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**DISTRIBUTION, PHENOTYPE AND FACTORS
INFLUENCING THE PRODUCTION POTENTIAL OF NGUNI SHEEP**

by

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DECLARATION

I, **Peter A. Oosthuizen**, declare that:

1. The research work documented in this dissertation was done in Northern KwaZulu-Natal, at the Dundee Research station and Makhathini Research station under the supervision of Professor Mark Laing and Dr Erika van Zyl.
2. The research reported in this dissertation is my original work, except where otherwise indicated.
3. This dissertation has not been submitted for any degree or examination at any other University.
4. This dissertation does not contain other person's data, pictures, graphs or other information, unless acknowledged specifically as being sourced from other persons.
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PREFACE

The research work portrayed in this dissertation was done in Northern KwaZulu-Natal, at the Dundee Research station and Makhathini Research station under the supervision of Professor Mark Laing and Dr Erika van Zyl.

The studies denote original work done by the author and have not been submitted in any form for any degree or diploma to any university. Where other writer's work was used, appropriate acknowledgement was cited in the text.

DISSERTATION SUMMARY

The Nguni sheep of South Africa is an indigenous breed that is adapted to its environment. Migrating from Central Africa down the sweltering east coast of Africa down to Southern Africa, the sheep were exposed to different diseases. Survival of the fittest was synonymous with the breed, resulting in a breed harmonized with its environment. Nguni sheep that formed a part of this migration ended up as a remnant of the original sheep in KwaZulu-Natal.

The sheep have been in South Africa for hundreds of years and the breed is primarily recognized by its geographical environment and by the people keeping the sheep than by breed herd books and breed societies. Conservation of the breed is important, but the sheep has to perform competitively with other breeds of sheep, and empirical research is needed to identify its superior characteristics.

A survey was done in KwaZulu-Natal to locate Nguni sheep owners and to complete a questionnaire regarding their management and challenges. During the survey process, 52 farmers were found in four prominent agro-ecological zones in KZN, with a total of 1184 sheep. The largest flocks were found in the Ingwavuma zone with 347 animals among 11 owners. One of the primary management problems identified was the frequent death of lambs. Previous work with this breed suggests that this is often caused by gastro-intestinal nematode infection in young lambs. Reasons furnished for keeping the sheep was mostly for extra income and home consumption.

The perception exists that the Nguni sheep does not compete with industrial sheep breeds such as the Dorper in terms of mutton production and therefore crossbreeding with Dorper and Merino is being practiced to improve the carcass quality of offspring. As a result, the original breed is now endangered and decisive efforts will have to be made to protect the pure Nguni sheep genome.

Little is documented about the characteristics of the sheep, but many anecdotal concepts exist, defining what the phenotypic characteristics of the Nguni sheep should be. These characteristics were assessed by measuring traits such as heart girth, shoulder height, pelvis width, ear length and tail width. The measurements and observations were taken using the Nguni sheep flocks from the Dundee and Makhathini Research Stations. The Research Stations are situated in widely different

bioclimatic regions, and the management of the two flocks differs also (intensive versus extensive). However, the original flocks are related because the Dundee flock was obtained from Makhathini in 2009. In the intervening nine years, measurable differences between the two flocks have developed.

To investigate their performance when exposed to good and poor feed quality, the performance of Nguni sheep was examined under good (grazing maize) and poor (winter veld) nutritional circumstances. Merinos were used as a comparative breed. The Merino sheep were roughly double the size of the Nguni sheep. In this trial there was no significant difference ($P>0.05$) regarding lactating ewe performance within the nutritional treatments. There were also no significant differences ($P>0.05$) in the lamb growth within treatments between the breeds. Regarding ewe efficiency, the Nguni sheep ewes were more efficient over treatments than the Merino ewes. This data lead to the conclusion that the Nguni sheep has production comparable to that of the Merino. Under conditions of nutritional stress Nguni sheep tend to outperform Merino sheep.

The final trial was to determine the relative levels of resistance or susceptibility of Nguni and Merino weaner lambs to gastrointestinal nematode (GIN) infection. This trial was done using lambs that were weaned from the winter trial mentioned above. They were placed on either Kikuyu or veld pasture for the summer. Faecal egg count (FEC) was to measure the level of GIN infection on the two different forages (as it is postulated that the inoculum level of GINs will be higher on the dense, humid environment in the Kikuyu). FEC indicated a significant difference ($P<0.05$), between the breeds, but there was no significant difference ($P>0.05$) between the two forage treatments. However, the Nguni weaner lambs in poor body condition could withstand GIN infection better than the Merino weaner lambs.

An overall observation from the feeding trials was that if nutritional stress was removed, the Nguni sheep performed as well as an industrial sheep breed such as the Merino, although the mean Nguni live mass was approximately half that of the Merino weaners.

The challenge for the future of the Nguni breed is to make the breed commercially attractive, i.e., with larger forequarters and hindquarters, without diluting the genome and losing the positive traits of the pure Nguni sheep. A cross with the Dorper breed,

followed by back-crossing back to the Nguni parentage for seven generations, could be used to achieve this, with less than a 1% dilution of the genome. A detailed DNA fingerprint of the pure Nguni genome could be used to confirm the process.

CONFERENCE ABSTRACT

Grassland Society of South Africa Congress 52 – July 2017

Overwintering sheep on the Sourveld of KwaZulu-Natal has a set of difficulties because the forage quality of the veld deteriorates rapidly. Little is known about the production of the Nguni sheep. A trial was done to compare the performance of two breeds of sheep, namely the Merino and Nguni sheep breeds, on grazing maize as alternative to veld for overwintering purposes. Animals used in the experiment were lactating Nguni (n=28) and Merino ewes (n=24) with lambs. The Nguni ewes had one twin with a mean of 1.03 lambs per ewe, and the Merino ewes had 13 twin lambs with a mean of 1.54 lambs per ewe. The Nguni and Merino ewes were randomly assigned to either grazing maize or veld treatments. The Merino (n=12) ewes per treatment and the Nguni ewes were (n=14) per treatment (two replicates each). Average daily gains, weaning weights and weaning percentages of the lambs were recorded and compared. Adaptation period was 14 days with the duration of the trial as 98 days. An area of 40 ha of veld grazing and 4.5 ha of grazing maize was used for the trial. Grazing maize has a carrying capacity of 20 small stock units (S.S.U.) Ha⁻¹ a⁻¹. The Sandy Sourveld of KwaZulu Natal (BRG 14) has a carrying capacity of 1.125 Ha S.S.U.⁻¹ a⁻¹. Forage samples from five sites within the grazing plots were taken before grazing and monthly thereafter. Indicators of palatability and nutritional quality were considered. *Eragrostis curvula* hay was supplied *ad libitum* to both feeding treatments. Voermol Landelek™ (protein supplement) was supplied to the sheep on the grazing maize and Voermol Maxiwool™ (protein supplement) was supplied to the animals on the veld.

Ewes from both breeds showed a positive live weight gain over the trial period, on grazing maize, where the Merino ewes averaged an increase in body weight of 15.88% and the Nguni ewes averaged 10.87%. Ewes in both breeds lost weight on veld forage. Lambs from both breeds gained live weight on both treatments: on grazing maize Merino lambs averaged 182.6g day⁻¹ and Nguni lambs averaged 131g day⁻¹. The lambs on the veld performed a little worse with the Merino lambs averaging 62g day⁻¹ and the Nguni lambs' 65g day⁻¹.

As was expected, veld did not manage to supply even the maintenance needs of ewes, indicating quality constraints. The quality of forage was used to explain sheep performance. The performance of the Nguni sheep was superior to the Merino on veld. It can be concluded that grazing maize provides a good alternative to veld for overwintering lactating ewes.

LIST OF ABBREVIATIONS

| | | |
|------|---|--|
| a | - | annum |
| ADG | - | Average daily gain |
| ADF | - | Acid detergent fibre |
| AnGR | - | Animal Genetic Resources for Food and Agriculture |
| ARC | - | Agricultural Research Council |
| AUC | - | Area under the curve |
| BC | - | Before Christ |
| b.p. | - | Before present (time) |
| BRG | - | Bio resource group |
| °C | - | Degrees Celsius |
| cm | - | Centimetres |
| CP | - | Crude protein |
| DM | - | Dry matter |
| DNA | - | Deoxyribonucleic acid |
| DRS | - | Dundee Research Station |
| EIA | - | Early Iron Age |
| EPG | - | Eggs per Gram |
| ER | - | Effective Rainfall |
| EW | - | Ewe weight at weaning |
| FAO | - | The Food and Agriculture Organization of the United Nations |
| FEC | - | Faecal Egg Count |
| g | - | Gram |
| GIN | - | Gastro-Intestinal Nematodes |
| GPS | - | Global Positioning System |
| Ha | - | Hectare |
| HG | - | Heart girth |
| HH | - | High nutritive value treatment in winter followed by high nutritive value treatment in summer. |
| HL | - | High nutritive value treatment in winter followed by low nutritive value treatment in summer. |
| HUF | - | Heat unit factor |
| Kg | - | Kilogram |

| | | |
|--------|---|--|
| KZN | - | KwaZulu-Natal |
| KZNDAE | - | KwaZulu-Natal Department of Agriculture and Environmental Affairs |
| LBW | - | Litter weight at birth |
| LH | - | Low nutritive value treatment in winter followed by high nutritive value treatment in summer |
| LL | - | Low nutritive value treatment in winter followed by low nutritive value treatment in summer. |
| LTM | - | Long term mean |
| LWW | - | Litter weight at weaning |
| mm | - | Millimetres |
| M | - | Meters |
| MF | - | Management factor |
| MNI | - | Minimum numbers of individuals |
| MRS | - | Makhathini Research Station |
| NDF | - | Neutral detergent fibre |
| NRC | - | National Research Council |
| OPG | - | Oocytes per Gram |
| RHn | - | Relative Minimum Humidity (expressed as percentage) |
| RHx | - | Relative Maximum Humidity (expressed as percentage) |
| S | - | Soil factor |
| SF | - | Sunshine factor |
| S.S.U. | - | Small stock unit |
| VFA | - | Volatile fatty acids |
| WEE | - | Estimated ewe productivity |

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CHAPTER 1

INTRODUCTION

1.1 PREAMBLE

Livestock is the largest user of agricultural land in developing countries, directly through grazing of rangelands and indirectly through production of crops. As the global human population increases, so does the demand for food of animal origin, which in turn puts more pressure on natural resources. This demand will increase dramatically over the next 20 years (Thomas *et al.*, 2004). Most animal production areas can be described as harsh and challenging (Howe and Turner, 1984) with livestock production systems being stagnant and any production increases having been mainly due to increased livestock numbers rather than productivity increases (Mahavedan, 1981).

To supply the increasing demand for animal products, higher yielding breeds are being developed, which are also being used in developing countries. Scientists at the UN Food and Agriculture Organization's first Summer Summit on animal genetics, held at Interlaken, Switzerland, 2007, warned that many African and Asian indigenous livestock breeds could disappear because of competition with introduced high-yielding breeds. However, the indigenous breeds often carry valuable traits, such as drought or disease tolerance attributes, which will become increasingly important to farmers in the future (Du Toit, 2008).

One endangered breed is the indigenous Nguni sheep, known as Imvu (or izimvu in plural), which are today only found in relatively small flocks, scattered throughout the northern and north-eastern parts of the traditional Zululand region of KwaZulu-Natal.

The breed is listed as "Nguni" under "Declared Landrace breeds: Indigenous and locally developed", in the Animal Improvement Act (Act 86 of 1998) and are also internationally referred to as "Zulu" or "Nguni" sheep (Epstein and Mason, 1971; Mason, 1996; ANON 1, 2009). According to the Domestic Animal Diversity Information System (ANON 2, 2009) the Nguni sheep breed consists of a total population of 109 800 with 69 200 breeding females. However, these numbers are in doubt and may be much lower. In 1995, it was estimated that only 3000 Nguni sheep were left in South

Africa (Campbell, 1995). Today there are even fewer pure Nguni sheep left and the breed should be regarded as critically endangered. Steps towards its protection and conservation should be taken as a priority (Snyman, 2014).

1.2 BACKGROUND AND JUSTIFICATION

Ancestors of the Nguni sheep entered South Africa at least 2000 years ago, according to archaeological evidence found in the Soutpansberg (Voigt and Plug, 1984). Archaeological findings describe historical migration routes, and therefore assumptions can be made on how the Nguni sheep arrived in the province of KwaZulu-Natal (KZN) (Voigt and Von den Driesch, 1984). Many of the flocks of sheep that still exist in the province can be found in communal areas with extensive grazing of low quality forage. The Nguni sheep are kept in both temperate (where winter temperatures can drop to below 0 °C) and sub-tropical zones in the province.

Besides the danger of low numbers and with the imminent threat of inbreeding (fragmentation/isolation in scattered, small flocks), the breed is also seriously endangered by crossbreeding due to imports of other sheep breeds into the free range communal areas. These are mostly western and composite breeds such as the Dorper and Merino. Crossbreeding on purpose is also practised, where sheep owners seek to “upgrade” their flock. As a result, several scientific and popular publications have warned that the pure Nguni sheep is “at the brink of extinction” (Nicholas, 1998; Du Toit, 2008).

The breed should be preserved because valuable traits could be lost if not conserved. Taberlet *et al.*, (2008) mentioned: “The efficiency of modern selection methods successfully increased the production, but with a dramatic loss of genetic variability.”

Important genetic resources of developing countries are the highly adapted breeds of sheep that have been subjected to natural selection, with little artificial selection, under unfavourable tropical and sub-tropical environments for thousands of years (Howe and Turner, 1984; Terrill, 1984). Thomas *et al.*, (2004) noted that animal breeding programs in most developing countries have tended to neglect the characterisation

and improvement of valuable indigenous breeds that are associated with small-scale farming systems.

The reasons for keeping livestock in communal areas are much more complex than simply milk or meat, because there also exists an important cultural dimension (Bayer *et al.*, 2004). It can be therefore expected that individuals in different environments will give different reasons for keeping Nguni sheep.

For the purpose of this dissertation an investigation into the spatial distribution of Nguni sheep in KZN was done and a rural participatory questionnaire was completed to establish farmer perceptions regarding the Nguni sheep. To collect more information regarding Nguni sheep morphology, a phenotypic study was done involving various Nguni sheep flocks from widely different environments (agro-ecological zones). Phenotypic characterisation was done to measure and describe genetic diversity in these resources (Nguni sheep) as a basis for understanding them and utilising them sustainably (FAO, 2012).

Sheep owners practise crossbreeding in order to enhance the production potential of sheep and to verify this, an investigation into the production potential of the sheep was undertaken. The Merino, a general breed often used in cross breeding, served in some trials as a reference commercial breed. The study investigated the performance of lactating Nguni sheep and their lambs on either a low or high nutritional level during winter. The effect of nutritional constraints on lamb's post weaning was followed by allocating the post- weaned lambs to either a low or high nutritional level. The prevalence of and resistance to gastrointestinal parasites was also monitored.

1.3 GENERAL AIM AND OBJECTIVES

1.3.1 Aim

The aim of the research was to determine the spatial distribution of Nguni sheep in KZN, gain knowledge on rural management practises and production perceptions of Nguni sheep owners and describe the breed in terms phenotypically characterisation and production potential.

1.3.2 Objectives

The objectives of this study were therefore to:

1. Determine the location and perceptions of farmers / owners of Nguni sheep regarding the value of the sheep and the challenges the farmers encounter.
2. Determine the phenotypic diversity within the Nguni sheep in two different agro ecological zones.
3. Determine the response of the Nguni sheep to different levels of nutrition as an environmental stressor in relation to the response of a known industrial breed, the Merino.
4. Determine the response of the sheep to environmental stress in terms of their susceptibility to gastrointestinal nematode infections.

1.3.3 Hypotheses

The following hypotheses were tested:

1. The pure breed of Nguni sheep is endangered because the breed is being subjected to indiscriminate crossbreeding to improve the carcass quality; owners do not value the pure Nguni sheep breed.
2. Phenotypic differences occur within the breed when flocks are bred in two different agro-ecological zones in KZN.
3. The Nguni sheep responds to different levels of nutrition but is more tolerant of low nutrition levels than an industrial sheep breed, the Merino.
4. The Nguni sheep possess superior resistance to gastrointestinal nematode infections than the Merino sheep.

1.4 STRUCTURE OF THE DISSERTATION

The dissertation is divided into four research areas (Chapters 3, 4, 5 and 6) each focusing on aspects of sheep production.

Chapter 2 Literature review on the Nguni sheep.

Chapter 3 A survey to determine the spatial distribution of Nguni sheep in KwaZulu-Natal and indigenous production practices.

Chapter 4 Phenotypic characterization of the Nguni sheep.

Chapter 5 Investigation of the production potential of Nguni sheep under different nutritional conditions during winter and the following summer.

Chapter 6 Investigates the resistance or susceptibility of Nguni sheep to gastrointestinal nematodes.

Chapter 7 Overall conclusions and suggestions for future work.

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CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The current global sheep population stands at more than 1 billion head with 19% found in Asia and Africa (Global sheep market, 2017). Approximately 43% of the world's sheep breeds are found in developing countries (Terrill, 1984). According to Salem and Smith (2008), small ruminants represent the principal economic output and they contribute a large share of the income of farmers in the low-rainfall areas of Africa and Asia.

Scientists at the UN Food and Agriculture Organization's first Summer Summit on animal genetics, held at Interlaken, Switzerland, 2007, warned that many African and Asian indigenous livestock breeds face a 'meltdown', because of the relentless march of high-yield breeds, bred in first world countries. Many of the world's rare livestock face extinction, unless conservation measures are taken immediately. Modern agriculture overlooked the benefits of genetic traits that have evolved in breeds found in developing countries, while drought or disease tolerant attributes would become increasingly important to farmers in the future (Du Toit, 2008).

Such a breed is the indigenous Nguni sheep, which are mainly found in rural communal areas in KwaZulu-Natal (KZN), that can be described as developing areas. The environment in most developing countries is generally harsh, which in turn implies suppressed animal production (Howe and Turner, 1984; Salem and Smith, 2008). According to studies, communal grazing lands in South Africa, with special emphasis on communal grazing lands in KZN, are among the worst and most overgrazed in South Africa (Peden, 2005). The Nguni sheep has a long history of survival under these harsh conditions and is found in KwaZulu-Natal, with the larger populations concentrated in the northern part of the province at places such as Jozini, Msinga and Nongoma (Mavule, 2013). The Nguni sheep is found in sub-tropical regions of KZN, but the sheep is also found in more temperate areas of the province where winter temperatures can be low.

Research can contribute to improved animal production under the conditions described above. Production increase (in the past) has been mainly due to livestock numbers rather than productivity. It is further mentioned that overstocking is a fundamental problem in the developing areas where communal grazing is practiced, and that the level of animal production is closely linked to nutrition, whatever breed or genotype is used (Mahavedan, 1981).

Cause for concern is that in 1990 an estimate was made that less than 3000 pure Nguni sheep is left in the KZN province (Campbell, 1995). Today there are even fewer pure Nguni sheep and the breed should be regarded as critically endangered with steps towards its protection and conservation taken as priority (Snyman, 2014).

The Nguni sheep breed is believed to be relatively resistant to ticks and tick borne diseases, such as heart water and red water (Campbell, 1995). Their characteristics, such as adaptation to humid and hot conditions, their ability to tolerate internal and external parasites, their ability to walk long distances and favourable foraging behaviour are the main reasons why rural farmers keep these sheep (Ramsay *et al.*, 1998; Kunene and Fossey, 2006; Nyamukanza *et al.*, 2010).

According to the FAO (2012), characterization of genetic resources for food and agriculture (AnGR), involves three types of information: historic, genetic and phenotypic.

2.2 HISTORY

Knowledge of the history of the Nguni sheep breed can be derived from the archaeological record, as well as linguistics and ethnography linked to the development or evolution of the Nguni sheep (MacDonald, 2000).

Figure 2.1 is a painting illustrating life at a Zulu home, roughly 200 years ago (Angas, 1849). Phenotypically the sheep in the foreground resembles the Nguni sheep currently found in rural Kwa-Zulu-Natal. Resemblance of the animals in this painting to the sheep illustrated in Figures 2.4 and 2.5 is distinct.



Figure 2.1: A painting of a Zulu homestead, roughly 200 years ago, including their animals (Angas, 1849)

Archaeological evidence leads back to the Southern Levant (Middle East), where the goat was undoubtedly the first bovid domesticated, by c. 9000 b.p. Subsequently, there is good evidence for the presence of domestic sheep and goats from c. 8000 b.p. at the site of Asraq. The indigenous development in Africa of wild cattle stock appears to be c. 7000 b.p. (MacDonald, 2000).

One of the most contentious postulated African domestication is that of sheep and this argument first derived from the observation of rock art depictions of the “ornamental rams” of the Atlas Mountains. These animals seem to resemble wild rather than domestic sheep and the traditional assumptions of their introduction from western Asia was questioned, but more osteological evidence from early Holocene of Africa, the Levant and Sinai must be excavated and scrutinized to confirm the lineage of domestic sheep (MacDonald, 2000; Muzzolini, 2000).

Fat-tailed sheep were introduced from the Middle East into Egypt during the Middle Kingdom and into the Maghreb (Western parts of North Africa) during the historical period (Muzzolini, 2000). The Middle Kingdom of Egypt (also known as The Period of Reunification) is the period in the history of ancient Egypt between approximately 4100 b.p. and c.3800 b.p (Franke, 1995). The existence of pre-Neolithic wild ovicaprines in Africa seems plausible (Muzzolini, 2000).

The Nguni sheep would have migrated with people from North Africa down into Southern Africa. Faunal remains on an archaeological site do not directly reflect all aspects of the economic and social importance of livestock, therefore detailed anthropological studies are needed to assist the archaeozoologist in interpreting the results of the bone analyses. Evidence of this is found in some archaeological sites in South Africa dating back to the Early Iron Age (EIA). Sites reviewed for the purpose of this paper includes: Broederstroom, (Transvaal), Happy Rest – Soutpansberg, Magogo, Mhlopheni Ndondondwane and Kwagandaganda (Natal). Little is known about the physical appearance of these animals (of which bone and bone fragments were found), i.e., woolly/hairy and fat-tailed/thin-tailed. Metapodial shafts suggest that the animals were generally long-legged, much like the "unimproved" sheep and goat breeds still found today. It may be assumed that the early sheep in southern Africa were hairy, since the modern "indigenous" sheep tend to have hair rather than wool (Beukes, 2000).

At an archaeological site called "Happy Rest" in the Soutpansberg, dated to the Early Iron Age (EIA) (1670 b.p. and 1550 b.p.) there is evidence that EIA communities depended on herding as a basis for their economy. The predominance of small stock over large stock appears to be a common pattern among EIA stock-keeping communities (Voigt and Plug, 1984). Similar findings were made in an excavation done in Ndondondwane, Natal (Voigt and Von den Driesch, 1984). At the "Happy Rest" site the numbers of sheep bones outnumbered those of goats, and the suggestion is that on some sites, sheep were more commonly slaughtered than goats. Goats might have had another purpose such as the provision of milk and were not kept primarily for meat. (Voigt, 1984).

On another site (24/73 – Broederstroom, Transvaal), aged 1670 b.p. to 1400 b.p., the accumulation of debris showed intermittent residence by EIA people for approximately 250 years. Among the debris were bones of 153 individuals (animal remains) of which 19 were from sheep or goats, with only one from domestic cattle. It seems that the Broederstroom community supported a pastoral economy based on the raising of sheep and goats, with cattle being acquired only rarely, over a century after the establishment of the village (Mason, 1981).

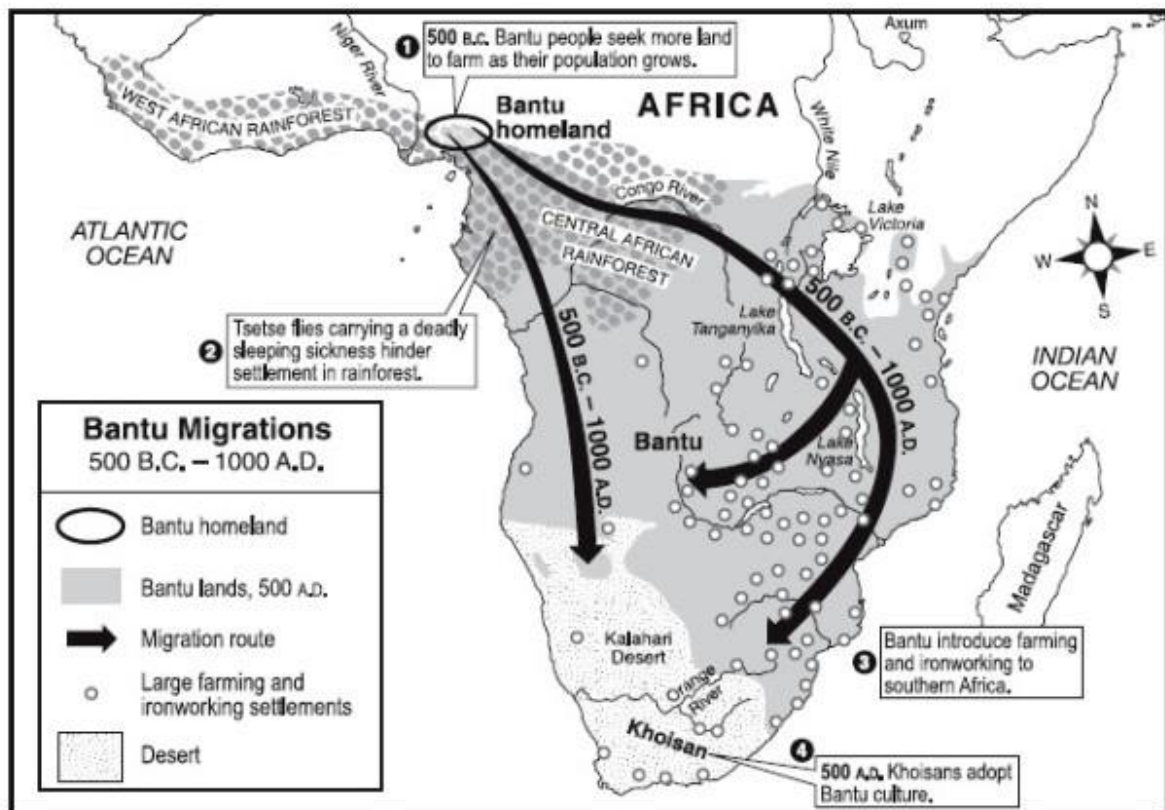
At a third EIA site (Kwagandaganda, KwaZulu-Natal), it was found that the community was heavily dependent upon their domestic stock for food, particularly their small stock (Beukes, 2000). The assemblage provided excellent evidence for both sheep and goats in Natal by 1428 b.p. (Voigt and Plug, 1984).

2.2.1 Migration Routes

Migration routes of people can be traced back towards Central and North Africa, where fat tailed sheep are still found today. Figure 2.2 displays the possible routes that early migrants took from the Sahel down to Southern Africa. It indicates a prominent eastern and western route that was followed.

There is evidence for two migration routes to Southern Africa by the Bantu migrants. Firstly, there was a westerly route from the south of Tanzania through Zambia towards Namibia into South Africa (Henshilwood, 1996). The second route was from north-east of Botswana towards the Eastern areas of South Africa and eventually down to the Cape (Elphick, 1977).

A challenge to early pastoralists was the 'tsetse fly barrier' in the area of the Central African Rainforest (Congo). However, there was a tsetse-fly free area next to Lake Victoria (Figure 2.2) that was used by these early migrant pastoralists to gain entrance to the South with their livestock (Epstein and Mason, 1971; Campbell, 2003; Du Toit, 2008).



Source: *The Nystrom Atlas of World History* (adapted)

Figure 2.2: An indication of the possible migration routes followed by ancient people of Africa, (Source: <https://arianasiresearch.files.wordpress.com/2015/02/ques1.jpg?w=619andh=453>)

A pastoral nation, the Khoikhoi were resident in South Africa before the Bantu migrants arrived. They were forced south by the stronger migrants, approximately in 1520 b.p. The Khoikhoi appeared to already have flocks of fat tailed sheep (Epstein and Mason, 1971; Bachman, 1983; Campbell, 2003). An easterly route was identified down the African coast (hot, humid with ticks and disease) where black people brought with them ‘small hairy thin-tailed sheep’ and some hairy goats (Bachman, 1983).

With this evidence, it is assumed that the fat-tailed sheep moved down the continent via the Westerly route and the Thin-tailed sheep moved south via the Easterly route. Campbell (2003) mentioned bartering and raiding between these different nations, whereby the Khoikhoi acquired goats from the black nations and the black people acquired the fat tailed sheep from the Khoikhoi. Henshilwood (1996) declared that

whatever the route, clearly pastoralism was introduced to the southernmost Cape from the north.

In rock art found in South Africa, fat-tailed sheep are clearly portrayed (Figure 2.3). According to Muzzolini (2000), rock art (iconography) faithfully reflects the introductions of the basic animals into the domestic livestock, and their importance in the economic sphere as well as within the symbolic field, where the first domestications (those of cattle and sheep), found expression as major events generating appropriated myths.



Figure 2.3: Rock art found in South Africa clearly indicating a fat tail sheep (Source: Google.com)

As a part of the Khoikhoi nation, the San were hunter / gatherers but were responsible for the rock art found in the region. The Khoi were the pastoralists with domesticated animals, but they were not known to practice rock art.

Du Toit (2008), in collaboration with Bachman (1983), mentioned a 'second wave' of sheep that came with Bantu-speaking farmers; where two breeds can be identified, specifically the Pedi and the Nguni sheep. Van Zyl and Dugmore (2010) concurred with this concept, and cited Epstein and Mason (1971) and Mason (1981), who classified these sheep as Nguni sheep, which included the Pedi, Landim, Swazi and Nguni sheep.

