 7.11-7.19 below.

Appendix 6: Milk utilisation recording sheet

Name of community…………………………………………………………………….

Name of Farmer...……………………………………………………………………...

Month…………………………………………………………………………………

							Milk consumption Quantity		Milk sales Quantity			
							Fresh	Sour	Fresh		Sour	
Cow ID	Breed	Weight	BCS	Calving date	Parity	Milk yield			Quantity	Price	Quantity	Price

Who does the milking? Adult female Adult-male Female-youths Male-youths Children (circle appropriate response)

Who consumed the milk? Adult female Adult-male Female-youths Male-youths Children (circle appropriate response)

What do you do with milk produced by your cows? Give to : Pig and dogs Neighbours Sell

If you give milk free to your neighbours what are the reasons

Who sold the milk? Adult female Adult-male Female-youths Male-youths Children (circle appropriate response)

Reasons for selling the milk?

Reason for not selling milk?

What assistance would u need if you want to produce more milk?

Any other comments