According to Carles (1983), the indigenous sheep flocks in Central Africa and parts of Southern Africa show many similarities with the Tanzanian long tailed sheep, and it is

possible that all the sheep in the region comprises one large group within which there are sub-groups showing local variations in colour and tail type. By evaluating findings from archaeological excavation sites, San art and previous research work on the subject, it is clear that the Nguni sheep must have originated from Central to Northern Africa and that the animal has moved south with migrant herders.

2.3 GENOTYPE

DNA was proven to be an important measurement as to the purity of any animal breed. It also indicates how some of the ecotypes within the breed are related. Kunene *et al.*, (2009) recommended that population genetic studies of Nguni sheep should be undertaken using microsatellites to generate a DNA based linkage map of the sheep breeds.

What is significant is that a great diversity exists within the breed and that this was consistent with phenotypic characteristics that are highly diverse (Gizaw *et al.*, 2008). The great phenotypic variation of the Nguni sheep is probably due to the broad ancestral genetic pool of the breed. It is therefore highly likely that the genetic diversity between various Nguni sheep populations is high (Kunene *et al.*, 2009; Kruger 2011). To compare different genotypes to distinguish between potential productivity in the absence of stress, the realized productivity and the improvement of production by genetic means, requires an understanding of factors which cause the differences in production between different genotypes in different environments (Frisch and Vercoe, 1980). The Nguni sheep have been exposed to natural selection in Africa for hundreds of years, and therefore the breed is likely to be valuable for future breeding of other sheep breeds. "In the foreseeable future, resistance to parasites and heat stress are likely to remain necessary for efficient production and breeding programs must still incorporate selection for these attributes" (Frisch and Vercoe, 1980). Whilst the Nguni sheep is well adapted to the harsh environments of the agro-ecological zones of KwaZulu-Natal, it is unknown to what degree is the Nguni (like the Barbarine sheep of Tunisia) are able to deposit and mobilize body reserves (Salem and Smith, 2008).

2.3.1 Genetic similarity and diversity between breeds

Carles (1983) commented: “The classification of indigenous tropical sheep is beset by many problems. This is due to sheep having been of much less importance than cattle as a sign of wealth and so very little selection has been carried out by man.” There seems to be some controversy between researchers as to whom or what was responsible for the current Nguni genotype. Kunene *et al.*, (2009) were of the opinion that the animals adapted to the climatic conditions of KwaZulu Natal through traditional selection. Thomas *et al.*, (2004) agreed with Carles (1983) who stated: “Animal breeding programs in most developing countries have tended to neglect the characterization and improvement of valuable indigenous breed that are generally most associated with small-scale farming systems.” They commented: “On the one hand, poor genotype imposes limits on potential for increase from new technologies, and on the other hand, developing countries are rich in domestic livestock biodiversity and superior genotypes with resistance to environmental stresses exist within the indigenous breeds of various species”.

2.3.2 Previous DNA work done

Buduram (2004) and Kunene *et al.*, (2009) conducted preliminary research based on DNA studies of the Nguni sheep. The aims of their studies were to provide preliminary genetic diversity data for Nguni sheep and to link this data to some existing linear body measurement data. Among three populations, they found the lowest genetic similarity in the Makhathini population and the highest in the UNIZULU population (Kunene *et al.*, 2009). Further genetic sampling is of importance to complement data collected by previous research work.

Selepe *et al.*, (2018) conducted a study on eight Nguni sheep populations and Damara, Dorper and Merino sheep, using microsatellites. They found a high level of genetic diversity in the Nguni sheep populations, but found clear evidence that Dorper genes were diluting the Nguni breed in some populations.

2.4 PHENOTYPE

FAO (2012) maintained that phenotypic characterization of AnGR is the process of identifying distinct breed populations and describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors that affect them. When observing the sheep in the different environments of KwaZulu-Natal, this would include the following factors:

- a) Geographical – taking into account where the sheep occurs in the province;
- b) Managerial – taking into account different levels of management input from resource poor farmers and animals from agricultural research stations that also own Nguni sheep.



Figure 2.4: Indigenous Nguni sheep at the Makhathini Research Station - Northern KwaZulu-Natal. Note that the lamb has no ears (vestigial ears)

FAO (2012) also noted that populations within a breed or type might be known to be multiple crosses of recognized breeds, and that some animals may belong to homogenous groups that are distinguishable from neighbouring populations, on the basis of identifiable and stable characteristics. However, here is no detailed database for phenotypic and genetic characterization of the Nguni breed (Kunene *et al.*, 2009).

In FAO (2012) is a comment that breeds that have had to survive and reproduce in the presence of particular stressors and combinations of stressors such as high temperatures, poor quality of feed, disease and parasites that create selection pressure on each breed to develop adaptations to these stressors. Horst (1984) emphasised body size as being a critical determinant of productive adaptability in hot and stressful environments. Both the Nguni cattle and Nguni sheep have smaller body frames than equivalent European animal breeds.



Figure 2.5: An example of Nguni sheep (ewe) at the Dundee Research Station

The first impression of the Nguni sheep is that it has long thin legs and that the flocks move fast, while staying together, indicating an animal that is used to walking or running for the purpose of covering a large area in search of its food. Some of the sheep have fat tails, and some do not have ears or their ears are very small. The

breed does not strike the observer as a breed with high mutton production capabilities, having relatively long, thin legs.

Scarce old photos such as the one taken by Cipriani (1927) shows a typical Zululand setting in the background (Figure 2.6). In the foreground of the flock one can see goats, but there are sheep in the rear of the flock that resembles the current Nguni sheep.



Figure 2.6: A photo taken of indigenous sheep (behind the goats) in 1927 by Lidio Cipriani called: “A herd of Zulu sheep in Zululand”. Source: Italian Society of Pietermaritzburg

Although sheep cannot be considered as endangered species according to the number of individuals, it is clear that many breeds are highly endangered and that we are losing genetic resources (Taberlet *et al.*, 2008). Certain threats to local breeds with low population sizes do exist, in the form of socio-economic, management, adaptation and geographic confinement contexts. Examples of these include

inbreeding and crossbreeding that can lead to adaptive traits being lost due to the dilution of local genetics (Köhler-Rollefson *et al.*, 2009). Mavule (2013) stated that the effect of inbreeding may be another factor contributing to the decline of Nguni sheep numbers in some areas of KwaZulu-Natal.

Valuable traits exist in the Nguni sheep, including resistance to local parasitic diseases, adaptation to poor forage, homing and gregarious behaviour, can easily be lost and would be difficult to rescue (Taberlet *et al.*, 2008).

Crossbreeding the Nguni sheep with an industrial breed such as Dorper will result in progeny requiring better nutrition than provided by overgrazed veld in communal areas. Preston and Leng (1987) confirmed that breeding for increased production per animal and more weight per day of age is at the cost of the requirement of increased nutritional intake, to the point that only the most digestible feeds of high protein content (largely milled cereal grains combined with legume and oilseed meals) are suitable for the high potential livestock. This is not feasible for the small scale farmers of Zululand, using a communal grazing system with minimal inputs. Therefore, livestock systems must be matched with the resources available in a way that aims for economic optimization rather than biological maximization (Preston and Leng, 1987).

Livestock diversity is shrinking rapidly and there is an urgent need to define strategies to prioritize breed conservation (Hanotte and Jianlin, 2006). Taberlet *et al.*, (2008) identified threats to local breeds in four different contexts, i.e., socio-economic, the management of small sized populations, threats to adaptation and geographical confinement. Furthermore, Taberlet *et al.*, (2008) stated that indigenous breeds in marginal areas are seriously endangered because farmers are often obliged to abandon their traditional breeds, in order to raise more commercially competitive industrial breeds.

2.5 PRODUCTION EFFICIENCY

In tropical and sub-tropical countries, low-quality forages comprise practically the whole diet of ruminants either from grazing or being fed under subsistence conditions (Leng, 1990). Salem and Smith (2008) mentioned that animal numbers have

increased over the last two decades, driven by a demand for animal products, but that changing climatic conditions are increasing desertification, resulting in a decline in rangeland resources. Under grazing conditions there is usually a wide variety of pasture plants available, but only some are selected for grazing, and these species are not necessarily abundant in pastures, especially if there is overgrazing (Preston and Leng, 1987).

In a study in 2000, communal grazing areas in South Africa were classified by agricultural officers as the most degraded agricultural land in South Africa. This causes a concern about a substantial decline in animal productivity (Peden, 2005). The reduced forage quantity and quality of communal grazing at the end of the dry season is widely recognized as the main constraint on animal production (Scogings *et al.*, 1999). Vetter (2004) affirmed that no grazing, or very light grazing, allows the veld vegetation to reach its climax stage, whereas heavy grazing pushes it back to a pioneer stage dominated by low-quality grass and forbs species.

According to Nyamukanza *et al.*, (2010) Nguni (Zulu) sheep are able to maintain body weight through selective feeding in communal areas where the forage is generally poor.

Consensus between the studies of Leng (1990), Salem and Smith (2008) and Thomas *et al.*, (2004) is evident. Leng (1990) mentioned that the diet of ruminants in tropical and sub-tropical countries often comprises of low-quality forages under either fed or grazing conditions, and that when low-quality forage intake is low without supplementation, significant responses in feed intake occur when a non-protein N deficiency is corrected by the supplementation of a by-pass protein (Leng, 1990).

Answers to over wintering of ruminants needs to be sought due to quality and quantity constraints (Owen and Jayasuriya, 1989). The level of production from the animals is of paramount importance and the farmers' animal production requirement must be taken into consideration (for instance, improved carcass weight, higher weaning percentages or lower mortalities).

Current economic pressures are driving farmers and sheep owners, the current custodians of the Nguni breed, to consider improving the breed for better mutton production by crossbreeding with breeds such as Dorper. This will defeat the objectives of a scheme to re-introducing purebred Nguni sheep rams back into the community if the farmers are planning to 'improve' their herds by crossbreeding with Dorper rams.

Production of commercial products from Nguni sheep (considering meat, wool and milk) are lower than from commercial breeds such as the Merino. However, Nguni sheep also have some social and cultural functions, and serve as a means of insurance against drought and other adversities (Hassen *et al.*, 2002).

However, it remains unclear what the Zulu communities are using the sheep for, such as mature mutton, yearling mutton, lamb or wool (Carles, 1983). Carles (1983) mentioned that mature mutton is the predominant choice in the tropics, which is characterized by low-quality mutton, slaughtered on demand, with minimal expenditures on marketing and processing. He also noted that the production of indigenous sheep is not recommended in arable areas. Yearling mutton or even late-maturing lamb could be a viable option if small improvements could be made to the primary product. This might be done using nutritional supplements such as the grazing of crop residues or even planted fodder crops. Further improvements that could be made, would be in connection with the animal's health status, supplementing the diet with minerals or the introduction of a genotype with faster growth potential (Carles, 1983). Consistent with this, Adogla-Bessa *et al.*, (2005) pointed out that any intervention that improved the productivity of sheep would be an important route to creating wealth and to improving the standard of living of resource-poor farmers.

The small stock farmer/owners are resource poor, and will prioritize funds firstly to their families, with the ruminants at the bottom end of receiving inputs. This usually means that the farmers or stock owners cannot increase the nutrients available to their animals if the animals do not get enough nutrients from the communal grazing areas or pastures available. Salem and Smith (2008) noted that many technologies have been developed for the better use of local feedstuffs, or to reinforce the feeding programs of ruminants with even less known feed sources (e.g., cactus and tree fruits).

However, Adogla-Bessa *et al.*, (2005) noted that the typical features of production systems for resource-poor farmers are small numbers of animals, the grouping of animals from several owners for grazing, and that owners have little technical expertise. Therefore, altering a production system becomes a challenge.

Globally, indigenous sheep breeds are livestock that are well adapted to their natural environment, but because of the environment (low quality feed), they are more attuned to surviving (maintaining body weight) the challenges of their environment (added to this environment is the imminent climate change) than to a high level of production.

Frisch and Vercoe (1980) stated that productivity is a consequence of two genetically determined factors: potential productivity (in absence of environmental stress) and resistance to environmental stresses. Likewise, carcass composition is markedly affected by stocking rate, and improvements to productivity can be achieved by controlling or modifying the environment (Frisch and Vercoe, 1980). Nutrition is continually mentioned as an important factor in the production of ruminants. If the diet of ruminants is properly supplemented, then they can convert fibrous feed into protein of high biological value.

Sheep kept under communal conditions are subject to breeding throughout the year because the rams graze freely with the ewes. If better control could be exercised over the timing of breeding of the animals, then lambs could be born during the growing season of the vegetation, and better production could be expected. A noteworthy result from a study on multiple sheep breeds in Ethiopia was that there was little difference in the rate of gain of the various lambs due to differences in genotype. However, this was because the milk production of the small indigenous dams was inadequate to rear lambs, crossbred with breeds with larger body sizes (Hassen *et al.*, 2002).

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CHAPTER 3:

A SURVEY OF NGUNI SHEEP OWNERS IN FOUR AGRO-ECOLOGICAL ZONES IN KWAZULU-NATAL

3.1 ABSTRACT

The aim of this study was to identify and locate Nguni sheep owners in KZN and by administering a questionnaire, to determine the perceptions, challenges and reasons for keeping these sheep. Numbers of the sheep (especially the pure Nguni sheep) are limited, with the literature reporting the possibility that there are less than 3000 sheep in the province of KZN (Campbell, 1995). Owners (n=52) that were identified in rural areas were asked to complete a questionnaire with the assistance of an enumerator. In this study 1184 sheep were located in four areas of KZN. Of these animals, 19% were found in the Sandy Bushveld and 25% were found in the Lowveld. In the Dry Lowland tall grassveld, 21% of the animals were found and 17% were found in the Sourveld areas.

From the survey 318 sheep were located in Nkandla under the ownership of 15 owners. In Nongoma there were 200 animals identified with 10 owners. In Msinga there were 321 animals with 10 owners. Ingwavuma had the greatest number of sheep (n=347) and 11 owners. Farmers from both Nkandla and Msinga provided their sheep with supplemental licks in winter, while the owner of the sheep in Nongoma and Ingwavuma did not provide licks to their animals. In all the areas, the owners exercised tick control to some degree. Few health problems were identified, with the greatest problem being lamb deaths. Crossbreeding between Nguni and other breeds followed with the aim to improve carcass quality (improved mutton production). However, inbreeding was identified a threat to the purity of the sheep because the acquisition of unrelated Nguni rams was difficult to arrange. Not all farmers used the fat or skin of the animals. Home consumption and extra income were seen as the most important reasons for the keeping of the Nguni sheep.

3.2 INTRODUCTION

The indigenous Nguni sheep of KwaZulu-Natal, or as they are called by local people, imvu (or izimvu in plural) are today only found in relatively small flocks, scattered throughout the northern and especially the more north-eastern parts of the traditional Zululand region of KwaZulu-Natal where they are run as free-ranging livestock in communal grazing areas, with confinement at night (Van Zyl and Dugmore, 2010). However, a few commercial farmers also procure quite a number of this sheep. Their aim is not mainly farming, but more conservation and collection orientated, with high interest in adaptive traits (Haigh, R. 2009 and Van de Pypekamp, G. 2017), which could be valuable for selection of climate-smart animals for the future (Jordaan, 2018).

The breed is listed as “Nguni” sheep under “Declared Landrace breeds: Indigenous and locally developed”, in the Animal Improvement Act – Act 86 of 1998 – and are referred to as “Zulu” or “Nguni” sheep internationally (Epstein and Mason, 1971; Mason, 1996; ANON 1, 2009). According to “The Domestic Animal Diversity Information System (ANON 2, 2009), the breed consists of a total population of 109 800 with 69 200 breeding females. However, these numbers are in doubt and have been estimated to be much lower (Van Zyl and Dugmore, 2010). Besides the danger of small numbers and with the imminent threat of inbreeding (fragmentation/isolation in scattered, small flocks), the breed is today furthermore seriously endangered by crossbreeding due to imports of other sheep breeds (mostly western and composite breeds like Dorper and Merino) into free ranging communal areas. Except from randomly introduced foreign breeds, crossbreeding on purpose is also practised, where owners want to “upgrade” their flock. Several scientific and popular publications have warned that the Nguni sheep breed is “at the brink of extinction” (Nicholas, 1998; Du Toit, 2008). Bayer *et al.*, (2004) confirmed this by stating the Nguni sheep is still kept in Msinga (where he did his research), but that “the breed is becoming rare”.

However, the threat of extinction or decreasing of breed numbers is common to indigenous breeds in most developing countries. Scientists at the UN Food and Agriculture Organization’s first Summer Summit on animal genetics, held at Interlaken, Switzerland, in 2007, warned that many African and Asian indigenous livestock breeds face a ‘meltdown’ because of the relentless march of high-yield breeds. Many of the

world's rare livestock face extinction unless conservation measures are taken immediately. Modern agriculture overlooked the benefits of genetic traits that have evolved in breeds found in developing countries, while drought – or disease tolerant attributes would become increasingly important to farmers in the future (Du Toit, 2008).

The awareness of the value of indigenous livestock breeds in KwaZulu-Natal developed momentum in recent years with several institutions prioritizing this matter. The KZN Parliament and Department of Agriculture and Environmental Affairs, KZN initiated “The Nguni Revitalising Programme” and an “Indigenous Breeding Policy” was released (Attached to the dissertation as CD subfolder: “Department of Agriculture”).

The FACT (Farm Animal Conservation Trust) was established in 1994, with a mission to facilitate and promote the conservation of South Africa's indigenous farm animal genetic resources. They have the indigenous breeds of KZN high on their agenda, as do the Farm Animal Genetic Resources Division of the National Department of Agriculture (Ramsay *et al.*, 1998). Private breeders have also realised the value and importance of the breeds, and a few visionaries have established flocks/herds of indigenous breeds (e.g. Richard Haigh, Enaleni Organic Farm, Pietermaritzburg).

Mainly cattle and goats' issues have received official attention in the recent past, but in March 2009 preservation of the indigenous Nguni sheep breed was listed as a priority by the KZNDAE and it should have received priority attention. Several initiatives, coupled with time frames were decided on to support the conservation and revitalization of this breed (Attached to the dissertation as CD subfolder: “Department of Agriculture”).

Information on the social-economic reasons for keeping Nguni sheep, owner's perception regarding these animals, management principals and challenges, as well as the phenotypic character of the animals and occurrence of crossbreeding have not been documented thoroughly before. Verified information in this regard could be fed back into the “The Nguni Revitalising Programme” and the “Indigenous Breeding Policy”, with the aim to preserve and to promote the breed.

3.3 MATERIAL AND METHODS

3.3.1. Study area

The study area was the central and north eastern parts of KZN, where, according to literature, the Nguni sheep are found.

3.3.2 Methodology

Staff from the KZN Agricultural and Rural Development Department, such as extension officers, animal health technicians and research station personnel, in the northern parts of KZN, where the sheep is prevalent, were briefed and given a background to the study and requested to identify Nguni sheep owners in the areas of their responsibility. A questionnaire was designed to capture the farmers' views regarding the socio-economic reasons for keeping the sheep, management principals and challenges, as well as the phenotypic character of their animals (attached to the dissertation as CD subfolder: "Survey"). The identified owners were then visited and by means of a participatory rural appraisal, requested to participate by answering the questions posed to them by means of the questionnaire.

3.3.3 Data Collection

A global positioning system was used to pinpoint the precise location of each farmer. The farmer's name, contact number and number of animals was the initial part of the questionnaire. The household and the flock were inspected and photographs were taken to include in a database of the Nguni sheep in KZN (attached to the dissertation as CD subfolder: "Survey").

3.3.4 Statistical Analysis

Data was analysed by using a General Survey analysis (tallies) in Genstat® 18.1 software (VSN Int., 2015).

3.4 RESULTS

3.4.1. Distribution and prevalence of Nguni sheep in KZN

The survey, completed over an eighteen-month period, resulted in 52 owners of Nguni sheep being identified and interviewed. In total, they had 1184 sheep in their care. Their distribution in KZN could be grouped in four main zones. These are named after the local municipalities, namely Nkandla, Nongoma, Msinga and Ingwavuma (Table 3.1).

Table 3.1: Owners identified in four zones in Kwazulu-Natal and the number of sheep per zone

| Area | Number of owners | Number of sheep |
|-----------------|------------------|-----------------|
| Nkandla | 15 | 316 |
| Nongoma | 16 | 200 |
| Msinga | 10 | 321 |
| Ngwavuma | 11 | 347 |
| Total | | 1184 |

The location of these zones and the location of where the surveys were done are indicated in Figure 3.1.

The four zones mentioned above and the environmental conditions, cover nine different Bioresource groups (BRG's) with varying climatic conditions and vegetation, which resulted into varying livestock conditions.

3.4.2 Description of study sites (Bioresource groups present in the different study zones)

3.4.2.1 Nkandla (BRG 5, 8 and 12)

BRG 5 Moist midlands mist belt

Bioresource group 5 covers a region of broken topography which occurs in an interrupted belt along the Hilton escarpment from Eshowe in the north to the Transkei border in the south (Tainton and Camp, 1999). The area has undergone a great deal of intensification, particularly into pasture and timber, which is likely to continue because of the favourable conditions for plant growth during summer and the poor

nature of the natural veld. Open grasslands in its pristine state can be dominated by *Themeda triandra* Forssk. (red grass), which is extremely sensitive to even moderate grazing pressure. The veld is sour and can support animal growth only during summer, after which it loses quality and acceptability to grazing animals (Hardy, 1999; Hardy and Camp, 1999).

BRG 8 Moist highland sourveld

According to Hardy (1999), the vegetation can be described as a low, closed grassland, with the grasses seldom reaching a height in excess of 0.5m. Fire has played a major role in maintaining the area as a grassland which, in the absence of fire, could become dominated by shrubs and bushes and, in certain cases, progress to tall evergreen forests. Grazing also plays a role here, and it is through the interacting effects of fire and grazing that the highland sourveld remains a grassland suited to extensive livestock production. However, the incorrect use of fire, and poor grazing practices often reduce the livestock production potential of the veld. A predominance of *T. triandra* is taken to indicate that the veld is in good condition. Where the veld has been heavily grazed, species such as *Eragrostis curvula* Nees., *E. plana* Nees., and *Sporobolus africanus* Robyns & Tournay, (also known as the Mtshiki grasses) tend to increase in abundance, and replace species such as *T. triandra* and *Tristachya leucothrix* Trin. Ex Nees (trident grass). Most important species that decrease are *T. triandra*, *Brachiaria serrata* Stapf, *Diheteropogon amplexans* (Nees) Clayton, *Monocymbium ceresiiforme* Stapf and *Andropogon appendiculatus* Nees.

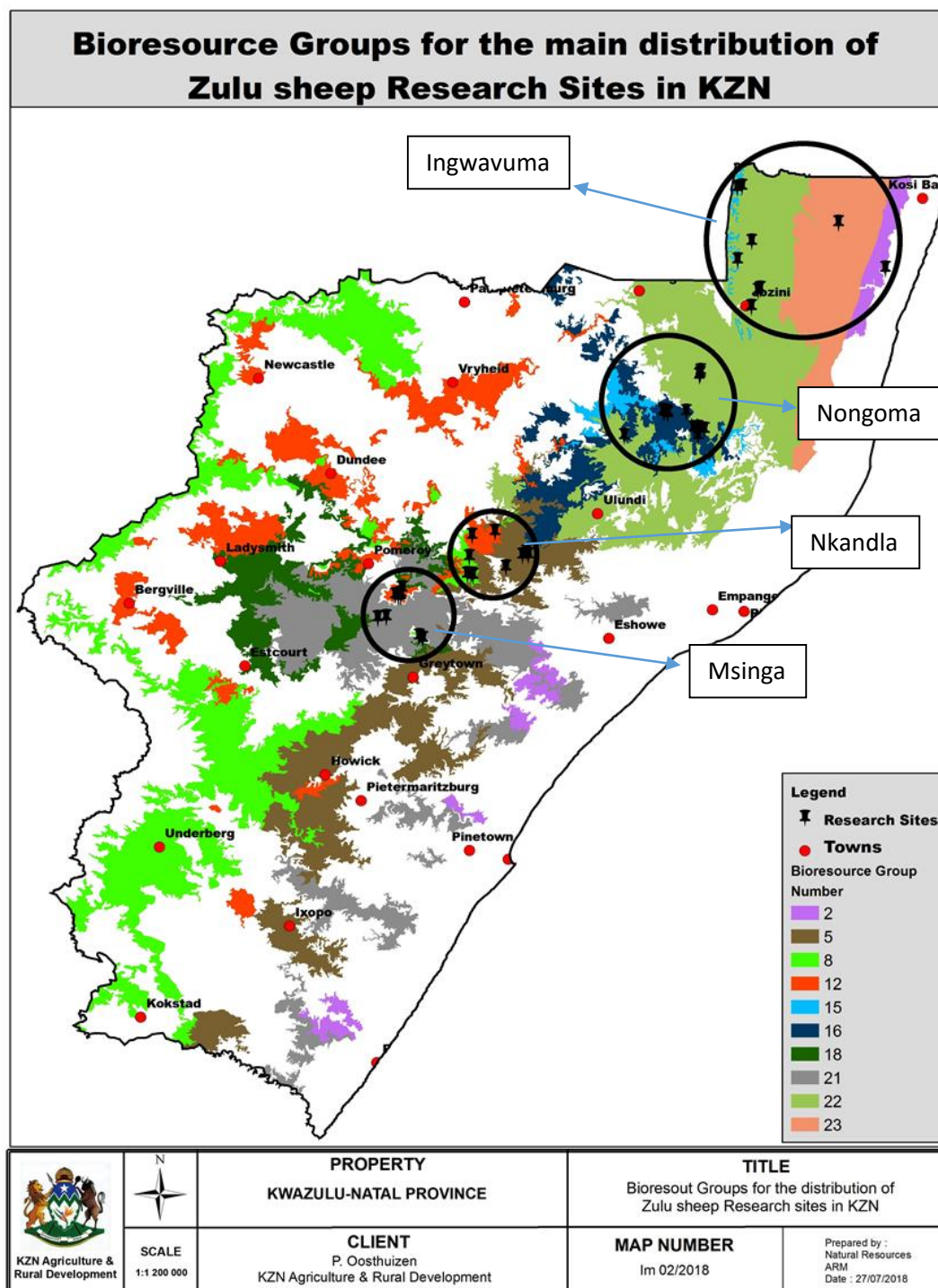


Figure 3.1: A map of KwaZulu-Natal, indicating the four zones of Nguni sheep prevalence, Msinga, Nkandla, Nongoma, Ingwavuma and the sites of the survey (including bio-resource group information)

BRG 12: Moist tall grassveld

The characteristic feature of the Moist tall grassveld is the abundance of thatch grass, *Hyparrhenia hirta* Stapf, and sparsely scattered paperbark *Vachellias*, *Vachellia sieberiana* Tausch. On road verges tall thatch grass species are common, including *Hyparrhenia dregeana* Stapf ex Stent, *H. tamba* Andersson and *H. rufa* Stapf. On the dolerite hillsides *Vachellia caffra* Willd woodlands and thickets occur. *Vachellia karroo* Hayne is found occasionally on dolerite hills and along watercourses. Bush encroachment in the form of *Vachellia* species is limited to a few isolated areas. The alien weed *Lantana camara* L., is a problem plant. *Themeda triandra* is the dominant grass on veld that has been well managed. Prominent grass species include: *Diheteropogon filifolius* (Nees) Clayton, *Harpochloa falx* (L.f) Kuntze and *Trachypogon spicatus* Kuntze. *Eragrostis racemosa* (Thunb.) Steud. and *Microchloa caffra* Nees are dominant on shallow soils (Hardy and Camp, 1999). The characteristic of this BRG in the summer months is the tuftiness of the veld, with tall ungrazed tufts of *Hyparrhenia hirta* Stapf in a short grazed sward.

3.4.2.2 Nongoma (BRG 15, 16 and 22)

BRG 15: Moist lowland tall grassveld

Hardy and Camp (1999) describes this BRG as Moist lowland tall grassveld and it is found in northern KwaZulu-Natal at elevations between 450m and 900m above sea level. The main areas covered by this BRG include an area extending from Hlomo Hlomo to the Ngome forest and eastwards to the town of Nongoma. Grassland dominates the veld in this BRG with bushed grassland in the areas transitional to Dry tall grassveld. *Hyparrhenia hirta* Stapf is the dominant grass species while *Alloteropsis semialata* Hitchc. is fairly abundant at the highest elevations near the Ngome forest, which indicates that these are sourveld areas. Nongoma also has the Lowveld BRG (BRG 22) as one of its main or dominating Bioresource groups. The other two Bioresources featuring in this area are the Dry lowland tall grassveld (BRG 16) and the Valley bushveld (BRG 21), (Hurt and Camp, 1999a; b).

BRG 16: Dry lowland tall grassveld

Dry lowland tall grassveld is dominated by *Hyparrhenia hirta* Stapf. *Sporobolus pyramidalis* P.Beauv. is an important indicator of overgrazing. Invading *Vachellia* species occurs, which includes; *Vachellia karroo* Hayne, *V. nilotica* H.Karst., *V. tortillis*

Hayne and *V. sieberiana* Tausch. *Dichrostachys cinerea* (L.) Wight & Arn., has become a problem species in bush encroachment and has formed thickets together with *Vachellia* species (Hurt and Camp, 1999a).

BRG 22: Lowveld

The Lowveld has a more tropical character and generally has a less rugged terrain. It lies mainly north of the White Mfolozi River. Its characteristic vegetation is an *Vachellia nigrescens*-*Sclerocarya-Themedra* savannah. The dominant trees are: *Vachellia nigrescens* Oliv., *V. tortilis* Hayne, *Schotia brachypetala* Sond., *Spirostachys africana* Sond., *Sclerocarya birrea* Hochst. and *Vachellia burkei* Benth.

On heavy clay soils the dominant grass species of the sweetveld are the tall form of *T. triandra*, *Aristida bipartita* Steud., *Bothriochloa insculpta* A. Camus, *Cymbopogon excavatus* Stapf ex Burt Davy, *Digitaria* spp., *Diplachne eleusine* Nees, *Eragrostis superba* Peyr., *Setaria incrassata* Hack. and *Sporobolus fimbriatus* Nees. *Panicum maximum* Jacq. and *P. deustum* Brickell & Enslin ex Muhl. grow in the shade of trees. On sandy soils *Aristida diffusa* Trin., *Brachiaria nigropedata* (Munro ex Ficalho & Hiern) Stapf, *Cymbopogon excavatus* Stapf ex Burt Davy, *C. pospischilii* K. Schum., *Elionurus muticus* Kuntze, *Heteropogon contortus* Beauv. ex Roem. & Schult., *Hyparrhenia hirta* Stapf, *Panicum coloratum* Kunth, *Pogonarthria squarrosa* Pilg. and *Sporobolus fimbriatus* Nees are among the common grass species. (Hurt and Camp, 1999b).

3.4.2.3 Msinga (BRG 18 and 21)

BRG 18: Mixed thornveld

The dominant plant association is a *Themeda*, *Hyparrhenia* grassland with sparsely scattered *Vachellia sieberiana* Tausch trees. However, this grassland has changed in species composition and structure due to poor grazing and burning management, which has resulted in the invasion of *Vachellia karroo* Hayne and *V. nilotica* H. Karst, with extensive areas of bushland and bushland thicket. The grass layer is dominated by *T. triandra* and *H. hirta*, the latter species being particularly dominant on disturbed areas such as old lands. Other species include *Bothriochloa insculpta* A. Camus, *Digitaria eriantha* Steud., *Heteropogon contortus* Beauv. ex Roem. & Schult., *Setaria sphacelata* (Schumach.) Stapf & C.E. Hubb., *Tristachya leucothrix* Trin. ex Nees and

Elionurus muticus Kuntze. Bush encroachment into grasslands is a major problem facing stock farmers in savannah areas and, at present, no satisfactory solution to the problem was available (Camp, 1999).

BRG 21 – Valley bushveld

The valley bushveld is found in the hot valleys of the major rivers of the Province. The topography of this BRG is mainly steep and rugged with the occasional flat to gently sloping valley bottom. The vegetation is characterized by open to dense scrub forest that contains many *Euphorbia* species. Within this Bioresource group, they found semi-deciduous bush, in the dry, hot areas of the valleys. *Vachellia* species mentioned in this Bioresource group include *Vachellia robusta* Burch., *V. karroo* Hayne, *V. nilotica* H.Karst., *V. tortillis* Hayne, *V. gerrardii* Benth. and *V. ataxacantha* DC. They mentioned that a major contributor to bush encroachment was *Vachellia tortillis*. The climax grasses are: *T. triandra*, *Heteropogon contortus* Beauv. ex Roem. & Schult, *Bothriochloa insculpta* A. Camus, *Setaria incrassate* Hack. and *Cymbopogon pospischilii* K. Schum. Grasses in the shade include *Panicum maximum* Jacq. and *P. deustum* Brickell & Enslin ex Muhl. (Hurt and Camp, 1999b).

3.4.2.4 Ingwavuma (BRG 1, 22 and 23)

In the Ingwavuma area the sheep were found in three Bioresource groups, i.e. BRG 1, 22 and 23. BRG 22 is described in section 3.6.2.2.3 above.

BRG 1: Moist coast forest, thorn and palmveld.

Vegetation consists of a tall grassland interspersed with bush clumps (Hurt, 1999). The grass layer is dominated by *T. triandra* while *A. karroo* is usually the dominant wood tree or shrub. This is significant as the *Vachellias* species are recognised by the sheep to provide an excellent source of protein in the form of the pods that are shed by the tree. Heavy grazing causes an increase in the abundance of *Aristida junciformis* Trin. & Rupr. (Ngongoni grass). Bioresource group 1 has a relatively low potential for livestock production and then only for beef (Hurt, 1999).

BRG 23: Sandy bushveld

BRG 23 is found on the Maputo land plain and stretches from the Mozambique border in the north and to the western shores of False Bay in the south with elevation ranges

from 0 m to 152 m. The vegetation varies considerably with patches of Sand forest in the west in a matrix of bush land thicket, while areas of bush land and bushed grassland are also found. Hurt (1999) mentioned that closer to the coast, the vegetation changes to Palmveld with pockets of bush land thicket, bush land and bushed grassland. *Terminalia sericea* Cambess., *Combretum molle* R. Br. ex G. Don, *Vachellia burkei* Benth., *Strychnos* spp. and *Albizia versicolor* Welw. ex Oliv. grow in the woodland areas. Grass cover is sparse and includes: *Hyparrhenia dissoluta* Andersson, *Pogonarthria squarrosa* Pilg. and *Perotis patens* Gand. (Hurt and Camp, 1999b).

The majority of the sheep were found in the Lowveld (25%), Dry Lowland tall grassveld (21.15%), Sandy Bushveld (19.23%) and Moist Tall grassveld (9.62%), with fewer in the Moist highveld sourveld (7.69%). Low sheep numbers were found in the Valley bushveld, Mixed Thornveld, Moist coast forest (Thorn and Palmveld), as well as the moist lowland tall grassveld and moist midlands mistbelt (Figure 3.2).

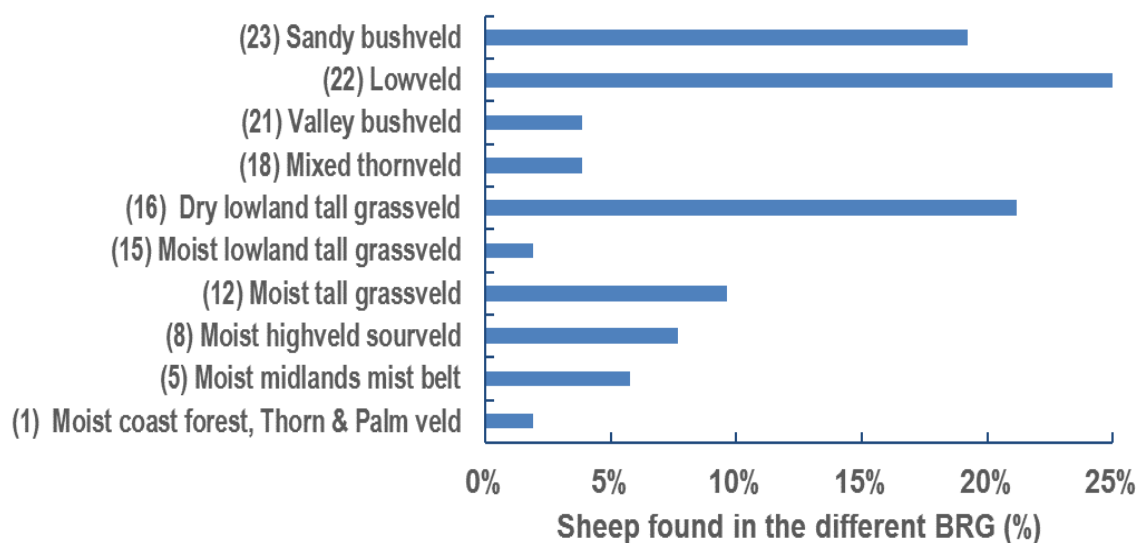


Figure 3.2: The distribution of Nguni sheep in KwaZulu-Natal (% of total sheep encountered) in the different Bioresource groups

3.4.3. Flock size and composition per zone

In Nkandla 15 flocks were visited. The mean flock size was 21 sheep per flock. In Nongoma (16 flocks visited) flock sizes were smaller (13 sheep per flock), but the total number of sheep encountered in the zone were also smaller. Flocks in Msinga (10) were bigger, with a mean of 32 sheep per flock. The mean flock size of the 11 flocks visited in Ingwavuma was also 32 sheep per flock. The mean flock size according to all flocks visited, was 24.5 sheep per flock. The overall ratio of rams to ewes were 1: 14. The numbers of lambs present were lower than expected (Figure 3.3).

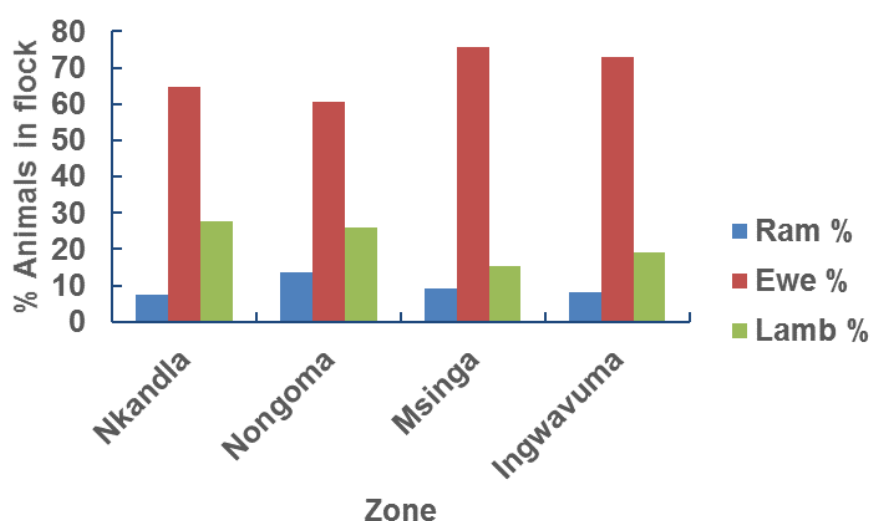


Figure 3.3: Flock composition within the zones of Nguni sheep occurrence in Kwa-Zulu-Natal

3.4.4 Responses of sheep owners regarding:

3.4.4.1. *Supplementary nutrition and kraaling*

All respondents, where extra feed supplementation was done, identified maize as the source of feed, which was given as whole maize and fed during kraaling at night. The maize was either sourced from home production or bought in. This was especially a practise done in the Nkandla zone. Nkandla owners also provided nutritional licks to their sheep. Nongoma sheep owners practised maize supplementation to a lesser extent, but they did not give licks to their sheep. In Msinga lick-feeding was a more popular practise. They also provided maize as supplementation, but to a lesser extent than in Nongoma and Nkandla. In Ingwavuma, being a sweetveld area,

supplementation in the form of licks did not occur, as opposed to the sourveld area of Nkandla.

Kraaling was a popular method used by all owners to ensure the security and safety of their sheep. All owners in Msinga practised kraaling, 80% in Ingwavuma, 68% in Nongoma and 57% of owners in Nkandla (Figure 3.4).

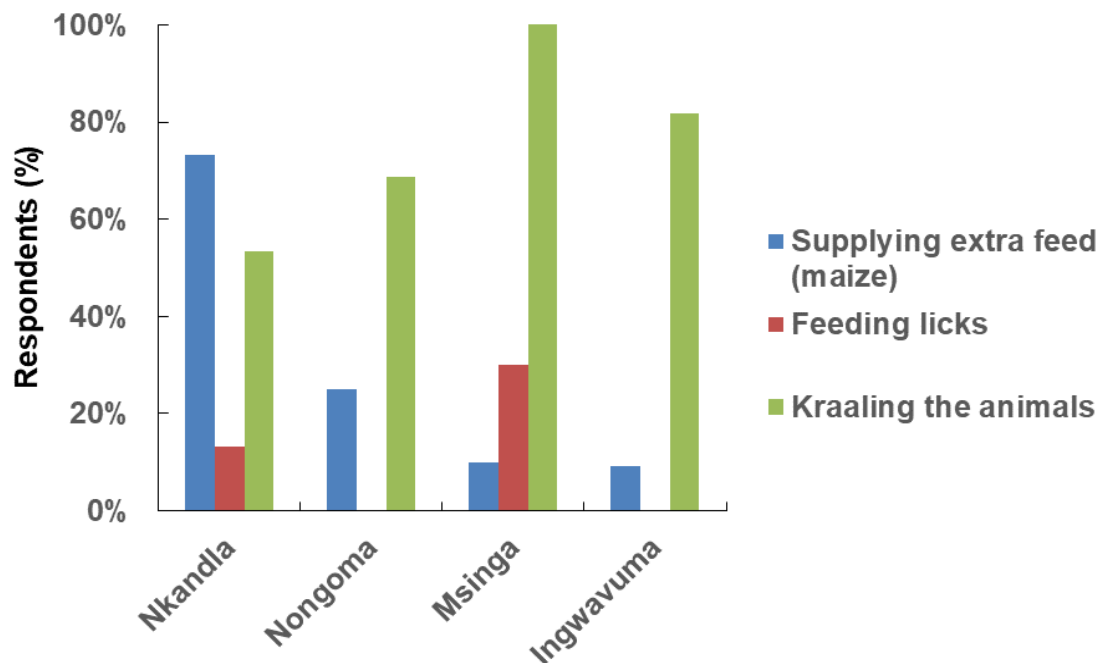


Figure 3.4: Respondents (% per zone) feeding supplements and kraaling their animals in the different zones

3.4.4.2 Basic animal health

Access to veterinarians was a challenge, and only a minority of respondents reported access to veterinarians. Respondents, especially at Msinga and Nkandla, reported access to veterinarians as a severe challenge. In Msinga only 6.7% of respondents had access to a veterinarian, while in the Nkandla zone it was 33% of respondents. (Figure 3.5).

All sheep owners actively treated animals for ticks. In Nongoma nearly all owners (93.3%) exercised tick control, in Nkandla 73%, while in Msinga, only 33.3% did. Internal parasite control was seen as being less important than tick control. In Nongoma, 73% of respondents controlled internal parasites. In Nkandla, this figure was 60%, but it was only 33% in both Msinga and Ingwavuma (Figure 3.5).

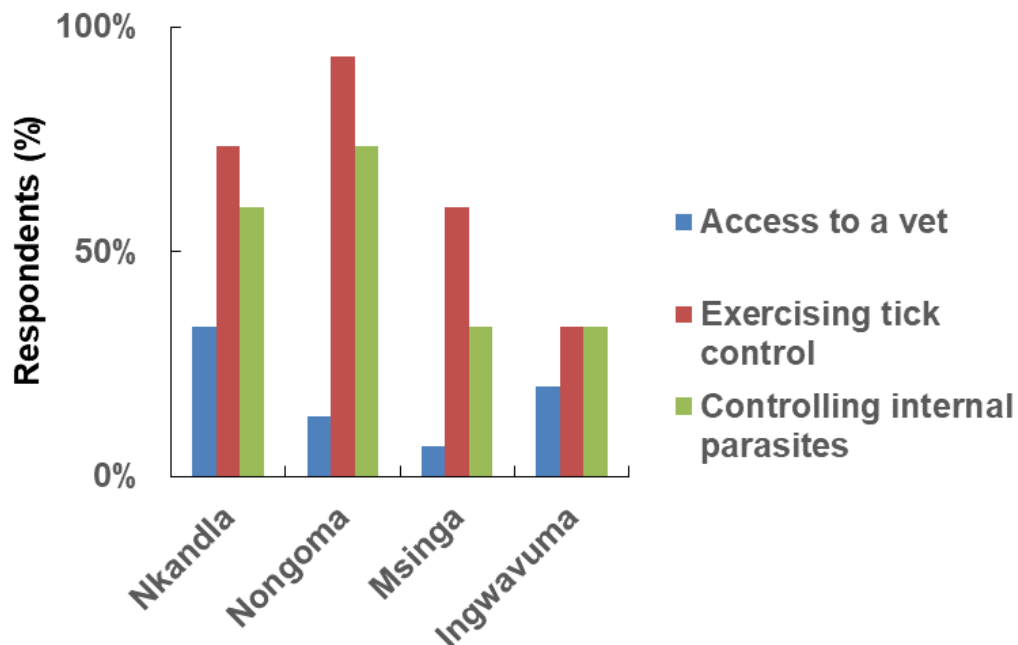


Figure 3.5: Health related answers as % respondents per zone

Regarding health challenges, respondents in Nkandla mentioned ticks as a health challenge. In Nkandla, Orf was mentioned as a notable disease condition. Msinga respondents had severe challenges with lamb death and diarrhoea, most possible interrelated. The respondents in Ingwavuma mentioned a variety of health challenges, namely nasal bot, worms and lung problems (Figure 3.6).

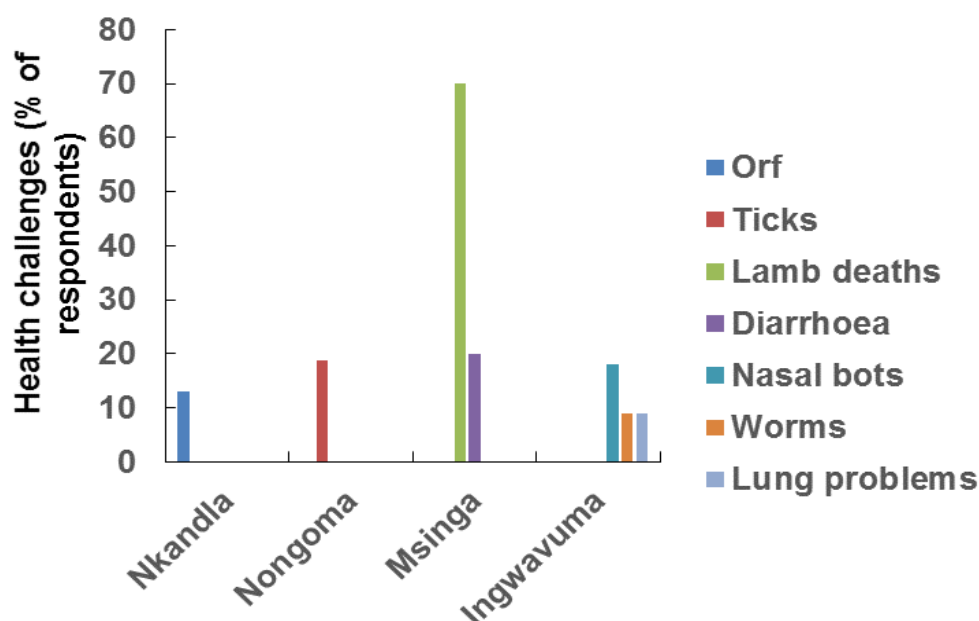


Figure 3.6: Different health challenges as % respondents per zone

3.4.4.3 Breeding

The vast majority of respondents (71%) in the total survey reported that they did not practise castration. Only 12% of respondents in Nongoma zone practised castration, while in the Nkandla and Msinga zones, 40% of respondents practised castration. Regarding crossbreeding, differences were reported. A high level of crossbreeding was practised in Nkandla where 93% of respondents reported doing crossbreeding. In all other zones, crossbreeding was done to a lesser degree (Msinga (30%), Nongoma (37%) and Ingwavuma (45%)). All the crossbreeding reported was done to improve mutton production (Figure 3.7).

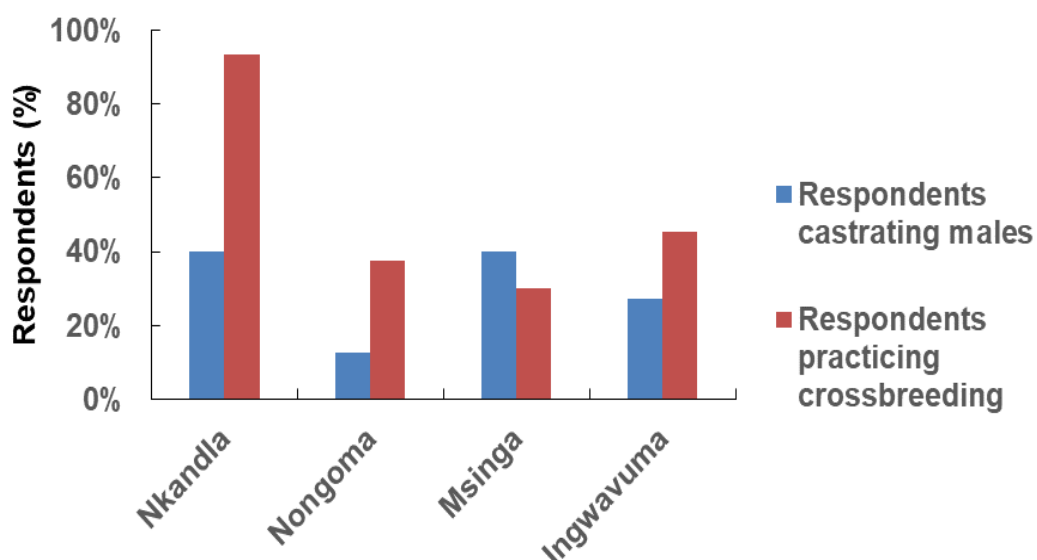


Figure 3.7: The farmers' responses regarding the castration of male animals

3.4.4.4 Use of animal products

The use of the fat tail was popular in Msinga (50%). In other areas it was less popular, and in Ingwavuma only 10% of respondents were using the fat. Respondents that did use the fat, used it in food preparation such as frying (Figure 3.8).

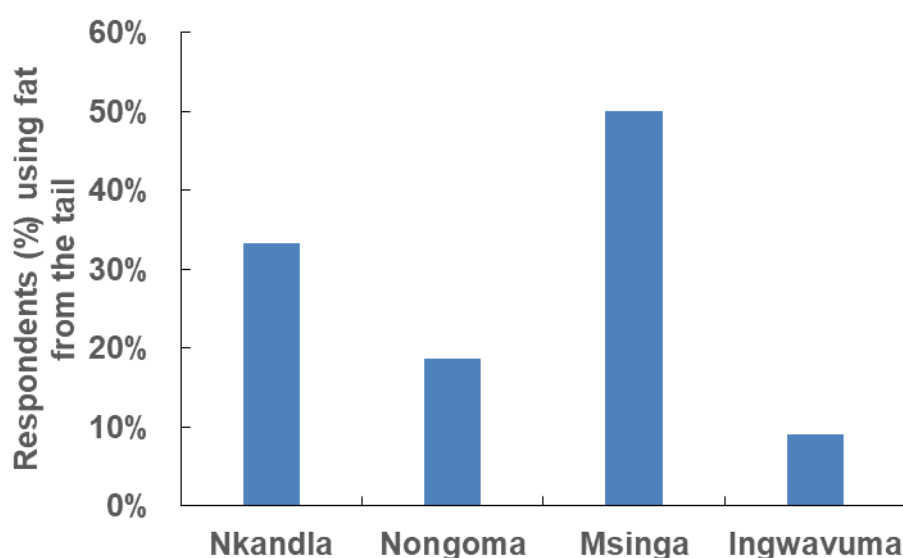


Figure 3.8: Respondents that make use of the fat from the tail as % of respondents per zone

As is the case of the fat of the tail, skins were also not used to a great extent. Skins were used by 50% of the respondents in Nongoma, by 40% in Nkandla, 39% in Msinga

and by few in Ingwavuma. Uses reported includes traditional clothing, seating and as a carpet (Figure 3.9).

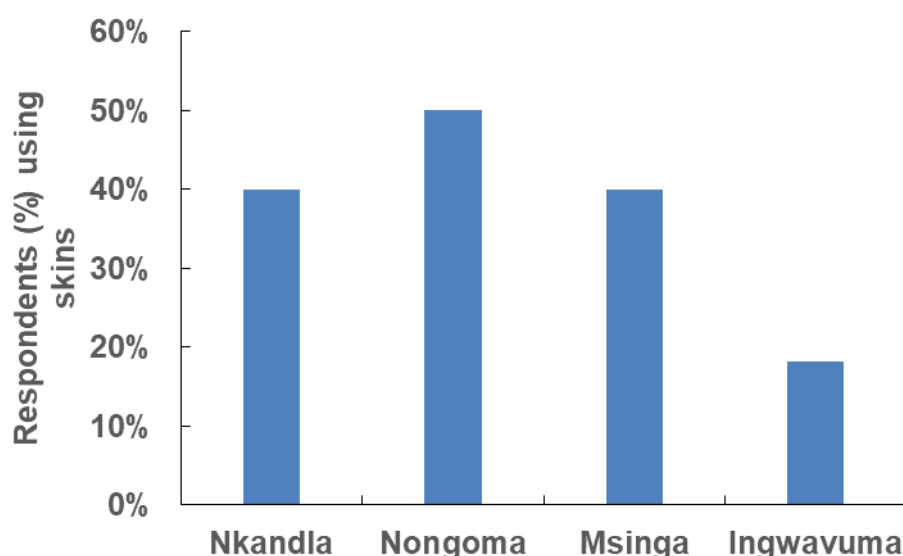


Figure 3.9: Respondents that made use of the skins as % of respondents per zone

3.4.4.5 Reasons for keeping sheep

The overwhelming response from the respondents in all zones (Figure 3.10) was that sheep were mostly kept for home consumption, and secondly, for added income. In Nongoma 87.5% of respondents stated that they kept sheep for home consumption. In Nkandla, this figure was 87%, in Msinga 70% and in Ingwavuma 90%. Sheep as a commodity of income was mentioned by 46.7% in Nkandla, 43.8% in Nongoma, 80% in Msinga and 54.5% in Ingwavuma. In Nkandla and Ingwavuma about 10% of the respondents mentioned that sheep were used for traditional purposes, while in Msinga, it was 20%. None of respondents in Nongoma reported that sheep were used for traditional purposes. Community respect and the taste of the meat were less important motivators for keeping the sheep. In Msinga 20% of respondents did not have a specific reason for keeping sheep.

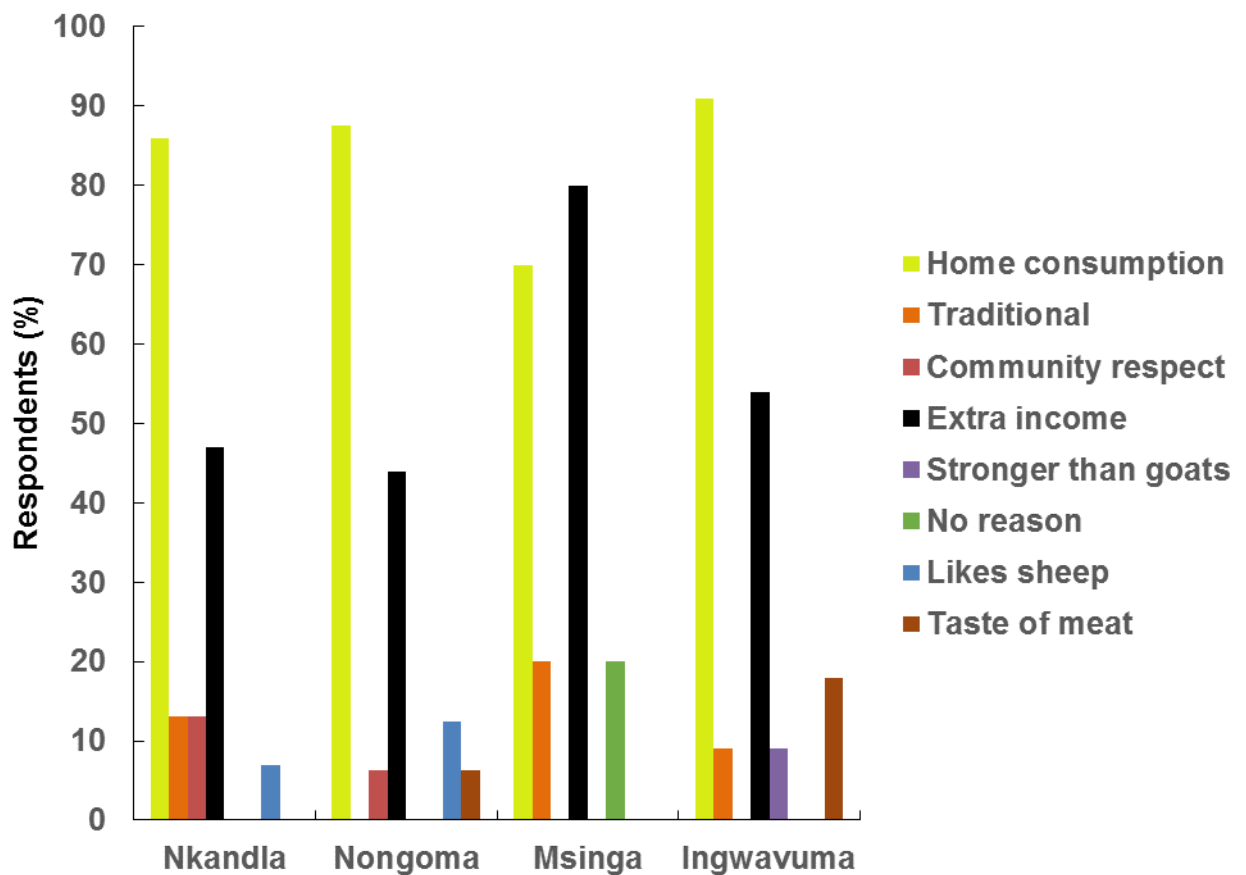


Figure 3.10: Reasons for keeping the sheep, expressed as % of the respondents interviewed per zone.

3.5 DISCUSSION

A total of 1184 sheep were located with the study. These sheep were kept by 52 owners. The aim of the study was not to verify total numbers of the Nguni sheep in KZN, but to identify as many as possible within a given time frame. However, the total number identified by the study were quite low compared to the official number of more than 100 000 given by the Domestic Animal Diversity Information System (ANON 2, 2009). Campbell (1995) estimated that only 3000 Nguni sheep were left in the country and the figure obtained in this study is in better agreement with his estimate.

The distribution of the sheep was grouped in four zones: Nkandla, Nongoma, Msinga and Ingwavuma.

A large number of sheep were found in either the Sandy Bushveld (19.23%), Lowveld (25%) or the Dry lowland tall grassveld (21.15%). These areas are classified as sweetveld areas with leguminous trees, where the pods of the trees would be a valuable source of protein in the dormant/winter period. A fairly large number of sheep were found in sourveld areas (17.31% of the sheep), where summers are cool and feeding conditions are challenging during winter, including the Moist Tall grassveld, with 9.62% of the sheep represented in this survey and the Moist Highveld sourveld with 7.69% of the sheep. The broader distribution of Nguni sheep was in accordance with Mavule (2013) who found the larger populations are concentrated in the northern part of the province at places such as Jozini, Msinga and Nongoma.

Flock sizes were small. The mean flock size encountered with the survey was 24.5 head per owner. Fewer flocks were encountered in Msinga and Ingwavuma, however, these flocks consisted on average of 32 sheep per flock. More flocks were encountered in Nkandla and Nongoma, but the flocks were smaller, with an average of 13 head per flock in Nongoma where 16 flocks were visited and 21 head in Nkandla where 16 flock were visited. Even though the survey was conducted over a time span of 18 months, a concern was that there were so few lambs in the flocks. According to the farmers, lamb deaths was a problem, but even with high mortalities, the ratio should have indicated more lambs in the flocks. An underlying problem could be reproductive diseases. The timing of the survey would also have had an influence on the number of lambs recorded.

Homing of livestock is a highly valuable characteristic of rural livestock and the provision of feed at kraaling at night is used as an incentive to lure sheep back to the kraal at night. Therefore, this connection between feeding of supplements and kraaling the animals exists. Due to the communal grazing systems practised, the only way a farmer can feed supplements is when his animals are kraaled during the night. Many farmers kraaled their sheep to counter theft of their animals. Kraaling was highly popular in Msinga. All owners in Msinga practise kraaling, 80% in Ingwavuma, 68% in Nongoma and 57% of owners in Nkandla.

The feeding of licks was not adopted by all owners. Their nearest outlets for supplements might be far away, and transport costs were too high for this to be

feasible. Maize was designated as the only supplement fed. However, feeding of maize to livestock is in direct competition with maize as the staple food of many rural households, where the needs of animals will only be considered once the availability of maize exceeds the human need. In Nkandla, however, the feeding of maize to sheep was a popular practice, due to the challenging winter periods, since the area is mostly a sourveld area and the veld is of low quality.

The provision of licks in areas with colder winters, such as Nkandla, was also practiced. Maize cultivation was also popular in the Nkandla and Nongoma areas, which makes maize an available commodity. In the warmer sweetveld areas, such as Ingwavuma and Nongoma, no lick feeding featured. It can be assumed that sheep found crude protein supplementation from the environment in the form of fallen pods and tropical legumes.

Access to a vet seemed to be problematic to most of the owners. A large number of respondents reported that they controlled ticks, especially in the Nongoma zone. This problem was also reflected in the answers to a question on the identity of the most important basic sheep health challenge(s). Several of the Nongoma respondents reported ticks as their most important health challenge. Orf is a problem mentioned in Nkandla. The incidence of Orf (contagious *Pustular dermatitis*) might not be diagnosed correctly because the owners have identified their problem as “Scalpy skin”, which might also be a *Sarcoptes ovis* infestation. Care must be taken in the diagnosis of whether it is mites or lice as the treatments are different. Orf is a disease for which a prophylactic vaccine works well, but it is a zoonotic. However, sheep owners in this zone reported reasonable access to a veterinarian.

The sheep owners in the Msinga area identified lamb deaths and diarrhoea as their greatest health challenge. In this area, grazing is open grasslands with poor quality in winter, with leguminous trees absent. Ewes tend to fall pregnant after first rains, when veld becomes nutritious and available, resulting in an autumn lambing season (Msuntsha and Van Zyl, 2017). Winter feeding conditions are challenging for lactating ewes and their lambs, especially towards the end of winter when the daily temperatures increase and internal parasites become active again. The combination of nutritional stress and internal parasite challenge might then result in high lamb

mortalities (Van Zyl, 2014). The Msinga owners also reported a constraint regarding access to a veterinarian.

The dominant veld type of the Nongoma zone is Lowveld, known for tick challenges, and this was as such reported by the Nongoma sheep owners. Also in this zone, access to a veterinarian was reported as restricted. The sheep owners in Ingwavuma, being in a humid, subtropical climate, reported worms, nasal bots and lung problems as their greatest health challenges. Twenty-seven percent of the respondents reported that they had access to veterinarians.

Crossbreeding was evident in the small herds of the farmers that was interviewed, as many of the animals show a resemblance to Dorper and Merino breeds. As was noted by Preston and Leng (1987), breeding knowledge of resource poor rural farmers has been underestimated in the past. Van Zyl and Dugmore (2010) mentioned that the introduction of a single ram of another breed into the free range (communal) system can have a devastating effect on the “purity” of the Nguni sheep in that particular locality. Respondents in the more temperate Nkandla practiced crossbreeding to a greater extent than respondents in the other three zones. Only 30% of the respondents indicated that they castrated their males (Table 3.1).

In their study, Bayer *et al.*, (2004) stated that sheep are kept for meat, skins, wool and customary slaughter. In Msinga, 50% of respondents made use of the fat of the tail for cooking. In all other zones the number of respondents using the fat tails were lower. In Msinga and Nongoma, the use of skins was reported by only 40% and 50% of respondents, respectively.

In all the zones, home consumption of mutton and generation of extra income were given as the main reasons for keeping the sheep. Community respect was given as reason to keep the sheep in the Nkandla area. Only a small number of respondents kept the sheep for traditional purposes, such as ritual slaughtering or “Lobola” (bridal dowry). Bayer *et al.*, (2004) mentioned that the women preferred *lobola* to be paid in sheep rather than goats. There were some respondents who indicated that they like the taste of the Nguni sheep meat, but these were low in number.

3.6 CONCLUSIONS

The number of sheep encountered during the survey was alarmingly low. Together with the low numbers, inbreeding is a major threat for the small flocks. Many respondents did not castrate their male animals. Furthermore, a large number of respondents made use of crossbreeding. Other respondents did not do crossbreeding, although the reality was that the animals graze in communal grazing areas where rams roam freely. As some respondents indicated; they do not do crossbreeding, but that it happened in the veld. The breed should therefore be regarded as critically endangered, with steps towards its protection and conservation taken as a priority (Snyman, 2014).

Most of the respondent's kraaled their animals at night and in sourveld areas, respondents tended to supply maize and supplementary feed. In all the areas, access to veterinary assistance was low, but respondents exercised tick and internal parasite control.

The majority of respondents did not make use of the fat from the tail nor of the skin of the sheep. The overwhelming reason(s) for keeping the sheep seemed to be firstly, for home consumption (mutton), and secondly, as an added income to the household.

The sheep were challenged with a variety of health problems, which related to the area in which they were located, such as more tick challenges in warmer areas (lowveld areas). In sourveld areas, where the sheep were challenged with the poor nutritional status of the veld, supplementary feeding was practised, either in lick form or as supplementary feeding with maize.

It is important that the problems which are encountered by resource poor farmers are addressed. Without proper feed, prophylaxis, medicines, information and veterinary assistance, the current challenges experienced will continue and escalate. This knowledge gained is important for further studies and government decision making processes.

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CHAPTER 4: PHENOTYPIC STUDY OF NGUNI SHEEP

4.1 ABSTRACT

The Nguni sheep of South Africa has been in the country for hundreds of years. As is typical for livestock in developing areas, the sheep is identified more by its geographical locality and the people keeping the sheep than by breed herd books and breed societies. Therefore, identification of the breed (phenotypic characteristics) has been loosely applied by the sheep owners.

Flocks of Nguni sheep on two research stations of the Department of Agriculture and Rural development were used in this study. The sheep are kept on the research stations in closed herds, but the flock on Dundee Research Station originated from the Makhathini Research Station. Both of the groups are adapted to the two different environments. Phenotypic assessment was done on both flocks to identify differences between the animals on the two different agro-ecological zones in KZN. Live weight was compared between seasons (end of winter and end of summer).

Different characteristics of the Nguni sheep were assessed, either by observing and recording the observed detail and physically measuring the animals. Adult females (n=103) were used in a phenotypic characteristics assessment and both male and female (n=292) were used in a live weight prediction study.

Differences were observed, especially in the widths of the sheep tails post-winter and post-summer between the two flocks. The Dundee flock had tails that increased in width from winter to summer by a mean 1.82 cm (from 12.87 ± 3.01 to 14.69 ± 3.79). The animals on Makhathini had a reduction in tail widths from 12.64 ± 4.02 cm to 12.03 ± 2.34 cm, a mean reduction of 0.61cm. The linear regression for the relationship between heart girth and live weight returned an $R^2 = 0.73$. By using the commercially available goat weigh band on the Nguni sheep the linear regression was $R^2 = 0.67$.

Differences in the agro-ecological zones and on-station management is assumed to have caused the differences between the flocks (especially skeletal dimensions) since both flocks originated from the same locality. Taking heed of management as human intervention when farming with Nguni sheep can make a difference in animal production, whether farming on the Sandy Sourveld of KZN or in the hot sub-tropical regions such as the Lowveld.

4.2 INTRODUCTION

FAO (2012) maintains that phenotypic characterization of animal genetic resources for food and agriculture is the process of identifying distinct breed populations and describing their external and production characteristics in a given environment and under given management, taking into account the social and economic factors that affect them.

In developed countries, breeds are defined in terms of a set of phenotypic standards, the use of breed herd books and breed societies exist that are usually supported by legislation. In developing countries, livestock keeping communities and governments apply the term more loosely and identify breeds more along geographical localities, ethnic identities and the traditions of their owners, rather than with phenotypic attributes (FAO, 2012).

Different animals evolve differently in different environments. The qualitative traits of animals can relate to the animal's adaptive attributes. Studies in Zimbabwe on an indigenous breed noted that the sheep's hairy coat was not prone to grass seed damage, and that its large ears assisted in the dissipation of body heat (Ward, 1959). In contrast, the Nguni sheep displays a phenomenon called "mouse ears" or "swelamadlebe" (those with no ears or very short to almost non-existing ears) (Wilson 1991; Ramsay, *et al.*, 1998). The cause of this unusual anatomic oddity is not known, but it may have evolved as a natural defence against attacks by ear ticks. The Nguni sheep is a fat tailed sheep, which can mobilize fat from its tail under conditions of nutritional stress (Atti *et al.*, 2004).

Dzama (2016) stated that farmers respond to climate change by preferring livestock that are heat and drought tolerant, and for this reason, opportunities exist to use the genetic resources of indigenous animal to improve established major breeds. These breeds will be adversely affected by an increase in temperature, reduced rainfall and other aspects of climate change, but this effect should not be as adverse in small ruminants due to their smaller body weight, well developed water retention in the kidney and lower metabolic rates.

Quantitative traits such as heart girth (HG) and wither or shoulder height (WH), as well as body length were measurements that correlated with selection for improved live weight (Gizaw *et al.*, 2008). The studies demonstrated the application potential of linear body measurements for the characterization of indigenous sheep breeds, but also the improvement potential of breeds. Agamy *et al.*, (2015) argued that measurements of various body conformation are of value in judging quantitative characteristics and mentions that it is relatively easy to do.

According to Buduram (2004) regarding indigenous sheep breeds in South Africa, the Nguni and the Swazi sheep have phenotypical similarities. Epstein and Mason (1971) described the Pedi sheep breed as being able to walk long distances with an easy gait which often changes into an amble.

The Nguni sheep is well adapted to harsh environmental conditions, and it is found surviving under conditions in which commercial breeds are not able to survive, i.e., in the north-eastern parts of KZN where heart water is rife (Chapter 3). Relative to the Merino and locally developed breeds such as the Dorper (the two popular commercial sheep breeds in KZN), the Nguni sheep does not compete regarding the quantity or quality of mutton that it produces (Nicholas, 1998). However, it is superior in terms of its gregarious nature, its ability to walk long distances to locate its food, its hardiness and its homing abilities (Ramsay *et al.*, 1998; Kunene *et al.*, 2009). As a result, there are attempts to crossbreed the Nguni sheep with both the Dorper and Merino to attempt to improve its carcass quality (Chapter 3).

Because of the possibility of intra-population genetic diversity, two Nguni sheep flocks in different environments (Dundee Research Station and the Makhathini Research Station flocks) were evaluated phenotypically by primary characterization (FAO, 2012). With this phenotypic study, a confirmatory approach was followed because some basic information on the breed was available in terms of phenotype and distribution (FAO, 2012). The flock of the Dundee Research Station (DRS) was sourced from the Makhathini Research Station (MRS) in 2009. The original genetic pool was the same, but the environment of the two research stations differs. Over nine years the flock of the DRS was exposed to a different environment, especially the nutritional conditions of the veld, i.e., the sourveld of DRS, as opposed to the

sweetveld of MRS. In addition, the management of the sheep have differed between the two research stations. It is hypothesised that these differences between the research stations might have changed the animals phenotypically.

Protein is in short supply on the sourveld (DRS) compared to the sweetveld of the Makhathini Flats (MRS), where sheep also consume the high protein pods of *Vachellia tortillis* Hayne. The sheep at the MRS are also not subjected to the harsh winter conditions of the DRS. Given the better conditions at the MRS, it is also hypothesized that the MRS sheep should have greater body weight than the sheep at the DRS.

Live weight is an important economic trait as well as a selection criterion (Cam *et al.*, 2010), but this is rarely measured by farmers because of a shortage of scales (Kunene *et al.*, 2007). However, Kunene *et al.*, (2009) found that live weight can be reasonably estimated from their heart girth.

A goat weight band using heart girth for predicting live weight of goats, (with the regression coefficient of heart girth measurement against live weight of 0.895) was previously developed and distributed to goat farmers. This has proven to be a helpful tool for the determination of goat weight for selling purposes, or for applying medication where the dosages depend on live weight (De Villiers *et al.*, 2010). However, this model has not been adapted for sheep, and it is unknown whether a goat band can be used to estimate the live weight of Nguni sheep. Due to the complication of fleece, such a weight band will not be applicable to woolly sheep, but it might work for hairy sheep. In this study a prediction model for body weight, using live body measurements of heart girth, was determined for the Nguni sheep. Secondly, the accuracy of the goat weight band was investigated as a tool to estimate the live weight of Nguni sheep.

The primary aim of this study was to phenotypically characterise the Nguni sheep of KwaZulu-Natal and to express its external and production characteristics within a given production environment. This production environment entails the natural environment and management practices. The secondary aims of the study were to develop a model of live weight based on phenotypic measurements, and to test a goat weight band on Nguni sheep, also to estimate live weight.

4.3 MATERIAL AND METHODS

4.3.1 Assessment sites

The Nguni sheep used in these assessments are kept as closed flocks on two of the research stations of the KZN Department of Agriculture and Rural Development, namely the MRS in the north east of KZN and the DRS in the north west of KZN (Figure 3.1). The two Research Stations are representative of two different agro ecological regions within the Province.

4.3.1.1 The Makhathini Research Station

The MRS is situated about 20 km north of Jozini (latitude 27° 23' 43" and longitude E 32° 10' 31") at an altitude of 104 m above sea level. The long-term mean rainfall is 450 mm annum⁻¹, which occurs during summer. Temperatures during summer range from 27°C to 34°C, accompanied by uncomfortably high humidity, forcing animals to abandon foraging and to find shade in the heat of the day. During winter, mean minimum temperatures rarely falls below 10°C, with no frost occurrence (Agricultural Research Council 2018).

The MRS is part of the Bioresource group, Lowveld (BRG 22), which has a more tropical than sub-tropical character, and in general has a relatively gentle terrain. It lies mainly north of the White Mfolozi River. The characteristic vegetation is an *Vachellia nigrescens* Oliv. – *Sclerocarya* - *Themeda* Savannah.

The dominant trees are *Vachellia nigrescens* Oliv., *V. tortillis* Hayne, *Schotia brachypetala* Sond., *Spirostachys africana* Sond., *Sclerocarya birrea* Hochst. and *Vachellia burkei* Benth., (Hurt and Kamp, 1999b). These trees provide a valuable source of browse to the animals. Figure 4.2 shows a typically lowveld scene, with *Vachellia* trees in the background.

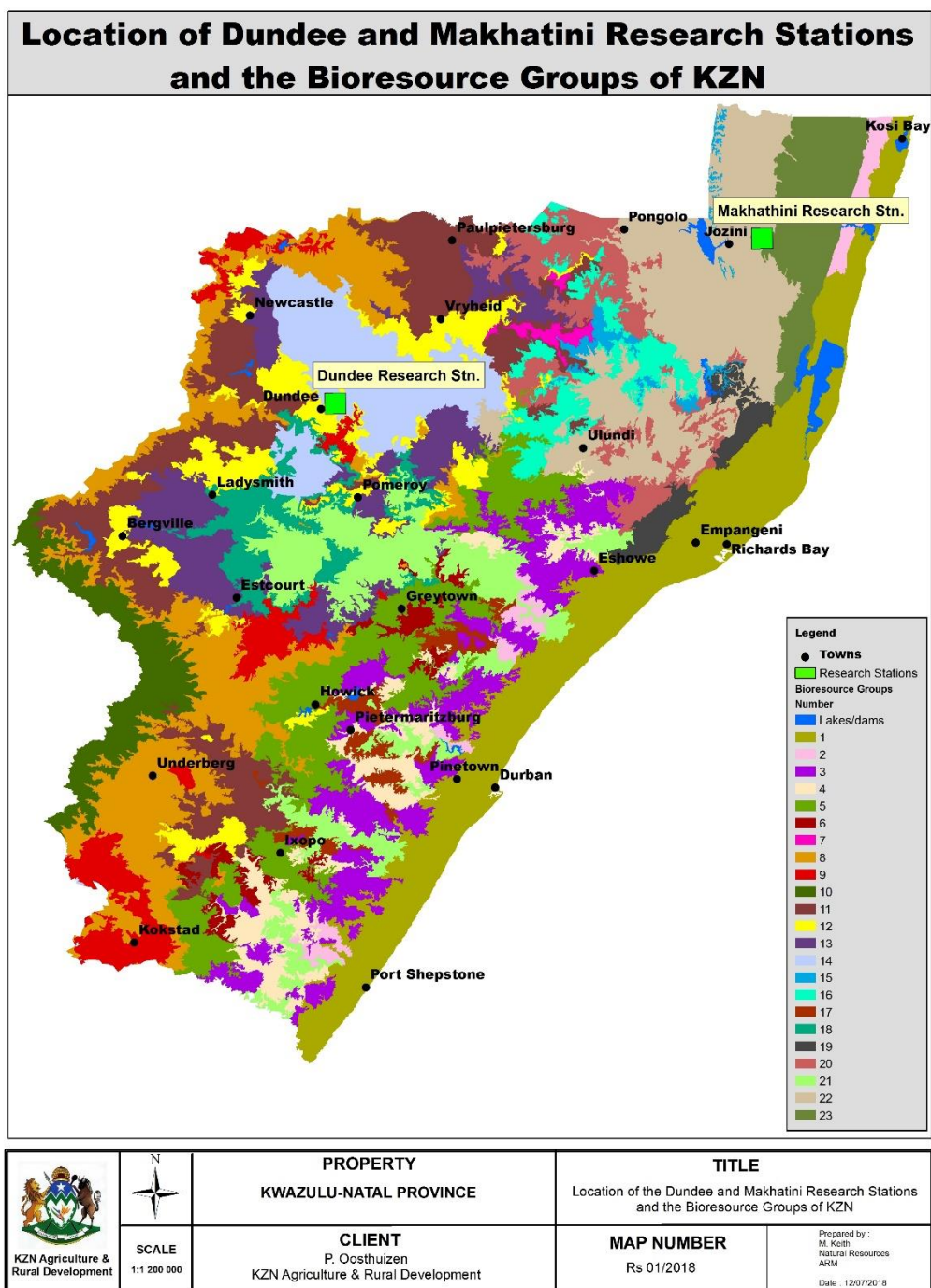


Figure 4.1: Map of KwaZulu-Natal indicating the location of the Dundee and Makhathini Research Stations



Figure 4.2: Nguni sheep at the Makhathini Research Station, showing the typical savannah environment with scattered *Vachellia nigrescens* trees

On the characteristically heavy clay soils, the dominant grass species of the sweetveld are the tall form of *Themeda triandra* Forssk., *Aristida bipartita* Steud., *Bothriocloa insculpta* A. Camus, *Cymbopogon excavates* Stapf, *Digitaria* spp., *Diplachne eleusine* Nees., *Eragrostis superba* Peyr, *Setaria incrassata* Hack. and *Sporobolus fimbriatus* Nees. *Panicum maximum* Jacq. and *Panicum deustum* Thunb. grow in the shade of trees.

4.3.1.2 The Dundee Research Station

The DRS is situated in the Highveld of Kwa-Zulu Natal, about 10 km east of the town of Dundee (latitude 28°10'S and longitude 30°31'E) at an altitude of 1219 m (2830 AB [grit reference]). The long-term mean rainfall is 782.8 mm annum⁻¹ and the distribution is a typical summer rainfall pattern with convectional rainfall in the months from October to March. The mean maximum temperatures (October to end of March) is 26.9 °C and minimum 13.9 °C. Winter conditions are harsh with a mean daily temperature of 22.9 °C and night temperatures plummeting to a mean of 5.6 °C, with heavy frost (Agricultural Research Council, 2018). Soils in the area are predominantly sandy, with a low nutrient status.



Figure 4.3: Nguni sheep on the Dundee Research Station showing the typical grassveld, with no trees

The soils, together with high rainfall and harsh winter conditions, have resulted in a sourveld, with a relatively short growing season and poor quality foraging in winter. The bioresource classification is Sandy Sourveld (BRG12).

Common grasses to this bioresource group include *Tristachya leucothrix* Trin ex. Nees. (dominant grass species), *Digitaria tricholaenoides* Stapf., *Harpachoa falx* Kuntze, *Monocymbium cerasiiforme* Stapf. and *Setaria nigrirostris* Durand & Schinz. Other grass species that appear include *Themeda triandra* Forssk., *Andropogon schirensis* Hochst., *Digitaria monodactyla* Stapf., *Eragrostis racemosa* (Thunb.) Steud., *E. gummiflua* Nees, *E. curvula* Nees., *Panicum natalense* Hochst. and *Hyparrhenia hirta* Stapf. (Camp and Hardy, 1999; Hurt and Camp, 1999a). Indigenous trees, especially leguminous trees, are absent due to climatic and soil conditions. As such, browsing do not form part of the diet of animals.

4.3.2 Animals

The MRS has had a Nguni sheep flock since 1988. These animals were procured from the surrounding Zulu community, where these sheep were relatively common. The flock was used in some characterization trials during the years 1993 till 2003 (Goetze, 2001). In 2009 the flock was randomly divided, with one half of the flock being transferred to the DRS and the other half being retained at the MRS as a closed flock, with the aim of studying the influence of environment on the two flocks. Rams

sourced from the MRS flock were used in the DRS group. Both flocks thus share the same original genetic pool. Management applied to the MRS group is orientated to replicating local management practices, including year round breeding, whereas the DRS flock is managed as a commercial flock, and seasonal breeding is practised.

4.3.3. Methods

Two methods were used in this study, namely a phenotypic characteristics assessment of sheep, and secondly, live weight predictions based on either heart girth or a goat band. Heart girth being the circumference of the body at a point immediately posterior to the front leg and shoulder and perpendicular to the body axis (Agamy *et al.*, 2015).

4.3.3.1 The Phenotypic characteristics assessment







An assessment form was completed with a guide to measure phenotypic traits (Figure 4.4). The form was based upon FAO (2012) guidelines for phenotypic characterization of animal genetic resources (AnGR), with the recommendation that only adult animals are used for assessment and with sexes kept apart.

The effect of the environment on the production of the sheep was assessed using heart girth, tail width and live weight. Data from 103 adult ewes were used. It is postulated that animals from the MRS (sweetveld) would outperform the flock from the DRS (Sandy sourveld) especially during the summer months.

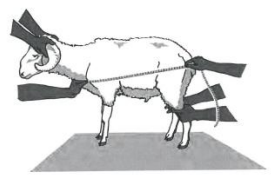
4.3.3.2 Live weight predictions

The weighing of the trial sheep was done at the end of winter and at the end of summer to determine the broad effect of seasons on the live weight of sheep. The sheep were weighed non-fasted, using a “Tru-Test” SR 2000 scale (Auckland, New Zealand), 12 Volt. The scale is accurate to 0.1 kg. Directly after weighing, the heart girth of each sheep was measured, using a measuring tape. A commercial goat weight band was then used to estimate the live weight of the animal (De Villiers *et al.*, 2010). The live weight and heart girth data were used to calculate the regression coefficient of heart girth measurement against live weight. The accuracy of the goat band weight prediction for the sheep was also established. For the prediction of live weight, ewes

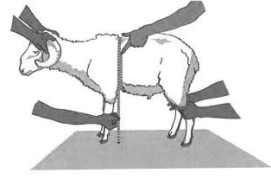
and rams were included to increase the number of measurements with the total number ($n=292$) of animals in the calculation.

| Phenotypic characteristics assessment form | | | |
|---|--------------------------|---|--|
| Owner Name | | | |
| District | | | |
| Flock total | | | |
| Blood sample | | | |
| | | Animal Number: | |
| | | | |
| | | Age - (teeth) | |
| | | | |
| Physical traits | | Dimensions | |
| Gender - M or F ---> | <input type="checkbox"/> | | |
| Horns - Y or N | <input type="checkbox"/> | Horn length (cm) | |
| Tail appearance | Tick | Tail length (cm) | |
| Fat (>10 cm in width) | <input type="checkbox"/> | Tail width (cm) | |
| Thin (<10 cm in width) | <input type="checkbox"/> | Whither height (cm) | |
| Lobbed | <input type="checkbox"/> | Ear length (cm) | |
| Facial profile | Tick | Head width | |
| Straight | <input type="checkbox"/> | Head length | |
| Concave  | <input type="checkbox"/> | Heart girth | |
| Convex  | <input type="checkbox"/> | Body length | |
| Ultra convex  | <input type="checkbox"/> | Pelvis width | |
| Back profile | Tick | Body weight | |
| Straight | <input type="checkbox"/> | Band weight | |
| Slopes up to rump | <input type="checkbox"/> | Scale weight | |
| Slopes down from withers | <input type="checkbox"/> | | |
| Dipped (curved)  | <input type="checkbox"/> | | |
| Fibre type | Tick | | |
| Hair | <input type="checkbox"/> | | |
| Wool | <input type="checkbox"/> | | |
| Length | <input type="checkbox"/> | | |
| Coat | Tick | Back profile explained | |
| Pattern | <input type="checkbox"/> | Slopes up to rump: | |
| Plain | <input type="checkbox"/> |  | |
| Patchy | <input type="checkbox"/> | | |
| Spotted | <input type="checkbox"/> | | |
| Colour % | % | Slopes down from withers: | |
| Dark brown | <input type="checkbox"/> |  | |
| Light brown | <input type="checkbox"/> | | |
| White | <input type="checkbox"/> | | |
| Red | <input type="checkbox"/> | | |
| Black | <input type="checkbox"/> | | |

Body length - sheep




Heart girth - sheep




Note: Press gently to ensure that the wool cover does not increase the measurement.

Horn length - sheep



Note: Measure the longest distance from root of horns to the tip along the outer curvature.

Ear length - sheep



Note: Measure 1/2 length on the back side of ear from the root to the tip.

Pelvis width - sheep




Figure 4.4: The assessment form for the phenotypic study done on two flocks of Nguni sheep (FAO, 2012)

4.3.4 Herd management practices

4.3.4.1 Makhathini Research Station

The sheep at the MRS have grazing access to the whole of the Research Station with no control over camp access. There is no specific allocated grazing camps and animals have to locate their feed throughout the year from veld, with no supplementary feed provided. An open breeding season is followed, with the rams having access to the females throughout the year.

4.3.4.2 Dundee Research Station

At the DRS, the sheep have access to a sheep lick (Maxiwol Production pellets™) year round. Except for grazing experiments, sheep are normally kept on veld during summer using a rotational grazing system, which is based on the carrying capacity of veld, which is estimated as 1.125 ha s.s.u.⁻¹ annum⁻¹. In winter, sheep are kept on pastures or grazing maize with a winter lick provided to alleviate nutrient deficiencies.

At the DRS breeding is controlled. Rams get access to ewes from December to January each year, resulting in an autumn lambing season. A strict health programme is followed, with vaccinations and a strategically managed external parasite control system.

4.3.5 Data collected

4.3.5.1 Phenotypic characteristics assessment

Qualitative descriptive traits used were tail appearance (thin or fat), facial profile, back profile, coat colour and pattern were concerned. The quantitative traits were head length and width, ear length, horn length, shoulder height, body length, pelvic width, heart girth, tail length, tail width and live weight. Linear body measurements should be divided into skeletal and tissue measurements, with skeletal measurements being all height and length measurements, while tissue measurements include heart girth, chest depth, paunch girth and width of hips (Blackmore *et al.*, 1958; Essien and Adesope, 2003). Quantitative traits that include tissue measurements, opposed to skeletal measurements, where the level of nutrition might have an influence, such as heart girth and tail width, were compared between seasons (end of winter and end of summer weights).

4.3.5.2 Live weight prediction

The live weight per individual sheep (electronic scale weight) was compared between seasons (end of winter and end of summer weights) and Research Stations. Heart girth was also measured with an ordinary measuring tape and the predicted live weight from the commercial goat weight band recorded.

4.4 Statistical analysis

Simple correlation coefficients (using Excel software) between body measurement (heart girth) and real live weight of the sheep (as measured using the electronic scale) was done (Agamy *et al.*, 2015). A comparison was done on the relationship for the goat band and predicted sheep weights and real scale weights.

The qualitative traits were assessed using a t-test with a 95% level of confidence (Genstat), (VSN Int., 2015). (Genstat outputs are available under the folder: Annexures\Stats analyses\Chapter 4).

4.5 RESULTS

4.5.1 Site climatic conditions

Climatic data obtained from the Agricultural Research Council (ARC) (Agricultural Research Council, 2018) weather stations, based at the MRS and DRS. Although the mean monthly rainfall recorded indicated normal rainfall figures, erratic rainfall was experienced, with long periods (characterized by high heat) between showers heightening the experience of a drought. Late rains in the latter part of the growing season (February and March 2018) in Makhathini was experienced, with one event in excess of 200mm, with large amounts of runoff water and erosion.

4.5.1.1 Makhathini Research Station

Notably high temperatures were experienced in December 2016 (Figure 4.6). This was a very dry period and dam levels plummeted.

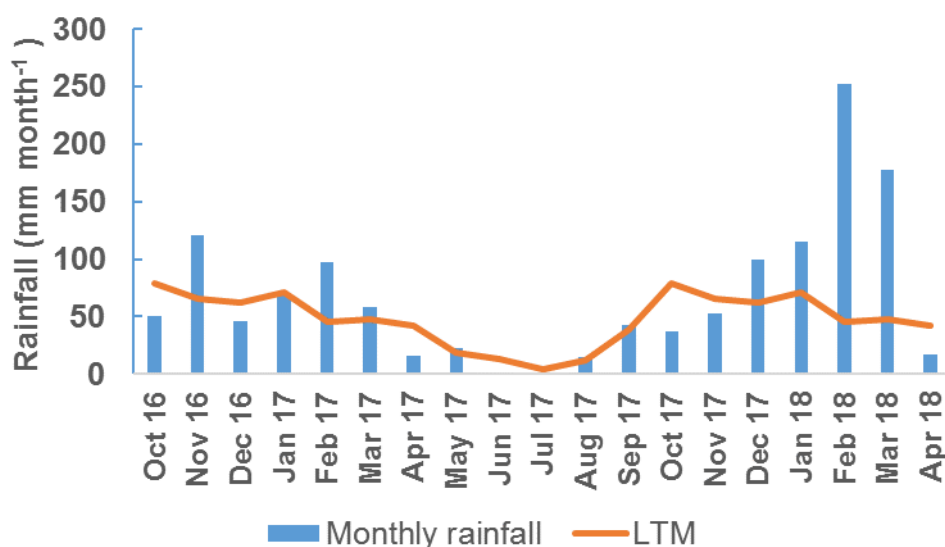


Figure 4.5: Makhathini Research Station mean monthly rainfall compared to the long term mean (LTM) rainfall (Agricultural Research Council, 2018)

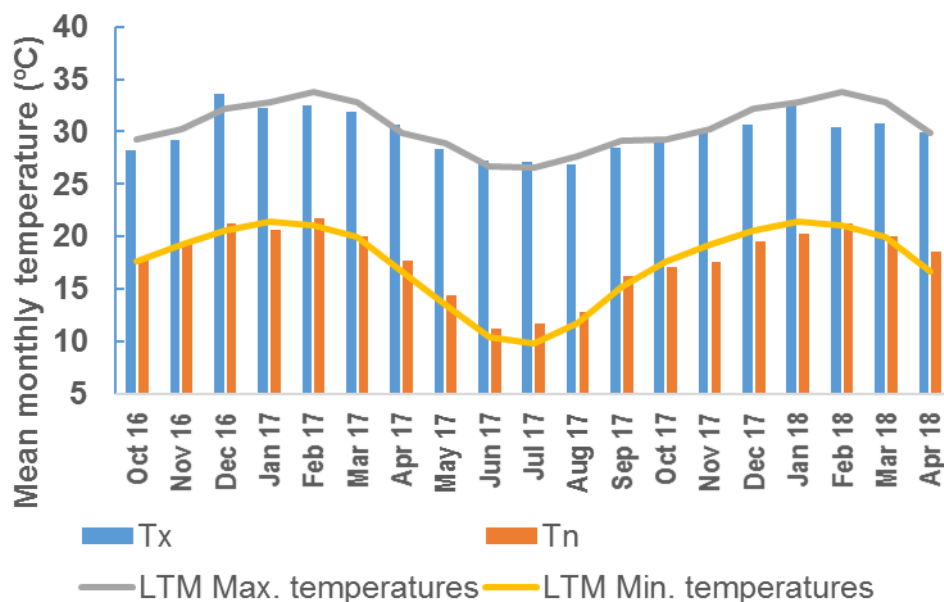


Figure 4.6: Makhathini Research Station mean monthly maximum and minimum temperatures compared to the long term mean (LTM) (Agricultural Research Council, 2018)

4.5.1.2 Dundee Research Station

Figures 4.7 and 4.8 illustrates the weather pattern experienced at the DRS in the period from October 2016 until March 2018.

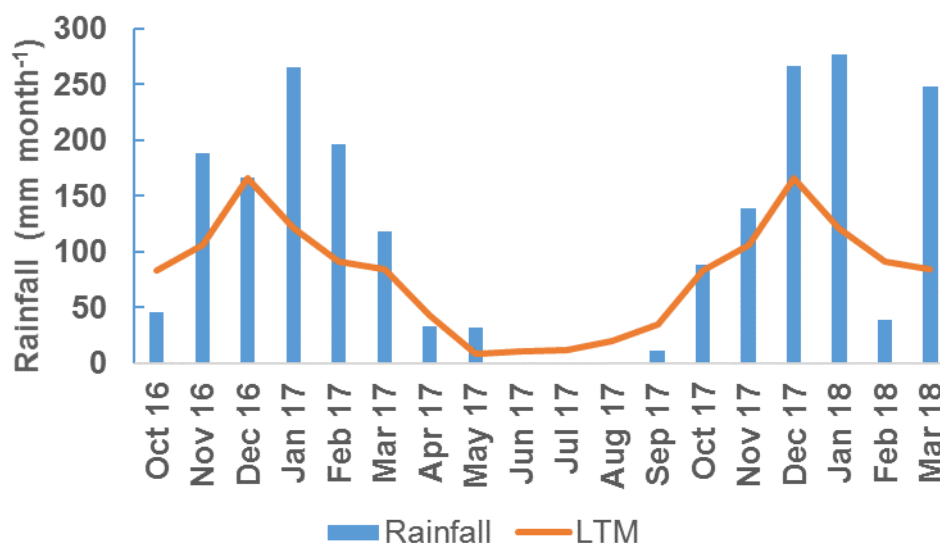


Figure 4.7: Dundee Research Station rainfall from October 2016 to March 2018 in relation to the long term mean (LTM) monthly rainfall (Agricultural Research Council, 2018)

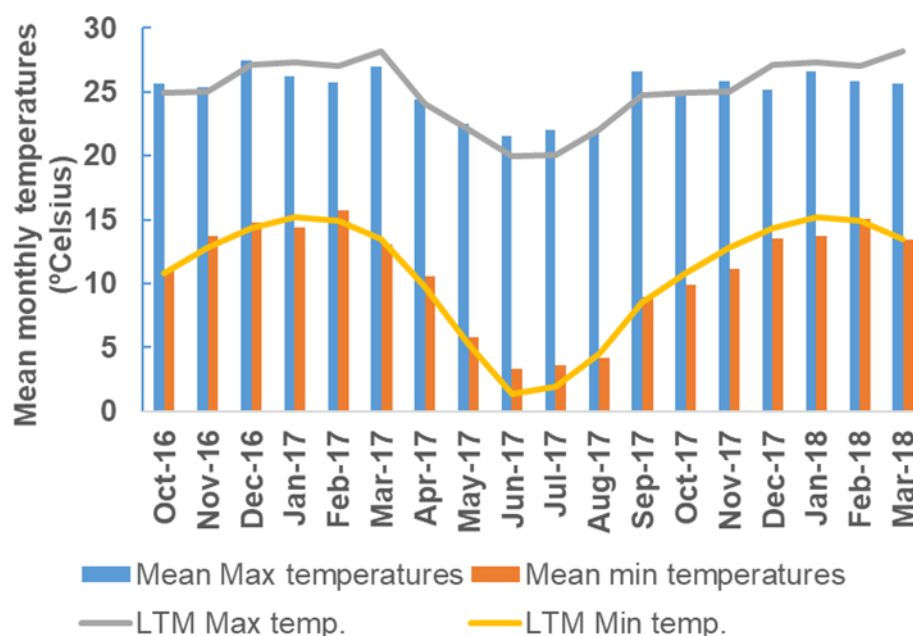


Figure 4.8: Dundee Research Station monthly minimum and maximum temperatures from October 2016 to March 2018 in relation to the long term mean (LTM) monthly temperatures (Agricultural Research Council, 2018)

For two growing seasons (2017 and 2018) above normal (LTM) rainfall was experienced at the research station, with showers in excess of 50mm at a time. This caused runoff and erosion. Temperatures stayed within the normal (LTM) ranges except for the winter temperatures that were higher than the LTM.

4.5.2 Qualitative traits – sheep evaluation

Figures 4.9 to 4.13 illustrate the qualitative traits of the Nguni sheep that were recorded at the MRS and DRS. Pie charts are used to indicate the incidence of the different characteristics, firstly within each research station and then as a mean for the breed.

The qualitative traits were visual appraisals, with only tails being measured to verify the visual appraisals.

4.5.2.1 Tail appearance

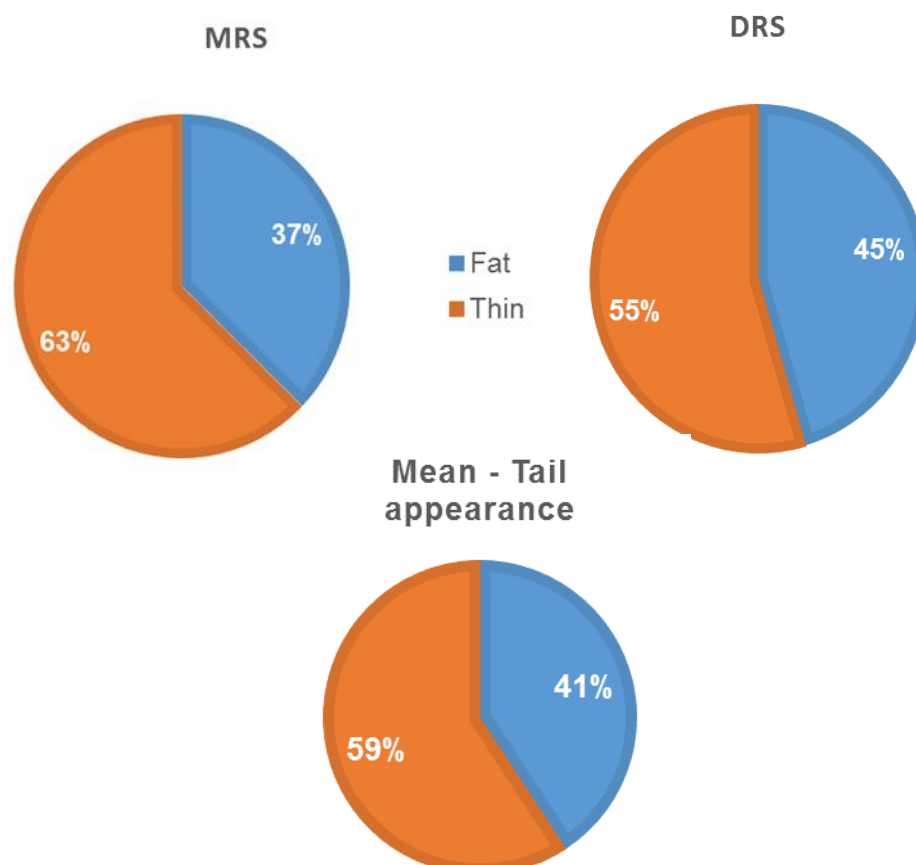


Figure 4.9: Occurrence of fat and thin tails in Makhathini Research Station and Dundee Research Station sheep

The majority of sheep at the MRS (63%) had thin tails compared to the 55% at the DRS, with an overall mean of 59% of sheep with thin tails, and 41% with fat tails (Figure 4.9).

4.5.2.2 Facial profiles:

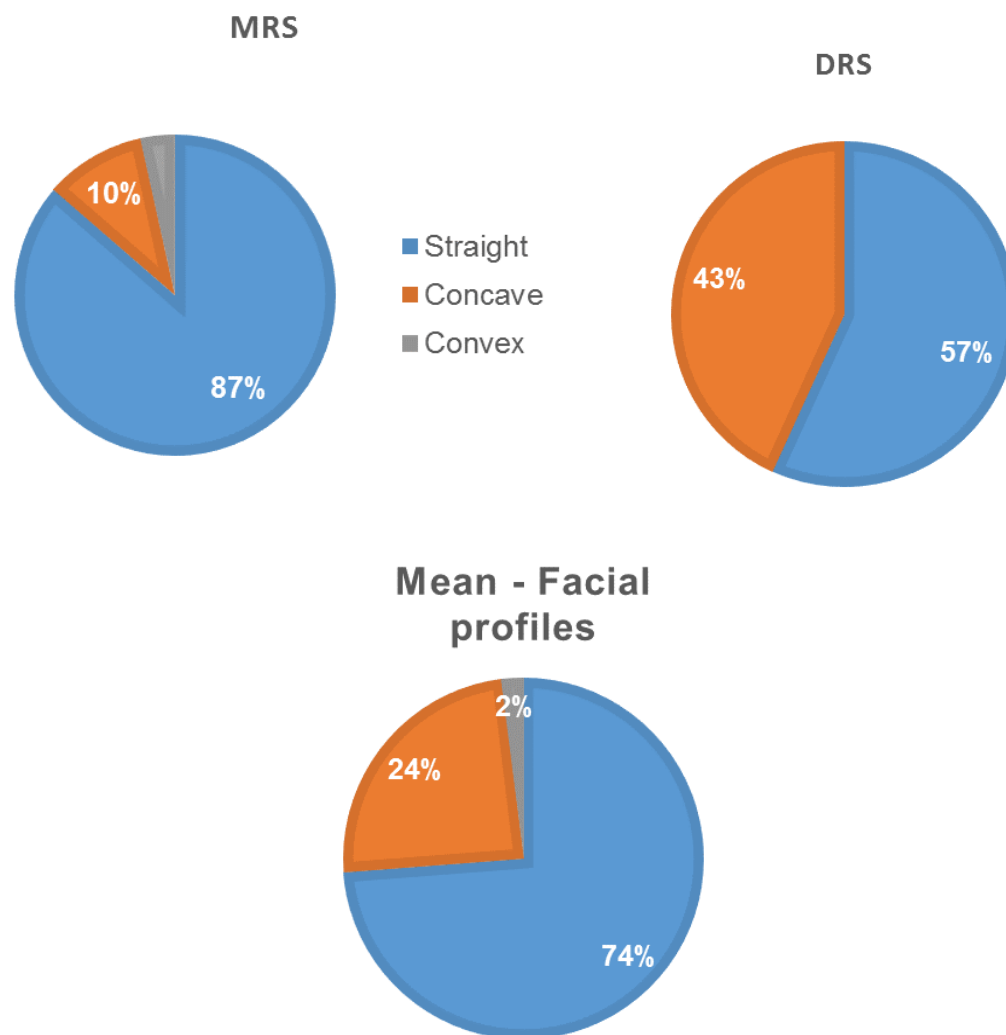


Figure 4.10: Occurrence of straight, concave and convex facial profiles in Makhathini Research Station and Dundee Research Station sheep

The majority of sheep at the MRS (87%) displayed straight facial profiles, compared to slightly more than half (57%) at the DRS. Only 10% of sheep at MRS displayed concave or Roman profiles, whereas at the DRS 43% displayed concave noses. Overall, only 2% of sheep had convex facial profiles (Figure 4.10).

4.5.2.3 Back profiles:

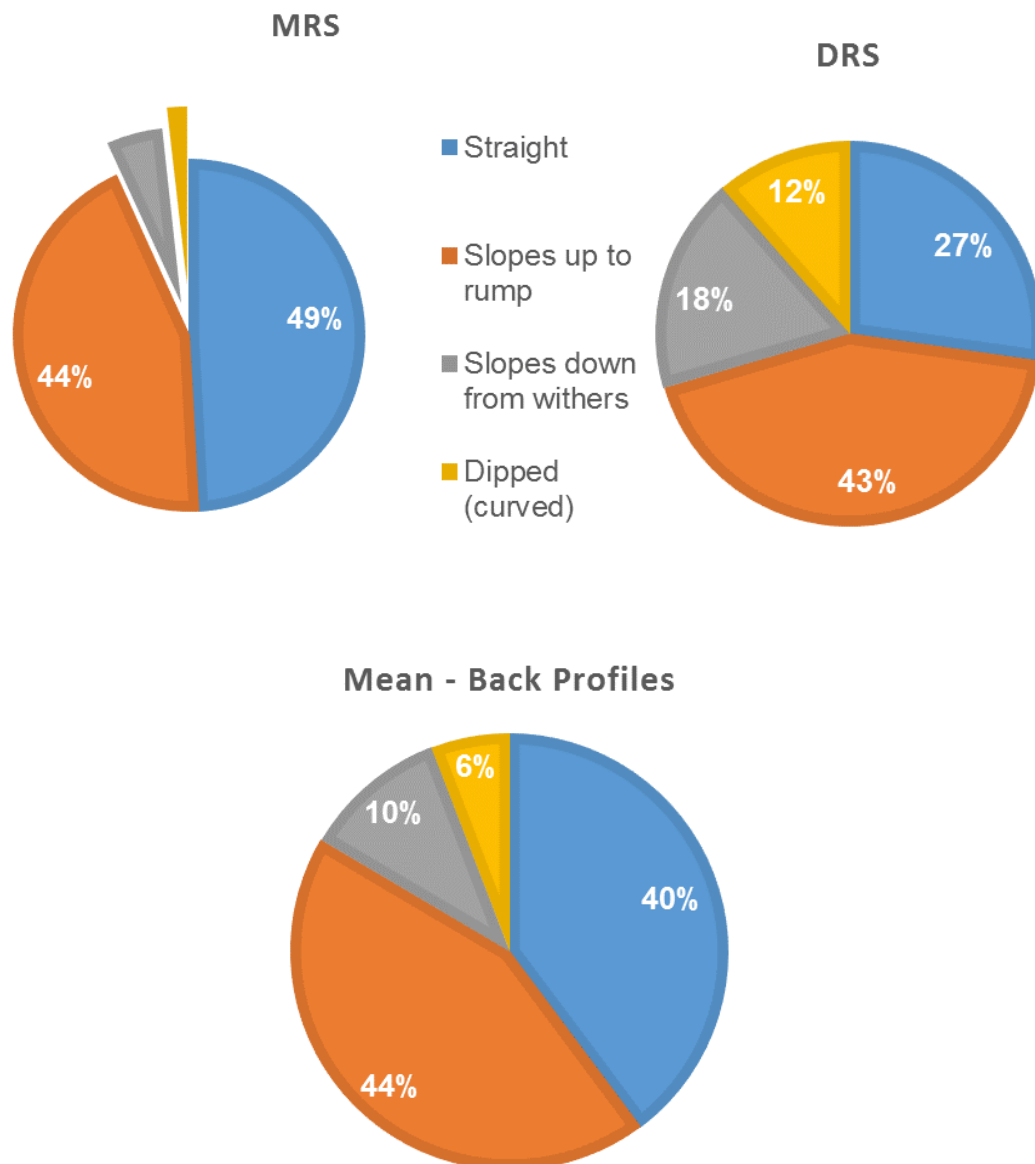


Figure 4.11: Occurrence of straight, sloping up to the rump, sloping down from the withers and dipped back profiles in Makhathini Research Station and Dundee Research Station sheep

The majority of MRS sheep displayed either a straight back (49%) or a back that sloped up to the rump (44%) (Figure 4.11). At the DRS there was a greater inconsistency in the appearance of the back profiles, with 43% showing backs that slopes up to the rump, 27% with straight backs, 18% that sloped down from the withers and 12% with undesirable dipped backs.

4.5.2.4 Predominant coat colouring and pattern

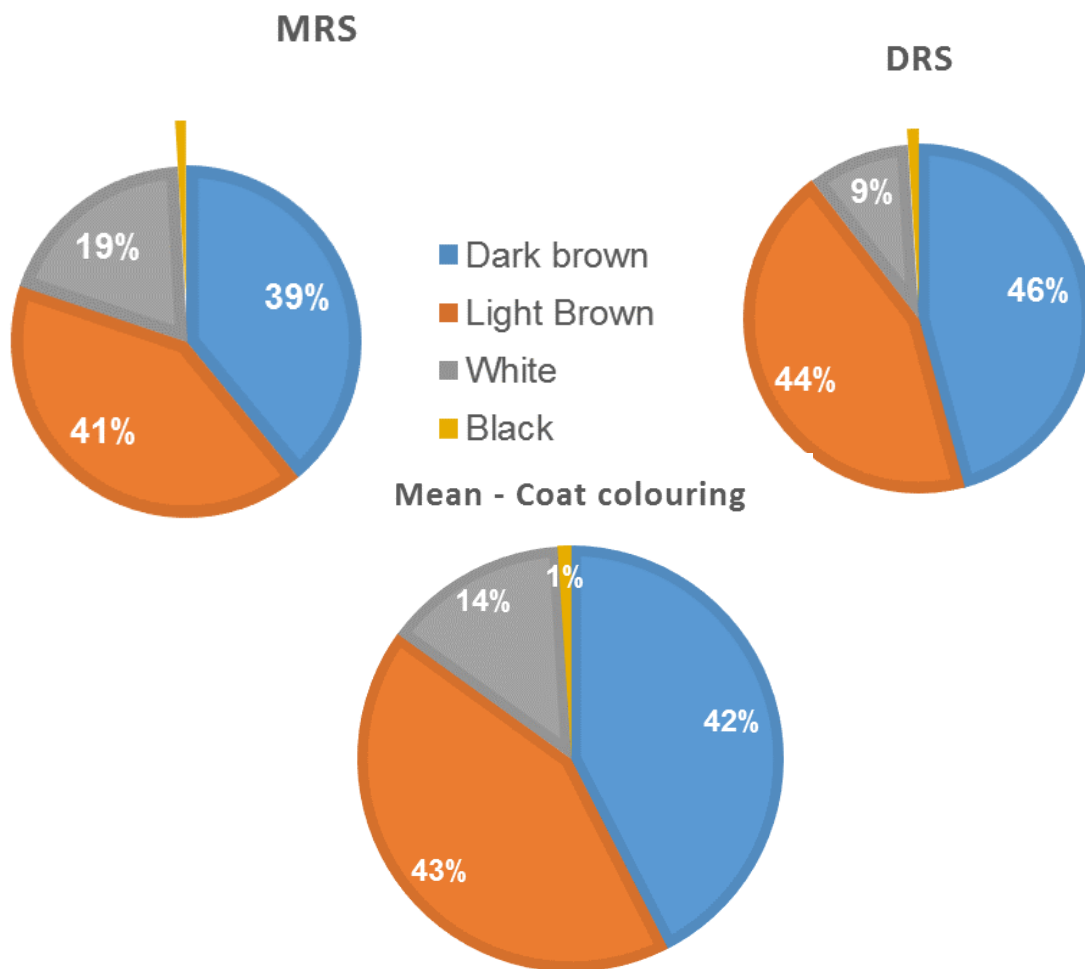


Figure 4.12: Occurrence of dark brown, light brown, white and black as predominant coat colouring in Makhathini Research Station and Dundee Research Station sheep

Dark brown (46%) and light brown (44%) were almost equally prevalent in the DRS group, as displayed in Figure 4.12. The colouring of the sheep at the MRS was more diverse, with white present in 19% of coats. Black as the dominant coat colour was very scarce, and black was found in either heads, feet or tail tips.

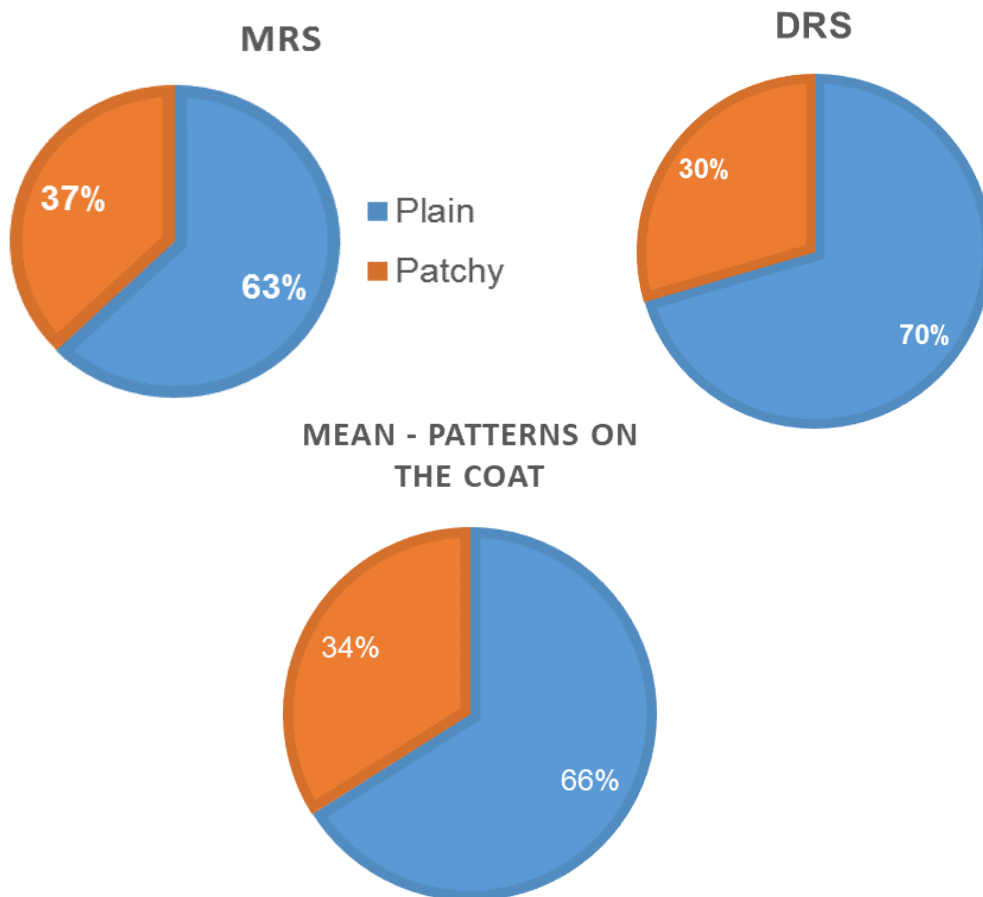


Figure 4.13: Occurrence of a plain, patchy and spotted coat pattern in Makhathini Research Station and Dundee Research Station sheep

The colours mentioned in Figure 4.13 indicate predominant coat colourings of the Nguni sheep. The Nguni sheep, however, do not always have a uniform coat colour but can have patterns, i.e., patches or less frequently spots, that occurred in a mixture of black, white, light brown or dark brown. Nguni sheep can be either dark brown or light brown as base colour. Black feet and heads (to complement dark or light brown) were common, with white patches on the sides of the ribcage or the tips of tails. Spots or dappling were not recorded in the two flocks.

The majority of the sheep at the DRS (70%) were plain dark brown, while the animals at the MRS displayed greater diversity, with 63% plain and 37% with a patchy coat pattern (Figure 4.13). Overall, two-thirds of the sheep had a uniform coat colour and a third had a patchy pattern on their coats.

4.5.3 QUANTITATIVE TRAITS

4.5.3.1 Head length, head width and ear length

Small differences regarding head length (which were insignificant) were found between the sheep at the DRS and MRS, with the sheep at the MRS having slightly longer, heads than the DRS sheep (Table 4.1). A highly significant difference ($P < 0.001$) was found in head widths between the flocks.

The sheep at the MRS also had slightly longer ears ($9.39 \text{ cm} \pm 2.53$) than the sheep at DRS ($8.13 \text{ cm} \pm 2.87$) (Table 4.1). Within the groups evaluated, there were four sheep at DRS that had ears shorter than 5 cm, which equals 9.1% of the flock, whereas at the MRS, only two sheep had ears shorter than 5 cm (3.4% of the flock). The difference between the flocks are however not significant.

Table 4.1: Sheep heads measurements indicating the mean length and width as well as the mean length of the ears

| Research Station | Sheep trait (cm). | | |
|------------------|-------------------|------------------|-----------------|
| | Head length | Head width | Ear length |
| Makhathini | 23.26 ± 1.34 | 11.89 ± 0.74 | 9.39 ± 2.53 |
| Dundee | 22.21 ± 1.76 | 12.94 ± 0.78 | 8.13 ± 2.87 |
| Probability | NS* | $P < 0.001$ | NS* |

*NS – No significance ($P\text{-value} > 0.05$)

4.5.3.2 Horns

Horns in the females are non-existent in the MRS flock, and in the DRS flock only 2 adult females (4.5%) had horns with lengths between 2.5 and 5cm.

4.5.3.3 Shoulder height, body length and pelvis width

Shoulder height, body length and pelvis width data are displayed in Table 4.2. The sheep at the DRS displayed larger mean body measurements in all these traits, except body length, compared to the MRS sheep. Differences in pelvis widths were highly significant ($P < 0.001$).

Table 4.2: Mean shoulder heights, body lengths and pelvis widths of the sheep on Makhathini Research Station and Dundee Research Station

| Research Station | Sheep trait (cm). | | |
|--------------------|-------------------|--------------|--------------|
| | Shoulder height | Body Length | Pelvis width |
| Makhathini | 61.97 ± 4.04 | 61.53 ± 3.38 | 17.57 ± 1.86 |
| Dundee | 63.45 ± 4.34 | 56.03 ± 7.15 | 19.84 ± 2.49 |
| Probability | NS* | NS* | P<0.001 |

**NS – No significance (P-value > 0.05)*

4.5.3.4 Heart girth

During the summer the animals on MRS increased in mean Heart girth by 4.92cm, while the mean heart girth of the flock on DRS decreased by 1.87cm, (Table 4.3). These differences were highly significant (P<0.001). Post-winter, the mean live weight of MRS sheep was 28.58 ± 3.98 kg ewe⁻¹ while post-summer the mean live weight of ewes was 29.88 ± 4.22 kg ewe⁻¹, indicating an increase of 1.30 kg ewe⁻¹ or 4.55% increase. In the DRS group the difference in the mean live weight of the animals between post-winter and post-summer was 2.84 kg ewe⁻¹ or an 8.48% increase (33.48 ± 5.71 kg ewe⁻¹ for post-winter and 36.32 ± 6.06 kg ewe⁻¹ for post-summer).

Table 4.3: Heart girth measured post-winter and post-summer

| Research station | Heart girth (cm) | | |
|--------------------|------------------|--------------|-----------------|
| | Post-winter | Post-summer | Mean difference |
| MRS | 70.00 ± 4.67 | 74.92 ± 4.03 | 4.92 |
| DRS | 77.74 ± 5.96 | 75.87 ± 5.68 | -1.87 |
| Probability | | | P<0.001 |

**NS – No significance (P-value > 0.05)*

4.5.3.5 Tail lengths and width

Considering the mean tail lengths, the sheep at MRS had slightly longer tails (34.20 ± 3.39 cm) than the DRS flock (32.68 ± 3.60 cm). The mean tail width measured post-winter for the DRS sheep (12.74 cm ± 2.90) was slightly wider than the MRS sheep (12.33 ± 3.11) (Table 4.4). Tail measurements had no significant differences.

Table 4.4: Mean tail length (cm) and mean tail widths (cm) post-winter and post-summer

| Research Station | Sheep trait (cm). | | | |
|--------------------|-------------------|---------------------------|---------------------------|---|
| | Tails - length | Tails – width post-winter | Tails – width post-summer | Tails widths – changes (cm) post-summer |
| Makhathini | 34.20 ± 3.39 | 12.64 ± 4.02 | 12.03 ± 2.34 | -0.61 |
| Dundee | 32.68 ± 3.60 | 12.87 ± 3.01 | 14.69 ± 3.79 | 1.82 |
| Probability | NS* | | | NS* |

**NS – No significance (P-value > 0.05)*

When the tail width was measured again post-summer, the mean tail width of sheep at MRS, however with some variation, decreased by 0.61 cm, compared to winter measurements. The mean tail width of DRS sheep increased by 1.82 cm compared to the post-winter measurements (Table 4.4).

4.5.4 Live weight predictions

4.5.4.1 The relationship between heart girth (cm) and live weight (All adult sheep)

The data to calculate the relationship between heart girth and live weight was collected from 292 sheep (Figure 4.14).

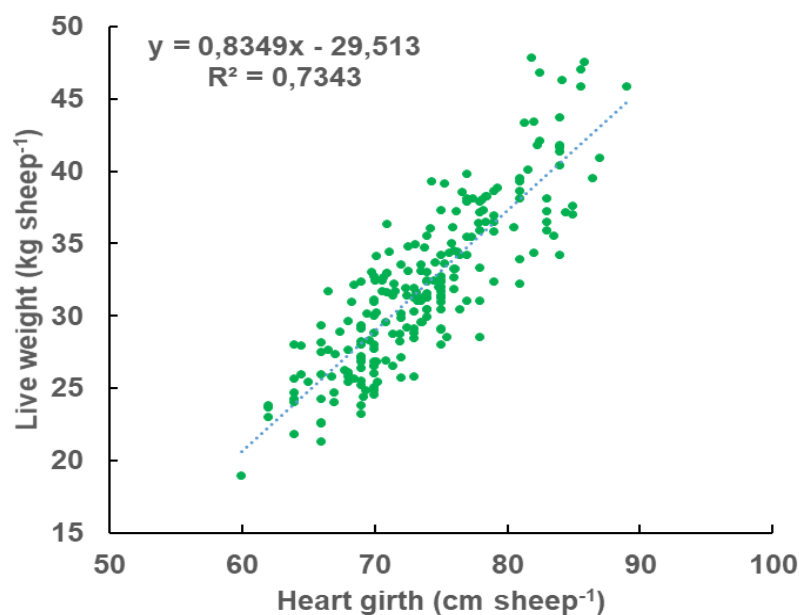


Figure 4.14: Correlation between heart girth (cm) and live weight (kg sheep⁻¹) determined by using an electronic scale for Nguni sheep

The linear regression equation for the heart girth versus scale live weight:

$$Y=0.8349x - 29.513$$

$$R^2 = 0.7343$$

4.5.4.2 Accuracy of a goat weight band to determine the live weight of Nguni sheep (kg sheep⁻¹).

The data to calculate the relationship between the predicted weight according to the goat band (De Villiers *et al.*, 2010) and the weighed live weight was collected from 292 sheep (Figure 4.15).

The linear regression equation for the goat weigh band versus scale live weight:

$$Y=0.6896x + 5.8142$$

$$R^2 = 0.6678$$

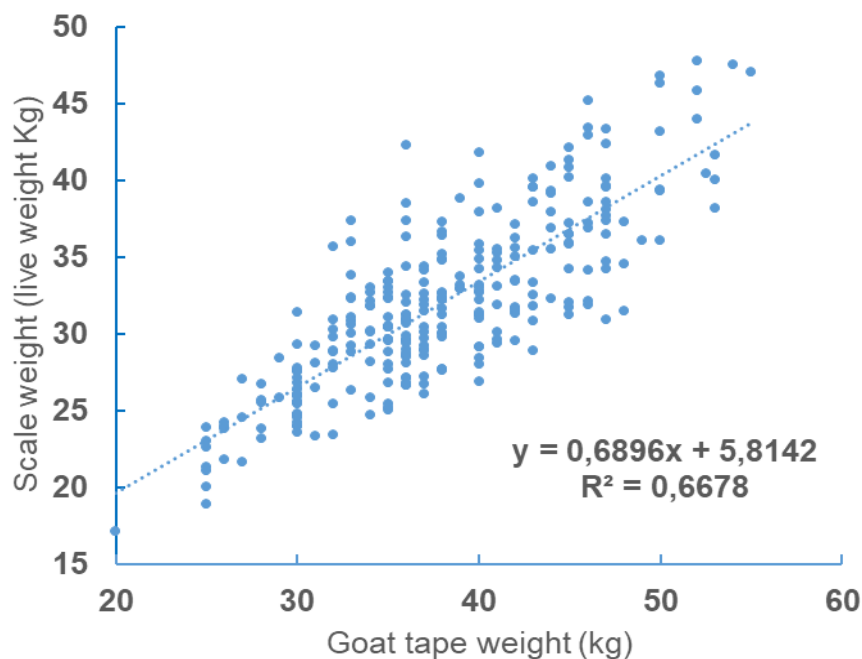


Figure 4.15: Weigh band weight correlated with body weight measured by electronic scale - Nguni sheep ewes of both Makhathini Research Station and Dundee Research Station

Live weight prediction using the goat weight band had a reliability of 66.78%, compared to predictions based on heart girth that had a reliability of 73.43%, indicating that, although it is a small difference, heart girth of Nguni sheep gave a 6.65% better estimation of body weight than the goat weigh band.

4.6 DISCUSSION

According to Nicholas (1998), the Nguni sheep is a semi-fat tailed breed with a tail that is broad at the base and tapered to the tip. However, Ramsay *et al.*, (1998) described the breed as fat-tailed. This study showed that 59% sheep had thin tails, and 41% had fat tails, which confirms that the breed can be described as a semi-fat tailed breed. Whilst not formally assessed during the study the males had lobbed tails, (tails that displays two lobes when observed from the bottom, indicating a very fat tail).

The majority of sheep displayed straight faces. However, variation occurred and in the DRS flock more concave faces were observed, compared to the MRS flock. Most of the Nguni sheep assessed had backs that sloped up to the rump (44%), or were level backs (40%). However, a notable difference was that different back profiles existed between the two flocks assessed. The sloping back profiles might be linked to typical traits such as an easy gait or walking ability of indigenous animals, which Epstein and Mason (1971) referred to. Ramsay *et al.*, (1998) also referred to the good walking and foraging ability of the Nguni sheep.

Light brown (43%) and dark brown (42%) were equally prevalent and were the predominant colours of the sheep assessed. Only 14% white sheep occurred, with black as a very scarce predominant colour. These colours were present as 66% plain and 30% patchy patterns over the sheep's body. Ramsay *et al.*, (1998) described the sheep as multi-coloured with brown and black variations as the most common. Kunene *et al.*, (2007) found in their survey of Nguni sheep in different localities in northern KZN that brown was the dominant colour (19%), with a combination of brown and white (18%) and black and brown (16%).

Nicholas (1998) reported that black was the predominant colour of sheep in the Makhathini area, but Kunene *et al.*, (2007) made the observation that lambs that started out as black in colour gradually changed to a brown or dark brown colour.

Jimmy *et al.*, (2010) found that coat colouring had no significance ($P>0.05$) on any live body measurements, whereas Kunene *et al.*, (2007) considered that coat colour had a significant effect on the live body measurements of the Nguni sheep ($P<0.001$).



Figure 4.16: Black lambs appear to be common in a flock where none of the adult sheep displays black as the dominant colour – DRS flock 2018

Regarding coat type, but not assessed in this study, Nicholas (1998) described the coat of the Nguni sheep as characteristically hairy, which can be matted and sometimes develops into shards on the back. The sheep's hairy coat might discourage tick attachment as an adaptive trait. Ramsay *et al.*, (1998) mentioned that the Nguni sheep tends to be more "woolly" than breeds such as the Pedi and Damara. Coat type might be correlated to the breed's tolerance of heat in sub-tropical areas, such as the locale of the MRS.

Regarding quantitative traits, a highly significant difference existed between DRS and MRS sheep, with DRS sheep showing larger head width. The differences between the head lengths were insignificant. The ear length differences between the two groups were also insignificant. Epstein and Mason (1971) mentioned that the "fat-

tailed sheep of East Africa are frequently devoid of the external ear; every degree of variation is noticeable – from a perfect ear to an ear of which only the scantiest vestige remains. Often the orifice of the ear is so small that it will not permit the introduction of anything thicker than a pencil”. However, Nicholas (1998) stated that the ears of most Nguni sheep are either short or underdeveloped with a few totally earless. Ramsay *et al.*, (1998) observed that mouse ears were present in large numbers in the breed. In this study “mouse ears” were only occasionally observed in 9.1% of sheep in the DRS flock and 3.4% in the MRS flock. But the absence of the auricular in sheep is due to a single hereditary factor and mouse ears were more prevalent in certain flocks (Epstein and Mason 1971). Many of the Nguni sheep flocks are small and scattered. This implies that they exist as genetically closed flocks, making this phenomenon more predominant.

Regarding the “mouse ears” phenomenon, Epstein and Mason (1971) commented that “the genetic factor governing the formation is relatively potent”. He further cited Wriedt (1927), who explained that the absence of the auricular in sheep is due to a single heredity factor. In crossing earless sheep with animals having normal length ears, the entire F1 generation carries ears of about half the normal size ears. If such short eared sheep are interbred, the F2 generation is composed of 25% homozygous earless sheep, 25% homozygous animals with ears of normal length and 50% heterozygous short-eared specimens.

In their study, Kunene *et al.*, (2007) found that ear length had no influence on body measurements.

Some variation was detected in the body measurements between MRS and DRS sheep. The sheep at the DRS displayed larger mean body measurements for shoulder height, which was insignificant. Highly significant pelvic width differences ($P < 0.001$) were found and sheep at the MRS had a longer mean body length, which was found to be insignificant. These skeletal measurements are part of tissue measurements and researchers found positive relationships between certain body measurements and accurate live weight predictions.

Fourie *et al.*, (2002) found in their study on Dorper rams that there was a positive correlation between body length and body weight ($R^2 = 0.76$). They also used shoulder

height and live weight in a medium correlation ($R^2=0.55 - 0.58$). Jimmy *et al.*, (2010) mentioned that they could predict live weight of the animals using linear body measurements (heart girth, wither (shoulder) height, corpus length and rump height). After pooling these measurements, a prediction of live weight was made with an R^2 of 0.91. Badi *et al.*, (2002), who worked on goats, found that in a linear equation to predict live weight, height at withers can be used as a supplementary variable with heart girth, and accounted for 91% of variation. However due to restricted numbers of sheep assessed, these relationships were not further analysed.

The positive relationship between heart girth and body weight is well documented (Slippers *et al.*, 2000; Badi *et al.*, 2002; Khan, 2006; Kunene *et al.*, 2007; De Villiers *et al.*, 2010; Jimmy *et al.*, 2010). However, Kunene *et al.*, (2007) found that age, location and pregnancy status seemed to make the biggest contribution ($P<0.001$) to the variation in linear body measurements of the sheep. The ewes assessed at DRS, were weaned post-winter off grazing maize and were in a good body condition. Post-winter, the mean heart girth of mature ewes at DRS sheep measured 77.41 ± 5.95 cm ewe⁻¹.

Summer grazing was done on veld. The early summer that followed the area received below normal rain and only after December, when good rains were received, did the veld grazing quality improve. (See rainfall records for DRS, Figure 5.1, Chapter 5). The mean heart girth of the ewes decreased with 1.87 cm ewe⁻¹ to 75.87 ± 5.67 cm ewe⁻¹ when measured post-summer. Although an increase in scale weight of the sheep was recorded from post-winter to post-summer, a decrease was noted in the heart girth from post-winter to post-summer. This phenomenon is hard to explain because heart girth was expected to increase with increased live weight. A possible explanation might be the production of cashmere in the DRS flock over the winter period. The DRS is much colder in winter than the MRS, which might promote the production of cashmere. This, however, needs further investigation.

The ewes at the MRS, following an open breeding season, were mostly lactating and were challenged with restricted nutrition - the effects of a period of more than a year with below rainfall (See rainfall records for MRS under Annexures: Weather data). Rainfall conditions improved during the following summer, resulting in more abundant

feed and mean live weight increase of 4.55%, followed by a heart girth increase from post-winter of 70.00 ± 4.67 to post-summer 74.92 ± 4.03 cm ewe⁻¹.

Atti *et al.*, (2007) stated that, in case of a restriction of energy supply, non-gut tissues are generally mobilized in the following order: fat, muscle and then bone, which is the reverse of the order of deposition. According to Kunene *et al.*, (2007), heart girth measured at the MRS was reported to be 75.48 cm, which corresponds well to the findings in the MRS sheep in this study.

MRS sheep had slightly longer tails than DRS sheep. Mean tail length varied between 33 and 34 cm, but this difference was found to be insignificant. Tail width was expected to vary between seasons and therefore was measured post-winter and post-summer. Research has shown that in fat-tailed and semi-fat tailed sheep, fat can be mobilized from the tail under conditions of nutritional stress, as was found by Atti *et al.*, (2004) in work done on the Barbarine sheep. However, it was concluded that the sheep mobilize reserves not only from the tail, but the rest of the body as well.

The mean tail width for ewes at the MRS, post-winter was 12.64 ± 4.02 cm and declined over the summer to 12.04 ± 2.34 cm, which indicates a slight loss of -0.60 cm. The mean tail width for DRS ewes was 12.87 ± 3.01 cm post-winter and 14.69 ± 3.79 cm post-summer which showed a mean increase of 1.82 cm, but this difference is statistically insignificant. Regarding MRS ewes, the trend was a slighter narrower tail. However, live weight and heart girth increased from post-winter to post-summer. Although the ewes at the DRS showed increased tail width the difference between the two flocks are insignificant. The Nguni sheep's mobilization of fat reserves from the tail, under limited energy intake, needs further investigation. More data is needed, as body measurements of the sheep is bound to change as seasons, climatic conditions and reproduction stage change.

The linear regression for the relationship between heart girth and actual scale weight of 292 sheep had an R^2 of 0.7343. This is in accordance with work done by Kunene *et al.*, (2009) who found the coefficient of determination (R^2) based on linear heart girth to be 0.71, but they mentioned that the third degree polynomial of heart girth increased R^2 to 0.76. The use of hearth girth as a measurement is compromised, however,

because there is great variation in coat type of Nguni sheep, between seasons and between individuals, is from hairy to sometimes matted and worn in shards (Nicholas, 1998) or be “woolly” (Ramsay *et al.*, 1998) or display kashmir (Van Zyl, 2017).

Body weight is one of the most important parameters in animal production. Weight determination of animals forms part of management and good animal husbandry, and as Agamy *et al.*, (2015) affirmed, when the producers and buyers of livestock are able to relate live animal measurements to growth characteristic, then an optimum production and value based trading system can be realized from accurate predictions. The administration of medicine is usually based on animal live weight as correct dosages must be administered when treating diseases or internal parasite infestations. This is also the case when animals have to be fed supplements, and timing when female animals can be mated (determining ideal weight). The weight band is a simple and practical tool for the resource poor farmer, where scales are normally not accessible, to estimate the live weight of the animals (De Villiers, *et al.*, 2010).

The linear regression resulting from calculating the relationship between the predicted body weight of sheep from heart girth and goat weigh band weight of 292 sheep, delivered an R^2 of 0.6678. By using the regression equation: $y = 0.6896x + 5.8142$, the live weight of a Nguni sheep can be estimated with fair accuracy (67%) by using the goat weight band. The linear regression resulting from calculating the relationship between heart girth and actual scale weight of 292 sheep for this study was more accurate than predicting the live weight using the goat band and was also in accordance with previous investigations (Kunene *et al.*, 2009). The live weight according to the goat band tend to overestimate the real live weight of Nguni sheep by $\pm 5.93 \text{ kg sheep}^{-1}$. It can be argued that the coat differences between the sheep and goats might have a contributing effect.

4.7 CONCLUSION

The aim of this study was to do a phenotypic evaluation of two flocks of Nguni sheep kept at the Makhathini and Dundee Research Stations. The natural environment (BRG 14 and BRG 22), as well as management practices between the two research stations, differ greatly. These variances appeared to result in some phenotypic differences in

mean skeletal dimensions (head widths, pelvis width and heart girth). The MRS sheep were longer in body length, but their pelvises were smaller.

Differences occurred in coat colour between the two flocks, but predominantly the sheep were plain dark brown with a short hair, straight backs with long slender legs, medium size ears and no horns. The majority of the sheep developed medium to fat tails. The more intensive management at the DRS probably resulted in a larger heart girth and pelvis width.

Live weight prediction using the goat weight band had a reliability of 66.78%, compared to predictions based on heart girth that had a reliability of 73.43%.

The data collected in this part of the study can be used in the future to link different body traits and production potential, although more data is needed to build a comprehensive phenotypic study of the Nguni sheep.

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CHAPTER 5

The influence of nutritional levels during post-natal and post- weaning life on the performance of Nguni sheep with Merino sheep as a comparative breed

5.1 ABSTRACT

The objective of the study was to assess the performances of Nguni sheep under different nutritional conditions and to compare its performance to that of the Merino, a breed commonly used in the area. The first part of the experiment (winter trial) was to assess performances of lactating ewes and their lambs (Nguni ewes: n=28 with lambs n=29 and Merino ewes: n=24 with lambs n=37) on forages with different nutritional levels (grazing maize and veld) during winter. The second part of the experiment assessed the performances of the lamb's post-weaning the next summer (Merino n=24 and Nguni n=20), taking into account the carry-over effect of nutritional conditions the lambs were exposed to during winter. Feed analyses were done to determine the quality of forages throughout the duration of the trials. The animals were weighed on a weekly basis and percentage live weight gained or lost was assessed. A highly significant ($P<0.001$) difference in ewe performance, (% weight change from starting to end weight) existed between the forage treatments during winter, but no significance was measured in ewe performance between breeds. The ewe efficiency in Nguni ewes were significantly better ($P<0.05$) than the ewe efficiency in Merinos. The carry-over effect of winter-feeding conditions affected future sheep performances and in both breeds, the lambs under nutritional stress in winter, whether on veld or kikuyu, became permanently stunted. Both treatments, (maize + Kikuyu = HH; maize + veld = HL; veld + Kikuyu = LH; veld + veld = LL) and the two sheep breeds presented highly significant differences ($P<0.001$) in lamb growth.

These results showed that if nutritional stress is relieved, the Nguni sheep can perform as well as Merino with regards to relative productivity.

5.2 INTRODUCTION

Small ruminants contribute a major component of the income of small-scale farmers in low rainfall areas of Africa and Asia. Communal farmers are dependent upon communal veld as the primary source of grazing for their animals. Salem and Smith (2008) commented that overgrazing of the communal grazing lands was becoming more and more evident in developing countries of the world, with resultant nutrient shortages. In most developing countries, rangeland (veld) management is restricted to continuous grazing, or burning, or a combination of the two. Mismanagement of veld, including overgrazing, usually results in a degraded rangeland condition, associated with changes in species composition. The surviving plant species are usually low in productivity, are unpalatable, have low digestibility and, depending on the soil type, contain low concentrations of minerals (Preston and Leng, 1987).

In Southern Africa, the livestock sector is an important component of the agricultural economies of the region, because over 60% of the region's total land area is non-arable (Dzama, 2016). Most of the region's indigenous livestock systems are based on communal grazing. The main constraint identified as common to all communal livestock systems in South Africa has been the inadequate quantity of rangeland forage at the end of the dry season (Scogings *et al.*, 1999). The condition of communal veld in KwaZulu-Natal is among the worst and most overgrazed in South Africa (Peden, 2005). Livestock mortality is often high during droughts in communal areas, especially if the animals are not fed supplements (such as protein in the winter), or do not have access to key resource areas, i.e. "vlei" (marshy) areas (Scogings *et al.*, 1999).

According to the survey on distribution of Nguni sheep in KZN (Chapter 3), herds of Nguni sheep are found in several bioclimatic zones in KZN, ranging from sub-tropical areas with sweetveld, to sourveld in the more temperate, high rainfall areas of the province. The general condition of this communal veld is described as overgrazed veld, and in many cases, the veld has been pushed back to a pioneer stage dominated by low-quality grasses and forbs (Vetter, 2004).

Preston and Leng (1987) stated that where nutritional and environmental constraints are absent, potential feed intake is determined by an animal's genetic potential for production. The quantity and quality of feed consumed determines the productivity that is achieved. In the case of poor quality forages, nutritional intake by animals is low without supplementation. Supplementation with a source of non-protein nitrogen (NPN) and bypass protein can increase the amino acid supply to the animal and increase nutritional intake (Kempton, 1982).

Overwintering of sheep, especially on the sourveld of KwaZulu-Natal, presents specific challenges because the crude protein (CP) content of veld grass declines to only 2.8% in winter (Elliot and Folkerson, 1961; Van Zyl *et al.*, 2007). A 60 kg lactating Merino ewe will have a dry matter (DM) need of 2.3 kg day⁻¹ or 3.9% of her body weight, and a CP need of 239 g day⁻¹. The natural supply of CP from the veld in winter is far too low to supply in her needs. The adapted values for smaller breeds of sheep, such as the Nguni sheep, are not available in the National Research Council (NRC), standards (NRC, 1985), but the smaller the ewe, the more dry-matter (DM) in terms of percentage body weight (W) they need, but the less CP that is needed (NRC, 1985).

Lactation, especially in the first 8 weeks, causes a dramatic increase in the nutritional needs of the ewe. The chances of survival for the lamb and its speed of growth in the first two to three months, depends largely on the level of nutrition of the ewe during late pregnancy and lactation. Lambs from undernourished ewes have a lower survivability (Van der Merwe and Smith, 1991; De Villiers, 1998).

The nutrition during the first 16 weeks of a lamb's life has an immediate and permanent effect on the current and future production, and mature body size of the sheep. Schinkel and Short (1961) reported these findings from a classical cross-over trial with Merino lambs and their mothers, which were exposed to either a high (H) or low nutritional level (L) for 16 week's post-partum. After weaning, the lambs either changed over or stayed on the same level of nutrition, resulting in the following treatments, HH, HL, LH and LL. Lambs exposed to the HH nutritional level weighed 53.2 ± 2.08 kg lamb⁻¹ after 108 weeks, compared to lambs on the HL, the LH and LL treatments with weights of 48.1 ± 1.23, 48.5 ± 58 and 44.4 ± 1.45 kg lamb⁻¹, respectively. The extreme feeding treatments, HH and LL, resulted in a mean difference of 8.8 kg lamb⁻¹. It

showed that when lambs were exposed to poor feeding conditions pre-weaning they became permanently stunted, and even with good nutrition post-weaning, they did not catch up with lambs that had not suffered nutritional stress pre- weaning.

One of the important reasons for crossbreeding Nguni sheep with either commercial or composite breeds are, according a survey on Nguni sheep (Chapter 3), is the small carcass weights of the Nguni sheep. It can therefore be argued that under the general veld based conditions where this breed of sheep is traditionally found, the sheep are routinely exposed to nutritional stress. Ewes tend to fall pregnant in early summer, in response to the onset of a spring flush of grass in the veld, resulting in an improved body condition, which results in an autumn lambing season. During lactation, which then coincides with challenging winter feeding conditions, with restricted quality and quantity of veld grasses, high levels of mortality typically occur in both ewes and lambs (Msuntsha and Van Zyl, 2017).

Farmers use crossbreeding as means of improving the carcass weights of Nguni sheep (Chapter 3). However, information on the influence of nutrition on the performance in Nguni sheep is currently not available in the scientific literature. All publications mentioning mature live weight of sheep were discussing sheep in their natural habitat, meaning on communal grazing lands, with the occasional access to harvested croplands. The mature weights for the measured ewes were reported as varying between 24 to 35 kg ewe⁻¹ (Goetze, 2001; Kunene *et al.*, 2007). A question arises as to whether better quality feed to relieve nutritional stress can improve live weights significantly.

To address this question, a study was conducted to investigate the production potential of Nguni sheep under different feeding regimes. The traditional conditions under which Nguni sheep are kept, namely veld-based, with a traditional autumn lambing season (Chapter 3) were incorporated in the trial. Lactating ewes were exposed to contrasting feeding levels during the winter season. After weaning, the weight gains of their lambs were monitored during the next summer, also on two different feeding regimes.

The two grazing regimes during winter were poor quality veld grazing and high quality maize grazing. The grazing of mature, whole crop maize in winter, called “grazing maize”, is an exceptionally good proposition as winter feed for sheep. It is a low risk, high quality winter feed, which is grown with summer rain and carried into winter as a standing forage (Van Zyl, 2013). Small scale farmers in South Africa are knowledgeable about maize because it is a staple food to many rural communities. Nguni sheep owners indicated that they provide maize grain to their sheep from time to time (Chapter 3). The high nutritional value of maize means that only a relative small area of maize needs to be cultivated in order to provide high quality feed in winter for the characteristically small flocks of Nguni sheep that Zulu farmers own.

After weaning, (following summer) the weight gains of the lambs were monitored again under two varying feeding regimes, not only to monitor the effect of summer feeding regimes on the animals, but also to monitor the carry-over effect of the winter feeding regimes. The summer feeding regimes were based on natural veld, compared to kikuyu (*Pennisetum clandestinum*), a very common used planted pasture with high resilience towards grazing, but of moderate quality. De Villiers (1998) classified kikuyu, in terms of feeding quality, as not acceptable to the grazing animal, towards the end of the growing season.

Merino sheep was used as comparative breed in the trial, since crossbreeding with Merino sheep was found to be popular with Nguni sheep farmers (Chapter 3). Verified norms regarding the performance of Merino sheep on veld and grazing maize is available in the literature and were used as a benchmark in this study. The Merino is a larger breed than the Nguni, therefore live weight change comparisons was calculated by determining the percentage loss or gain against the starting weight of the animal.

Ewe efficiency, which is the weight of the weaned lamb as percentage of the ewe's live weight, is a good indicator of animal performance. Lôbo *et al.*, (2012) used metabolic weight in their calculations to estimate ewe productivity (WEE), using litter weight at birth (LWB), litter weight at weaning (LWW) and ewe weight at weaning (EW). To estimate ewe production efficiency in this study, the following equation was used:

$$WEE = LWW \div EW^{0.75}.$$

According to Kleiber's law, the metabolic rate of an animal is a function of the animals' weight (W) to the power of 0.75 (Kleiber, 1947). There was a substantial difference in the mean size and weight of sheep of the two breeds. Taking the mean weight (W) of the breeds in consideration, the Merino's metabolic rate was $60.1^{0.75} \text{ kg} = 21.58$. For the Nguni sheep, the figures were $33.75^{0.75} \text{ kg} = 14.00$. This indicates that the Merino will have a metabolism 1.54 times greater than that of the Nguni sheep.

For the purpose of animal welfare in this study, none of the animals were exposed to food shortages, but to feed sources of contrasting levels of quality.

The objectives of this research were:

Experiment 1: To monitor the winter performance of lactating Nguni and Merino ewes and their lambs at two nutritional levels, namely:

- a. A higher nutritional level, based on grazing maize (H)
- b. A lower nutritional level, based on veld (L)

Experiment 2: To monitor the summer performance of the lambs from the ewes of the two breeds in Experiment 1, post- weaning, when raised on two nutritional levels, generating four possible nutritional combinations of the ewes + lambs, namely:

- a. A higher nutritional level, based on fertilized Kikuyu (*Pennisetum clandestinum* Hochst ex Chiov.);
- b. A lower nutritional level, based on veld.

5.3 MATERIAL AND METHODS

Two interrelated feeding experiments with Nguni and Merino sheep were conducted at the Dundee Research Station, Department of Agriculture and Rural Development, KwaZulu-Natal, South Africa, in which the Merino sheep served as a comparative breed.

The first experiment evaluated the performances of lactating ewes and their lambs during the winter (dormant season) on either a higher (H) (grazing maize) or a lower quality grazing (L) (veld). The second experiment focused on the performances of the same lambs post-weaning, during the following summer (growing season) on either higher (H), kikuyu pastures or lower quality grazing (veld), measuring the carry-over effect of quality of winterfeeding. This generated four treatments: HH, HL, LH and LL (maize + Kikuyu = HH; maize + veld = HL; veld + Kikuyu = LH; veld + veld = LL).

5.3.1 Experimental site and climatic conditions

The field trials were conducted at the Dundee Research Station, Department of Agriculture and Environmental Affairs, KwaZulu-Natal. The Research Station is situated about 10 km east of Dundee (latitude 28°10'S and longitude 30°31'E) at an altitude of 1219 m (2830AB). The long-term mean rainfall is 782.8 mm a⁻¹ and the distribution is a typical summer rainfall pattern with convectional rainfall between October to March.

Mild summer conditions are followed by severe winters, with regular frosts in winter, resulting in a relatively short growing season. The soils are mainly of a sandy texture, derived from Beaufort sandstone. The high rainfall of the area contributes to the low fertility of the sandy soil, due to extensive leaching over millennia, resulting in "sourveld". The veld grasses that grow are of a poor nutritional value, especially in winter (Van der Eyk *et al.*, 1969; ANON, 1988; Lurie, 1994; MacVicar, 1999).

The veld is accordingly classified as the Sandy Sourveld, a fire climax grassland, which rapidly degrades under mismanagement, such as overgrazing. Palatable grass species such as *Themeda triandra* Forssk, are then replaced by less palatable species such as *Sporobolus pyramidalis* P. Beauv., *Cynodon dactylon* (L.) Pers., *Eragrostis*

curvula (Schröd.) Nees and *Eragrostis plana* Nees. *Hyparrhenia hirta* Stapf follows these species during a recovery phase, and seems to remain dominant for many years (Hurt and Camp, 1999a).

5.3.2 Experiment 1: Overwintering of lactating ewes with lambs on veld and grazing maize.

Lactating ewes from both Zulu sheep (n=28) with lambs (n=29), and Merino sheep (n=24) with lambs (n=37) were used in the experiment that was conducted over the winter and early spring months of July to September 2016. The lambs were born in May 2016. The animals were blocked and assigned to either the grazing maize treatment or to veld grazing for winter feeding, post-lambing. The grazing maize treatment was considered to be the high nutritive value treatment (H), and the veld to be the low nutritive value treatment (L). The treatments were replicated twice.

5.3.2.1 Animal management

The animals in this study were bred and grazed on veld for the summer preceding the trial. Pregnant ewes were moved to Kikuyu pastures prior to lambing and supplemented with Voermol MaxiwoTM production pellets at the prescribed level for the duration of the six week lambing period.

The lactating ewes and their lambs, allocated to the grazing maize treatment, were adapted as follows:

Fourteen days prior to lambing, the ewes were slowly introduced to whole grain maize. On the first two days, the sheep were given 200 g of whole maize ewe⁻¹ day⁻¹, with an increase of 100 g whole maize ewe⁻¹ every second day. By Day Fourteen the sheep were given 800 g maize grain each. This treatment continued until the lambing season was completed and lambs were strong. During this period Voermol LandelekTM was supplied at 200 g day⁻¹. The composition of the lick is designed to counteract acidosis.

The veld grazing groups were moved to veld camps, and their grazing was supplemented with Voermol MaxiwoTM lick in pellet form at 500 g day⁻¹.

Eragrostis curvula (Schrud.) Nees hay was supplied *ad libitum* to both treatments. Fresh running water was available in all treatments. Lick and water troughs were cleaned daily.

The experiment was done during the winter months, July to September 2016, when the challenge of internal and external parasites is low and treatments for diseases are usually not necessary. For the duration of the experiment, no treatment of parasites was needed. Vaccinating with Multivax P® (vaccine) was done as prophylaxis against Enterotoxaemia (pulpy kidney), three weeks prior to starting the experiments.

5.3.2.2 Feeding treatments

5.3.2.2.1 Veld (low nutritive value treatment - L).

To determine grazing capacity a veld condition assessment was done using the method described by Camp and Hardy (1999). Based on the assessments, veld grazing camps that were rested for the full previous growing season were made available for the veld grazing treatments.

5.3.2.2.2 Grazing maize (high nutritive value treatment - H).

According to established grazing capacity norms for grazing maize, an area 4.5 ha of a maize cultivar, PAN 6P110 (a yellow medium season maize), was planted under dryland conditions during midsummer on a deep Hutton soil. Standard maize cultivation practices were applied.

Utilization of the grazing maize started on 1 July 2016. A system of strip grazing was practised by erecting temporary Bonnox fencing in strips across the maize land. This was done to restrict sheep movement and to avoid unnecessary losses of utilizable material through animal trampling. Care was taken to move sheep to the next strip in time before the quantity of the grazing became restricted.

5.3.2.3 Data collected

5.3.2.3.1 Forage quality Veld

To determine the herbage quality and dry matter (DM) yield of the veld, random quadrants (5 x 1 m²) were cut monthly with shearing scissors up to 5 cm above the soil surface level. The separate samples were weighed (wet weight) using an Adam LBK3 scale (<https://www.adamequipment.co.za/catalogsearch/result/?q=LBK+3>), and were then dried in an oven at 60°C for 48 hours to a constant weight. The samples were then submitted to the Cedara Feed Laboratory (KZN Department of Agriculture and Rural Development) for a full feed analysis (De Figueireiro and Thurtell, (1998), according to the Goering and Van Soest (1970) methods).

Grazing maize

Sheep consume the grain, cob and maize leaves of maize plants, largely leaving the stems and roots.

To determine grain yield, a standard method of grain yield assessment was followed. As the rows were planted 76 cm apart, a distance of 13 m was assessed for the number of cobs. The cobs were harvested, the pips removed and weighed on an Adam scale (Model LBK 3) to do a yield determination of grain production. A general maize yield equation, as described by Smith (2006), was used, which includes: effective rainfall (ER), heat unit factor (HUF), sunshine factor (SF), soil factor (S) and management factor (MF) – using the following method:

$$Yield (t\ ha^{-1}) = \left(\frac{ER}{100} \right) \times HUF \times SF \times S \times MF$$

For the feed quality analysis, 30 cobs were randomly harvested and the grain removed and 15 random plants were stripped of leaves. This was done randomly on five sites in the grazing maize land. Pre-grazing samples were taken monthly and submitted to the Cedara Feed Laboratory for a full feed analysis (De Figueireiro and Thurtell, 1998, according to the Goering and Van Soest (1970) methods). This exercise was repeated at the start of the months of July, August and September.

5.3.2.3.2 Animals

Live weight of both ewes and lambs were recorded weekly without fasting. Weighing was done in mornings between 8h00 and 10h00. The scale used was a “Tru-Test” SR 2000 (Auckland, New Zealand). The scale is accurate to 0.1 kg.

5.3.2.4 Statistical Analysis

The data on live weights of animals were analysed by using Genstat 18.1 software for Analysis of Variance (ANOVA), (VSN Int., 2015) to determine the levels of significance between the breed performances and the treatments applied. Fisher’s test of least significant differences (LSD) at a 5% level of significance was conducted.

5.3.3 Experiment 2: Post-weaning lamb performance on veld and Kikuyu pastures for summer

This experiment was done during the summer months (October 2016 to March 2017). Grazing on veld (low nutritive value treatment - L) and Kikuyu (high nutritive value treatment - H) were used as the summer feeding treatments. The lambs used in this experiment were weaned from the ewes used in Experiment 1, as described above. Lambs were then blocked according to their live weight, and were assigned to either the Kikuyu or veld treatments for the summer, resulting in four possible treatment groups: The lambs came from ewes fed on either veld (L) or grazing maize (H), and were then grazed on either veld (L) or Kikuyu (H) summer grazing, resulting in four combination treatments: LL, LH, HL and HH.

5.3.3.1 Animal management

In Experiment 2, lambs in both treatments received a similar supplement (Voermol Maxiwol™ production pellets). Prior to the onset of the experiment (three weeks), the lambs were vaccinated using Multivax P® vaccine, as prophylaxis against Enterotoxaemia (pulpy kidney disease). During the summer months, levels of inoculum of gastrointestinal-intestinal nematodes (GINs) were expected to be high, especially on the Kikuyu pasture. Close monitoring for infection of lambs by GINs was conducted because the animals were also part of an internal parasite resistance trial, as described in Chapter 6.

Clean running drinking water was available at all times.

5.3.3.2 Feeding treatments

5.3.3.2.1 Veld (low nutritive value treatment - L).

To determine grazing capacity, a veld condition assessment was done using the method described by Camp and Hardy (1999) based on the assessments, veld grazing camps that were rested for the full previous growing season were made available for the veld grazing treatment.

5.3.3.2.2 Kikuyu (high nutritive value treatment - H).

Four small (< 1 ha) dryland Kikuyu camps were made available for the experiment. Established carrying capacity norms were adhered to. The camps were fertilized using a nitrogen fertilizer (limestone ammonium nitrate) at a rate of 200 kg N ha⁻¹ annum⁻¹.

5.3.3.3 Data collected

5.3.3.3.1 Forage quality

Veld (L)

The same procedure was followed as is described in Section 5.3.2.3.1. above.

Kikuyu (H)

Kikuyu was sampled using the same procedure as described for veld in 5.3.2.3.1. The cuttings were done at the start of each month and the samples were dried in the oven at a temperature of 60°C for 48 hours. The dried samples were sent to the feed laboratory at the Cedara Feed Laboratory for a full feed analysis using the procedure described in Section 5.3.2.3.1.

5.3.3.3.2 Animals

Individual live weights were determined using a scale ("Tru-Test" SR 2000) as described in Section 5.3.2.3.2. The live weights were determined at time of weaning, and then on a monthly basis to gauge the performance of the animals on either veld or Kikuyu.

5.3.3.4 Statistical Analysis

The data on live weights of animals were analysed by using Genstat 18.1 software for Analysis of Variance (ANOVA), (VSN Int., 2015), to determine levels of significance

between the breed performances and the treatments used in the trial. Fisher's test of least significant differences (LSD) at a 5% level of significance was conducted.

5.4 RESULTS

5.4.1 Site climatic conditions

Climatic data was obtained from the Agricultural Research Council (ARC) (Agricultural Research Council, 2018) (Comp. 30109) for both the winter and summer (Experiments 1 and 2). The long term annual rainfall (LTM) for DRS is 782 mm annum⁻¹. In 2015 a dry early summer resulted in late planting of maize. Above average rains were experienced in December and January with fairly normal rainfall in February to April. This ensured a fairly good grazing maize crop for Experiment 1 (Figure 5.1). During the months of August, September and October 2016, co-incidence with below normal rainfall, maximum temperatures that were higher than normal, were recorded (Figure 5.2). June was warmer than the long term minimum temperatures, but August temperatures were below the long term minimum temperatures.

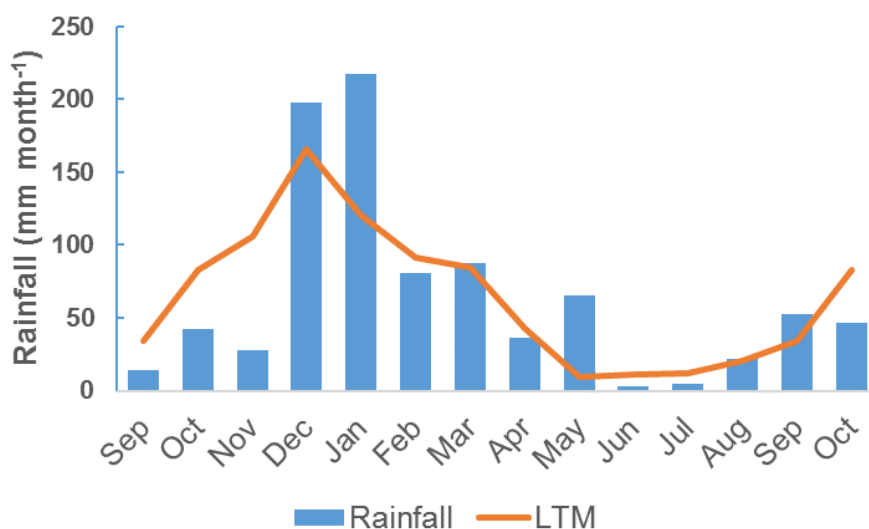


Figure 5.1: Monthly rainfall (mm month⁻¹) for September 2015 until October 2016, compared to the monthly long-term rainfall (LTM) for the Dundee Research Station (Agricultural Research Council, 2018)

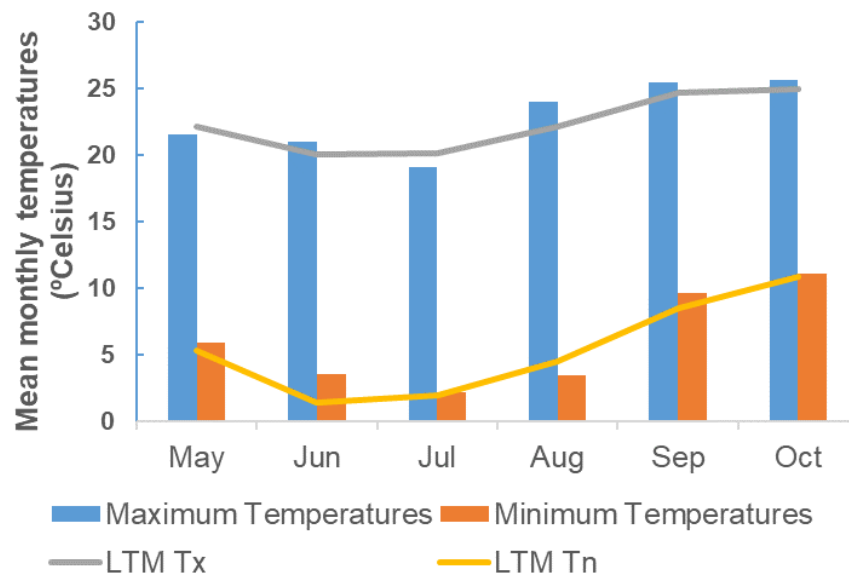


Figure 5.2: Mean monthly maximum temperatures and mean monthly minimum temperatures for May 2016 until Oct 2016 compared to the long-term mean monthly maximum (LTM Tx) and long-term mean monthly minimum (LTM Tn) temperatures for the Dundee Research Station, (Agricultural Research Council, 2018)

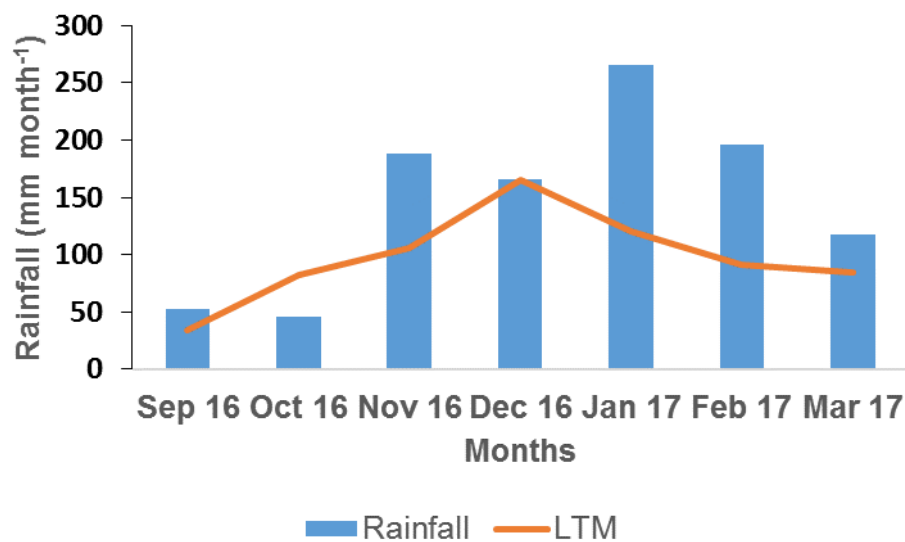


Figure 5.3: Rainfall during the months September 2016 to March 2017 and long term mean (LTM) (Agricultural Research Council, 2018)

5.4.2 Forage quality

For Experiment 1 the following results were obtained: The calculated yield of the maize grain in the grazing maize treatment was 3.6 t maize ha⁻¹. The results for forage quality for the grazing maize and veld in both treatments are displayed in Figures 5.4 to 5.6.

Crude Protein (CP)

The maize grain and maize leaves are considered to be the utilizable part of the maize plant. Maize grain samples had a CP content varied between 9.0 and 11.0%, while the range of CP in the leaves were 2.9% to 4.4%. The CP content of the veld samples varied between 2.15% and 4.29%. The increase in CP in maize is probably because of increased photosynthesis in September due to increased temperatures and sunshine. An improvement in the CP of veld samples can possibly be linked to the rain that incurred in August and September, which resulted in regrowth of the veld grasses.

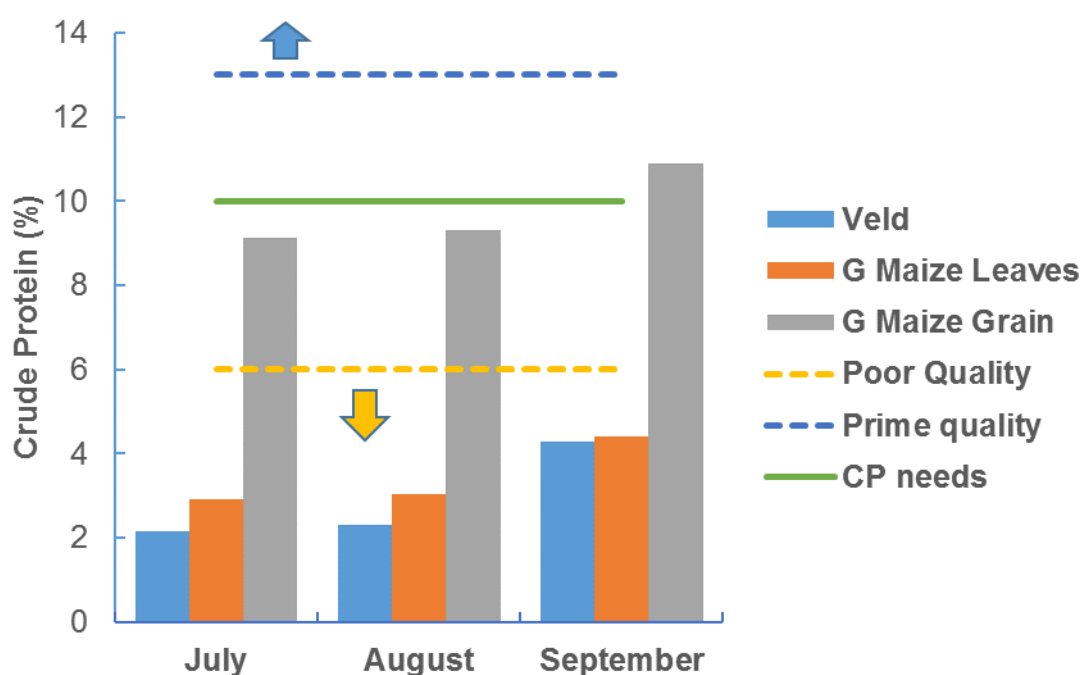


Figure 5.4: Crude protein (CP) values of veld and grazing maize (grain and leaves), indicating quality levels and the CP needs of a lactating ewe

Acid detergent fibre (ADF)

The ADF analysis of maize grain showed that the maize fell into the prime quality category, but an increase in ADF levels were noted the towards the end of the

experiment, indicating a deterioration in the quality of the forage. The ADF of the maize leaves were within acceptable levels, whereas the high ADF levels of the veld samples indicated that this grazing was of poor quality (Shaker, 2009; Van Zyl, 2014) (Figure 5.5).

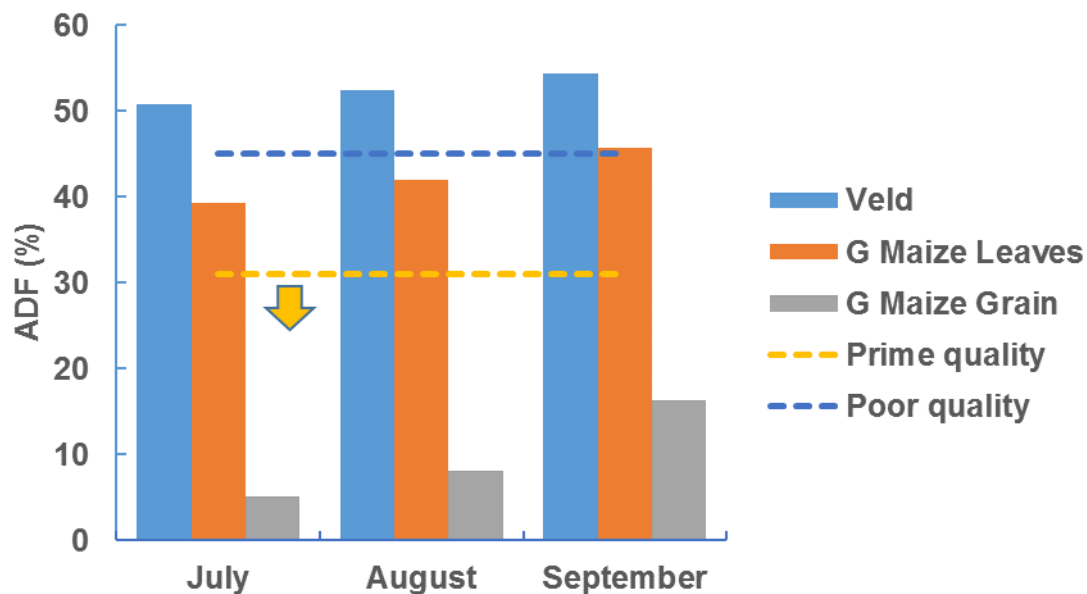


Figure 5.5: Acid detergent fibre (ADF) values of veld grasses and grazing maize (leaves and grain), as a measure of grazing quality

Neutral detergent fibre (NDF)

As with ADF, the NDF levels of the maize grain were low. The maize leaves, with NDF levels of 86.28%, 84.9% and 77.4%, for the months July, August and September, respectively, indicated their poor forage quality (Shaker, 2009; Van Zyl, 2014). The eld samples analysed constantly above 80% NDF, which indicates very poor digestibility (Figure 5.6).

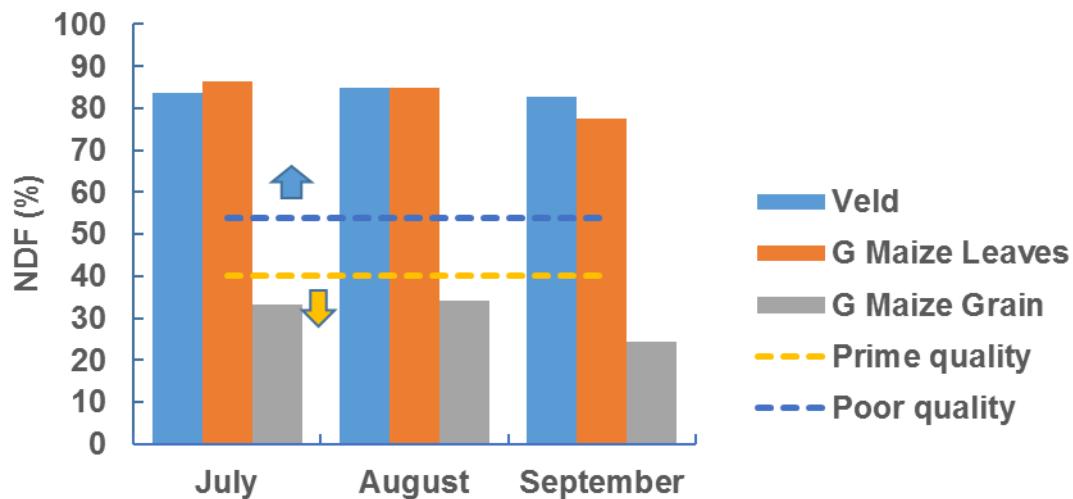


Figure 5.6: Neutral detergent fibre (NDF) values of veld and grazing maize, as a measure of grazing quality

For the Experiment 2 (summer) the following forage quality values were obtained:

Crude Protein (CP)

The CP levels of the fertilized Kikuyu pasture were very high in all three months (January to March), ranging from a CP content of 14.61 to 22.07%. These CP levels were enough to support body weight increase of the lambs (Van Zyl, 2014). The CP content of veld (CP%) ranged from 4.45 to 6.88% (mean 5.64%). In January it was at the highest level, and decreased slightly as the growing season progressed. The summer veld samples had noticeable better CP levels than the winter veld (Figure 5.7).

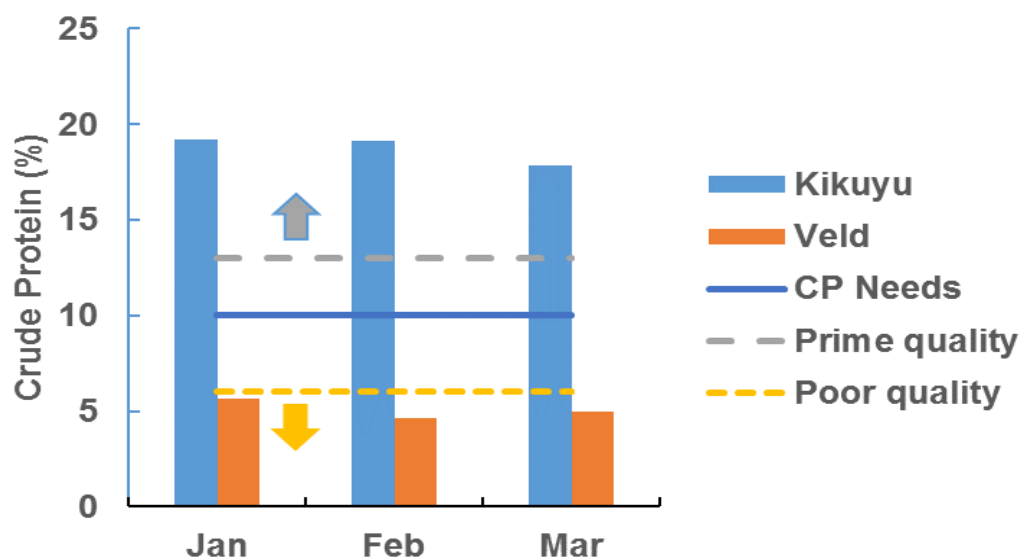


Figure 5.7: Crude protein content (%) of summer Kikuyu pastures and veld

Acid detergent fibre (ADF)

The ADF content in Kikuyu pastures ranged between 39.08 to 54.49%. The ADF level in January was high (pastures of low quality), but the ADF diminished in the subsequent months, when forage quality was good. The ADF levels in veld ranged between 50.54 to 60.35, and were above 45% in all three summer months, indicating a consistently poor quality forage in summer (Shaker, 2009; Van Zyl, 2014) (Figure 5.8).



Figure 5.8: Acid detergent fibre (ADF) content (%) of summer Kikuyu pastures and veld

Neutral detergent fibre (NDF)

The NDF% content in Kikuyu ranged between 67.16 to 76.76%, indicating poor quality. The NDF levels in veld ranged between 62.57 and 88.52%, which was not much poorer than the Kikuyu levels. Of importance was the difference in NDF levels between winter and summer. During winter the NDF levels on veld were, constantly above 80%, in all samples analysed, while in summer, some of the samples showed NDF levels of 62.57% (Shaker, 2009; Van Zyl, 2014), (Figure 5.9).

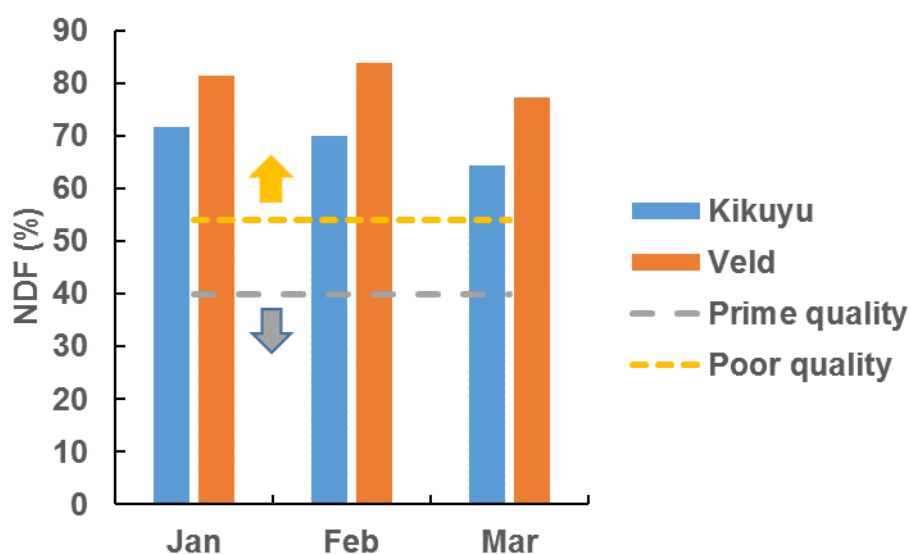


Figure 5.9: Neutral detergent fibre (NDF) content (%) of summer Kikuyu pastures and veld

5.4.3 Animal performance:

5.4.3.1 Experiment 1: lactating ewes

The lactating Nguni ewes started off with a mean body weight of 32.88 ± 4.49 kg ewe⁻¹ and 32.36 ± 4.58 kg ewe⁻¹, respectively, for the groups grazing maize and veld. At the end of the experiment the Nguni sheep ewes had mean body weights of 36.40 ± 4.66 kg ewe⁻¹ and 29.54 ± 3.70 kg ewe⁻¹, respectively, for the groups grazing maize and veld. For the Merino ewes the starting weight was 60.18 ± 8.85 kg ewe⁻¹ for the grazing maize group, and 60.02 ± 4.61 kg ewe⁻¹ for the veld group. The mean body weight of the Merino ewes feeding on grazing maize was 69.71 ± 5.38 kg ewe⁻¹, and

for those feeding on veld, it was $48.73 \pm 5.12 \text{ kg ewe}^{-1}$. The live weight of both breeds on the grazing maize treatment showed a gradual increase as the trial progressed.

However, a sudden weight loss was recorded in both the Nguni and Merino sheep towards the end of August, which reversed in September after rainfall. On the veld treatment the Nguni sheep maintained roughly the same live weight over the study period, whereas the Merino ewes showed a gradual weight loss. The weight changes in the breeds on the different treatments is illustrated graphically in Figure 5.10.

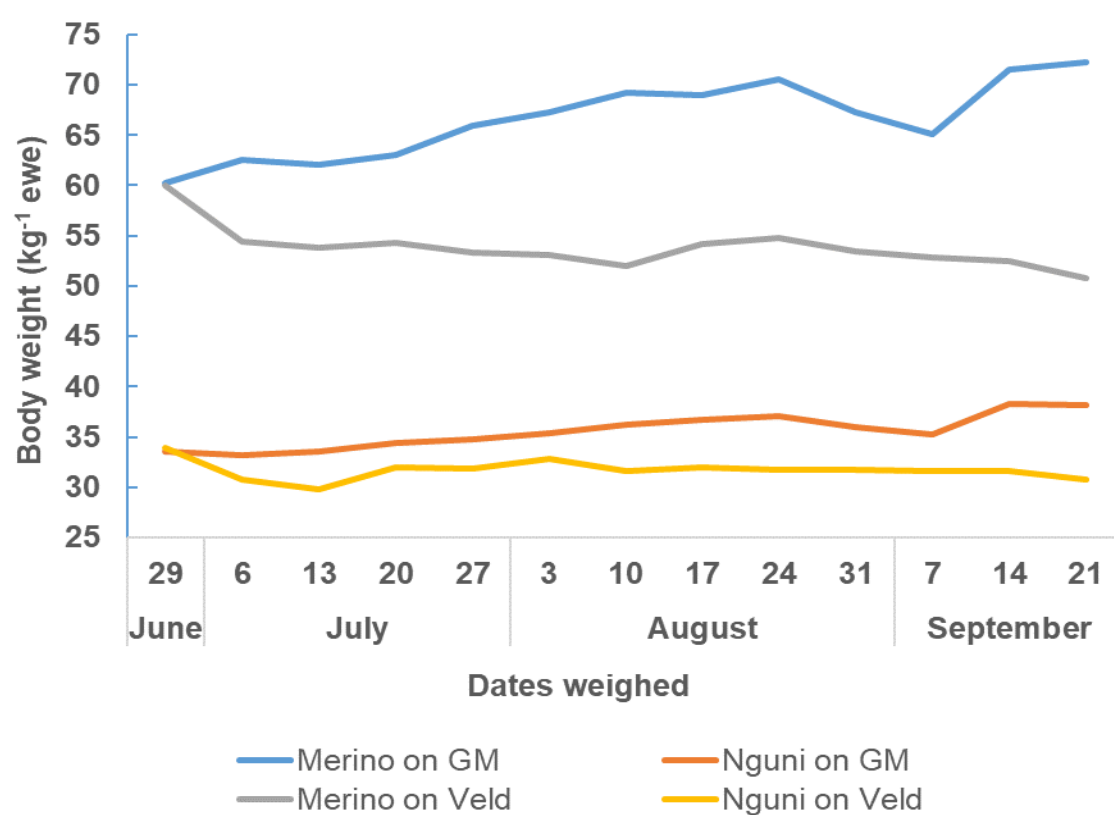


Figure 5.10: The mean body weight of lactating Nguni and Merino ewes on either grazing maize or veld over winter

The statistical analysis of the live weight changes, expressed as a percentage change from the starting weight of the lactating ewes of both breeds (to address the difference in body size), over the experimental period, are displayed in Table 5.1.

Table 5.1: Weight change (% from start weight), in the Nguni and Merino ewes over the period of Experiment 1

| Breed (B) | Forage (F) | | Means of B |
|-------------------|--------------------|--------------------|-------------------|
| | Grazing maize | Veld | |
| Merino | 11.96 | -10.52 | 0.72 ^a |
| Nguni | 7.64 | -6.78 | 0.43 ^a |
| Means of F | 9.80 ^a | -8.65 ^b | |
| LSD (5%) | Breed (B): | NS | |
| | Treatment (F): | 1.525 ** | |
| | B x F interaction: | 2.157 ** | |

*LSD=Least significant difference; NS=No significance, *=Significant, **=highly significant.*

Values with different superscripts within the column or row differ significantly.

The difference between the treatments was highly significant ($P < 0.001$), as expected, taking the chemical analysis of the material in both forages into consideration (Figures 5.4 to 5.6). No significant difference was found between the changes in live weight over the trial period between the two breeds ($P = 0.702$), but the interaction between the breeds and treatments was highly significant ($P = 0.001$).

Ewe efficiency is a popular parameter to use in animal production and the ewe efficiency return in Experiment 1 are displayed in Table 5.2. Significant differences ($P < 0.05$) were found between the feeding treatments and breeds.

Table 5.2: Table of means: Ewe efficiency in the Nguni and Merino breeds grazed on different fodders in Experiment 1

| Breed (B) | Forage (F) | | Means for B |
|--------------------|--------------------|-------------------|-------------------|
| | Grazing Maize | Veld | |
| Merino | 1.20 | 0.89 | 1.04 ^a |
| Nguni | 1.36 | 1.02 | 1.19 ^b |
| Means for F | 1.28 ^a | 0.95 ^b | |
| LSD (5%) | Breed (B): | 0.095* | |
| | Treatment (F): | 0.095* | |
| | B x F interaction: | 0.134NS | |
| | CV % = 8.5 | | |

*LSD=Least significant difference; NS=No significance, *=Significant.*

Values with different superscripts within the column or row differ significantly.

5.4.3.2 Lambs

Experiment 1: Pre-weaned lambs, winter

During Experiment 1 the initial mean body weight of Nguni lambs was 8.62 ± 2.34 kg lamb⁻¹ for the grazing maize group, and 7.29 ± 2.00 kg lamb⁻¹ for the veld group. At termination of Experiment 1, the mean body weight for the Nguni lambs was 20.64 ± 5.40 kg lamb⁻¹ for the grazing maize group and 13.25 ± 2.42 for the veld group. For the Merino lambs the mean starting weight was 12.02 ± 3.05 kg lamb⁻¹ for the grazing maize group and 10.54 ± 2.62 kg lamb⁻¹ for the veld group with a mean end weight of 28.82 ± 4.65 kg lamb⁻¹ for the grazing maize group. The mean end weight for the veld group of Merino lambs was 16.24 ± 3.69 kg lamb⁻¹. The recorded weight changes of the lambs showed the same trend of sudden decrease that was noticed in the ewes during the last two weeks of August, followed by an increase again in September.

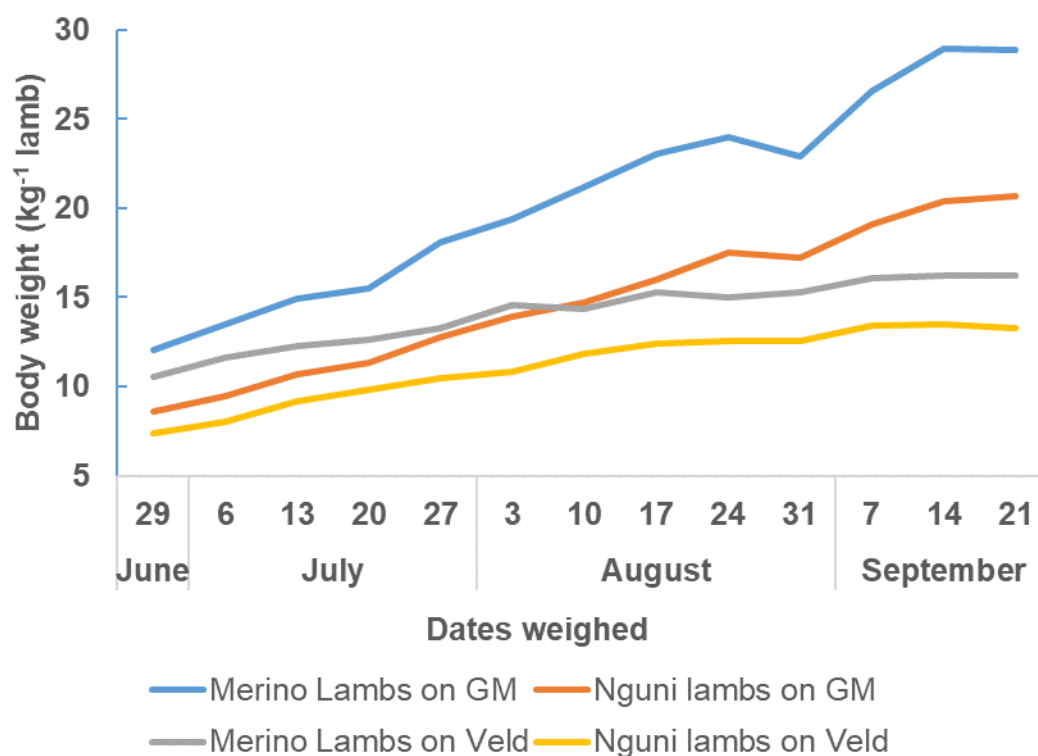


Figure 5.11: Response in body weight change (kg lamb⁻¹) of the Nguni and Merino lambs on grazing maize and veld

The statistical analysis of the live weight changes of lambs, expressed as average daily gain (ADG) g lamb⁻¹ day⁻¹ of both breeds over Experiment 1 are displayed in Table 5.3.

Table 5.3: Average daily gain (ADG) of lambs (g day⁻¹ lamb⁻¹) over the period of Experiment 1

| Breed (B) | Treatment – Forage (F) | | Means of B |
|------------|------------------------|---------------------|--------------------|
| | Grazing maize | Veld | |
| Merino | 184.2 | 65.8 | 128.5 ^a |
| Nguni | 134.3 | 68.0 | 103.1 ^b |
| Means of F | 163.6 ^a | 66.7 ^b | |
| LSD (5%) | Breed (B): | 6.478 ^{**} | |
| | Treatment (F): | 6.387 ^{**} | |
| | B x F interaction: | 12.85 ^{**} | |
| | CV% = 19.27 | | |

*LSD=Least significant difference; NS=No significance, *=Significant, **=highly significant.*

Values with different superscripts within the column or row differ significantly.

Breed difference in weight gain was found to be highly significant ($P < 0.001$). There was also a high level of significance between both the treatments ($P < 0.001$) and breeds, as well as a high level of significance in the interaction between breed and treatment ($P < 0.001$). Bias is observed towards the Merino as it is a larger breed than the Nguni sheep and to address this, the performance of lambs were, as in the case of the ewes, expressed as a percentage change from the starting weight per breed, over the experimental period (Table 5.4).

Table 5.4: Weight change (% from start weight) in the Nguni and Merino lambs over the period of Experiment 1

| Breed (B) | Treatment forage (F) | | Means of B |
|------------|----------------------|----------------------|--------------------|
| | Grazing maize | Veld | |
| Merino | 82.91 | 41.53 | 62.22 ^a |
| Nguni | 80.90 | 56.31 | 68.61 ^a |
| Means of F | 81.91 ^a | 48.92 ^b | |
| LSD (5%) | Breed (B): | NS | |
| | Treatment (F): | 13.935 ^{**} | |
| | B x F interaction: | NS | |
| | CV% = 50.2 | | |

*LSD=Least significant difference; NS=No significance, *=Significant, **=highly significant.*

Values with different superscripts within the column or row differ significantly

As indicated in Table 5.4, regarding the reaction of lambs to the treatments, the Nguni sheep had comparable live weight gain to that of the Merino, as the means for breed indicates ($P = 0.365$). There was also no significant interaction between breed and

treatment ($P=0.234$). As expected, a high level of significance was found between the treatments ($P<0.001$) in Experiment 1.



Figure 5.12: Weaned lambs on the left are from the grazing maize treatment (H) and the ones on the right from veld treatment (L) at the end of Experiment 1, and at the start of Experiment 2 (Overwintering trial 2016)

A marked difference between the lambs of the two treatments was visible, considering the relative body weight of the two groups of lambs.

Experiment 2: Post-weaned lambs, summer

The positive effect of grazing maize (H) as a winter forage during pre-weaning was evident from the data displayed in Table 5.5, with Merino weaners raised on grazing maize having a mean starting live weight of 28.6 ± 3.08 kg weaner⁻¹, whereas Merino weaners that over-wintered on veld had a mean starting weight of 16.48 ± 3.07 kg weaner⁻¹. The Nguni weaners from the grazing maize treatment had a starting weight of 21.55 ± 4.27 kg weaner⁻¹ and those from the veld weighed a mean 14.45 ± 2.54 kg weaner⁻¹.

The Nguni lambs, at termination of the experiment, recorded a weight change (% of summer start weight) of 63.74% in the LH and 64.43% in the LL treatment, compared to the Merino lambs, which had a weight increase of respectively 84.46% in the LH treatment and 88.41 in the LL treatment. Clearly, compensatory growth over summer in these lambs that were exposed to nutritional stress during winter, occurred. Lambs that started off on the H – treatment during winter did not show the same increase over summer.

Table 5.5: The start and end weight of Nguni and Merino lambs (kg lamb⁻¹ and % of start weight)

| Breed | Treatment combinations | Start of summer (kg lamb ⁻¹) | End weight (H or L) (kg lamb ⁻¹) | Weight change (% of start weight) |
|--------|------------------------|--|--|-----------------------------------|
| Merino | H H | 28.6 ± 3.08 | 36.79 ± 3.86 | 30.31 |
| | H L | 28.6 ± 3.08 | 33.73 ± 3.15 | 16.99 |
| | L H | 16.48 ± 3.07 | 30.88 ± 0.76 | 84.46 |
| | L L | 16.48 ± 3.07 | 30.82 ± 2.79 | 88.41 |
| Nguni | H H | 21.55 ± 4.27 | 27.54 ± 4.58 | 27.24 |
| | H L | 21.55 ± 4.27 | 24.26 ± 3.19 | 13.74 |
| | L H | 14.45 ± 2.54 | 23.78 ± 1.11 | 63.74 |
| | L L | 14.45 ± 2.54 | 23.88 ± 2.12 | 64.43 |

HH grazing maize followed by Kikuyu pasture

HL grazing maize followed by veld

LH veld followed by Kikuyu pasture

LL veld followed by veld

Highly significant ($P < 0.001$) differences existed between the breeds and treatments. However, the interaction of breed x treatment was not significant ($P = 0.646$) (Table 5.6).

Table 5.6: Mean weight of Nguni and Merino lambs at termination of the trial (kg lamb⁻¹)

| Breed (B) | Forage (F) | | | | Means for (B) |
|-------------|---|--------------------|--------------------|--------------------|--------------------|
| | HH | HL | LH | LL | |
| Nguni | 27.54 | 24.26 | 23.78 | 23.88 | 24.96 ^a |
| Merino | 36.79 | 33.73 | 30.38 | 30.82 | 33.14 ^b |
| Means for F | 32.58 ^a | 29.42 ^b | 27.38 ^b | 27.67 ^b | |
| LSD (5%) | Breed (B): 2.873** Treatment (F): 4.072** B x F interaction: NS CV % = 15.54 | | | | |

*LSD=Least significant difference; NS=No significance, *=Significant, **=highly significant.*

Values with different superscripts within the column or row differ significantly

At the end of the experiment the Merino weaners in the HH treatment had a mean end live weight of 36.79 ± 3.86 kg weaner⁻¹, which was significantly higher ($P < 0.05$) than

the weaners exposed to the veld treatment (LL), with a mean live weight of 31.05 ± 2.79 kg weaner⁻¹, resulting in a mean difference of 5.97kg Merino weaner⁻¹.

The Nguni weaners in the HH treatment had a mean end live weight of 27.54 ± 4.58 kg weaner⁻¹, which was significantly ($P < 0.05$) higher than the weaners in the LL treatment (23.88 ± 2.12 kg weaner⁻¹), resulting in a difference of 3.66 kg weaner⁻¹ (Nguni) in the HH treatment, Nguni weaners showed a gain of 27.24% in live weight over the trial period, compared to a 64.43% increase in the LL treatment.

The weaners from both breeds, coming from poor quality veld pre-weaning grew rapidly in summer on both high value Kikuyu pasture (88.46% gain with the LH treatment) and the veld (88.41% gain with the LL treatment) for Merino weaners. The same trend was observed in the Nguni weaners. The weaners in the LH treatments showed an increase in live weight of 63.74% and those in the LL treatment 64.43%. This corresponds with the results of a similar experiment conducted in Australia by Schinkel and Short (1961).

5.5 DISCUSSION

5.5.1 Experiment 1

Crude Protein, Neutral Detergent Fibre and Acid Detergent Fibre are good parameters to evaluate forage quality. Lactating ewes will maintain and increase body weight on CP levels of 13% and above, but if the levels of CP drop to below 6%, feed intake will decrease and the animals will lose weight (Van der Merwe and Smith, 1991; Shaker, 2009; Van Zyl, 2014). Forage material with ADF values of lower than 31% are considered of prime quality, while forage with ADF levels higher than 45% are considered low quality. Forages low in NDF (<40%) are considered high quality, and forages with NDF values higher than 54% are considered to be of low quality (Shaker, 2009; Van Zyl, 2014). From July to September the quality of forage from both grazing maize and veld deteriorated, as can be seen in the gradual increase of the ADF values of this experiment. Elliot and Folkerson (1961), Preston and Leng (1987) and Lyle (1991) concurred that the nutritive value of forages decreases rapidly with maturity and that during dry seasons, the available feed is of low digestibility and low in total CP (Leng, 1990). Lyle (1991) commented that the KZN veld in winter, especially in the

sourveld, is not suitable for lactating ewes or young growing sheep due to its poor nutritive quality. The nutritive value of the veld typically decreases to reach a low of 3% CP in July (mid-winter) (Meaker, 1978).

Throughout the three months of the trial, nutrient composition of the feed was stable, with a slight increase after some early rains in September. CP was not adequate in the veld and grazing maize grain and leaves. This shortfall was met by the supplements, the Landelek™ for the group on the grazing maize (with a CP content of 26%), and the Maxiwol™ supplement for the animals on the veld (with a CP content of 35%). The early summer rains had an effect on the nutritive value of the veld (September), with CP increasing, ADF increasing but NDF declining, probably as a result of the early rains.

The effect of feed on the sheep were measured in their performances in the different treatments. The ewes of both breeds on the grazing maize treatment were in good condition at weaning, which was also at the termination of Experiment 1. The good body condition of lactating ewes over-wintering on grazing maize is well documented (Moore and Muller, 1994; Kriek, 1999, Niemand and Van Pletzen, 2003; Van Zyl *et al.*, 2007, Van Zyl, 2013).

The ewes of both breeds gained weight on the H treatment. Merino ewes gained 11.96% of live weight. The Nguni ewes started off at a mean body weight 32.88 ± 4.49 kg ewe⁻¹ and ended the experiment with a mean body weight of 36.40 ± 5.60 kg ewe⁻¹, an improvement of 7.64%. These weights are already at the top of the range and above for the reported live weights of mature ewes of Nguni sheep varying between 24 and 35 kg ewe⁻¹ (Goetze, 2001; Kunene *et al.*, 2007).

The sheep's performance on the low nutritional treatment (L), veld was highly significantly ($P < 0.001$) lower, compared to the grazing maize treatment (H) for both breeds. The Merino ewes on the veld lost considerable weight over the course of Experiment 1. Mean starting weight was 60.02 ± 4.61 kg ewe⁻¹ and at termination of the trial (weaning), the mean body weight was 48.73 ± 5.12 kg ewe⁻¹, indicating a loss of 10.52%. The Nguni ewes also lost weight, but to a lesser extent. Their mean starting weight was 32.63 ± 4.58 kg ewe⁻¹, and at termination of the experiment (weaning), the

mean body weight was 29.54 ± 3.70 kg ewe⁻¹, indicating a loss of 6.78%. The end weights of ewes in the L treatment were comparable with the range of weights reported in literature (Goetze, 2001; Kunene *et al.*, 2007).

Lambs of both breeds also performed well on the grazing maize treatment (H). The mean ADG of Merino lambs recorded over the period of Experiment 1 was 184.2 g day⁻¹ lamb⁻¹, which is within the range reported in literature (Moore and Muller, 1994; Kriek, 1999; Niemand and Van Pletzen, 2003; Van Zyl *et al.*, 2007; Van Zyl, 2013). Nguni lambs also performed well, and a mean ADG of 134.3 g day⁻¹ lamb⁻¹ was recorded, although this was highly significant lower ($P < 0.001$) than the ADG in Merino lambs. The Nguni lambs weighed 16.94 ± 5.57 kg lamb⁻¹ at weaning. No comparative weaning weights for Nguni lambs were previously available in literature.

To accommodate the differences in body sizes of the breeds, the lambs' performances were compared as weight change (%) from the start of the experiment to termination of the experiment. No significant difference ($P > 0.05$) was found between breeds, which indicated that the Nguni lambs performed as well as the Merino lambs, in relative growth, over both forages.

The ADG of lambs on veld was only 65.8 g day⁻¹ lamb⁻¹ for Merino's to end the experiment with a mean live weight of 28.82 ± 4.65 kg lamb⁻¹. The Nguni lambs gained weight at a mean rate of 68 g day⁻¹ lamb⁻¹ and ended the experiment with a mean live weight of 20.64 ± 5.40 kg lamb⁻¹. The weight changes (% of end weight from start weight), to compensate for the differences in breed sizes, indicated that there were no significant differences in the lambs of the different breeds performances.

Being the bigger breed, the Merino produced well on the grazing maize (H) but lost a lot of weight on the veld (L). This is in accord with the statement Dzama (2016) made regarding the higher metabolic rate of larger breeds.

In comparing the parameter, ewe efficiency, it showed that in both treatments, the Nguni sheep were more efficient in terms of their lambs weaned. Figures obtained from their studies, Lôbo *et al.*, (2012) were consistent with the figures found in this experiment. To consider absolute weights might cause bias to a bigger breed of

sheep, therefore a variation of this would be to consider the metabolic weight of the ewe instead of the absolute weight (Bedier *et al.*, 1992). This makes it fairer to compare animals of different sizes and weights (Lôbo *et al.*, 2012).

5.5.2 Experiment 2

ADF has to be lower than 31% and NDF levels lower than 40% to indicate herbage in prime quality for ruminants. Forage analysis determined that both the Kikuyu and veld samples were of a poor quality forage. However, the CP content of the Kikuyu was acceptable for the weaners' needs. The supplementation with protein licks addressed the shortfall in CP because the lambs in all the treatments increased in live weight and showed reasonable to good AGD's.

The lambs started Experiment 2 with live weights directly affected by the different pre-weaning treatments they and their parent ewes were exposed to (grazing maize or low quality veld). Merino weaners from the H treatment during winter had a mean end live weight of 28.6 ± 3.08 kg weaner⁻¹, whereas the Merino lambs coming from the veld (L treatment) weighted only 16.48 ± 3.07 weaner⁻¹. The Nguni sheep (being the smaller breed) were weaned off the grazing maize (H) with a mean weight of 21.55 ± 4.27 kg weaner⁻¹ while the lambs coming off the veld (L) had a live weight of 14.45 ± 2.54 kg weaner⁻¹. The Merino lambs weaned off on grazing maize, and then moved to Kikuyu pastures (HH treatment) developed the best body weight by the end of the summer trial, but they were not the fastest growers during the summer trial. They only achieved a 30.31% body weight increase over the trial period. In contrast, the Merino lambs that over-wintered on veld and then stayed as weaners on veld for the following summer (LL treatment) had a live weight of 31.82, which was a live weight difference of 5.97 kg weaner⁻¹, which in practise would make a significant difference to the value of the lambs. These results correspond with the results from a similar crossover trial reported by Schinkel and Short (1961).

The relatively better performance of lambs on the L nutritional level in winter, moving to the LL or LH treatments in summer, can be explained by the phenomenon of compensatory weight gain. A study done by Thornton *et al.*, (1979) showed that during realimentation sheep consumed 3-4 times as much food per day as during periods of starvation, with live weight gains of 500 to 600 grams' day⁻¹. Of importance here was

the better quality of summer veld, compared to winter veld. Whereas the ADF levels did not vary much between winter and summer, the NDF levels were substantially better in the summer veld forage. The ADF and NDF levels of Kikuyu were poor to moderate although CP levels of Kikuyu were high. CP levels were noticeably better in the summer veld forage. However, lambs that were exposed to nutritional stress during the pre-weaning phase, could not compensate for the poor winter nutrition when moved to forage of better nutritional value in summer. This was true for both breeds of sheep.

5.6 CONCLUSIONS

5.6.1 Experiment 1

Given that the Merino is the larger of the two breeds, greater animal production was expected from it. Grazing on veld Nguni ewes lost less body weight as a percentage than the Merino ewes. There were also no significant differences ($P>0.05$) in the growth of lambs within treatments between the breeds, but Nguni lambs gain percentage was more than Merino lambs on veld. Regarding ewe efficiency, the Nguni ewes were more efficient over treatments than the Merino ewes. This lead to the conclusion that the Nguni sheep has production performance comparable to that of the Merino, albeit with smaller animals. Under conditions of nutritional stress, Nguni sheep tend to outperform Merino sheep.

5.6.2 Experiment 2

The anti-quality factors of Kikuyu are well verified and as Marais (1998) concluded, none of these factors can be eliminated by good farm management practices. Furthermore, multiple regression analysis showed that stocking rate on Kikuyu accounted for 58% of the variation in average daily gain of sheep weaners (De Villiers, 1998).

If nutritional stress is relieved, the Nguni sheep can perform as well as Merino sheep, relatively, taking in account the differences in the natural body size. Carrying capacity is also related to live weight of ruminants, therefore the veld will be able to carry slightly more Nguni sheep than Merino sheep. The attribute of the Nguni sheep regarding their ability to forage on diverse feeds must also be factored in.

Relatively good size lambs (20.64 ± 5.40 kg weaner⁻¹) were weaned off the H treatment, which is not much less the general live weight given in the literature for mature Nguni sheep (Goetze, 2001 and Kunene *et al.*, 2007).

In traditional circumstances Nguni sheep are kept on veld over winter after an autumn lambing season, and are therefore subjected to nutritional stress in the first year alive, in most years. In the two experiments, Nguni sheep lost less live weight than Merino sheep when grown on veld forage, and are therefore assumed to be better adapted to these conditions.

It can be concluded that owners of Nguni sheep should focus on the nutritional quality of forage available to their sheep, rather than to cross breed, in order to improve the performance of their flock.

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CHAPTER 6:

COMPARING RESISTANCE OF NGUNI AND MERINO SHEEP TO GASTROINTESTINAL NEMATODES

6.1 ABSTRACT

A great cause of lamb mortality worldwide is gastrointestinal nematodes (GIN) of which *Haemonchus contortus* plays an important part. The development of parasite resistance to chemotherapy has been identified as a great threat to the control of GIN. This study was conducted to determine resistance or susceptibility of Nguni weaner lambs, compared to Merino weaner lambs against GIN. The trial was done at the Dundee Research station and 42 post-weaned lambs, of which 20 were Nguni sheep and 22 were Merino sheep. These lambs came from either a high nutritional level grazing maize (winter foggage) or the low nutritional level veld and was assigned to either a high nutritional level Kikuyu pasture or a low nutritional level veld for the summer. The experiment was done in the summer of 2016 to 2017. For the assignment the lambs were blocked according to live weight and by using a cross over design were assigned to either the low nutrient level or the high nutrient level treatment for the summer. Ten to 20 g faeces was taken directly from the rectum of each animal and faecal egg counts were done. The samples were analysed by the Veterinary laboratory. As a counter measure to mortalities, FAMACHA© was used to assess the level of infection of each individual. An individual was drenched (to prevent death) when its laboratory result indicated an EPG of ≥ 5000 for 2 consecutive weeks. The sheep were also drenched when its FAMACHA© count was found to be 4 to 5. Assessing the results of the FEC, the area under the curve (AUC) was statistically analysed. A significant ($P < 0.05$) difference was found between Nguni and Merino sheep in favour of the Nguni sheep with the least FEC. No significant differences were observed between the treatments, but the veld had the lower result in FEC between the breeds. The relationship between FAMACHA© and FEC was low (R^2 of 0.18) during this experiment with the few animals tested. Actual resistance or susceptibility was concealed with compulsory drenching, but the number of weaner lambs needing treatment gave a true reflection of resistance. On the Kikuyu all the Nguni lambs needed treatment, while 43% of the Merino needed no treatment. On the veld 40% of the Nguni and 43% of the Merino needed no treatment, which supports the fact that

Kikuyu poses a higher GIN challenge, but also indicated that the Nguni was the more susceptible breed to GIN on Kikuyu grazing.

6.2 INTRODUCTION

GIN infections in small ruminant production are one of the most economically important diseases in small stock husbandry, especially in developing countries (Bishop, 2012). The strongylid nematode *Haemonchus contortus* (Rudolphi) Cobb has been identified as the greatest threat to small ruminants worldwide (Schwarz *et al.*, 2013). It feeds on blood from capillaries in the stomach mucosa and causes haemorrhagic gastritis, anaemia, oedema and associated complications reducing weight gain, and may even cause mortality in severely affected animals.

An associated problem, globally, is the development of parasite resistance to chemotherapy, which forms the backbone of controlling GIN. There is a limited number of effective anthelmintic and the constant use of these materials has naturally led to resistance build-up in GIN species (Saddiqi *et al.*, 2011; Roeber *et al.*, 2013; Van Zyl *et al.*, 2016), challenging the industry to find new innovations to control GIN sustainably.

Saddiqi *et al.*, (2011) discussed breeding resistant small ruminants as a viable strategy to control GIN. Bishop (2012) agreed with this statement, mentioning that there is no empirical evidence to suggest that nematodes will evolve rapidly in response to the development of nematode-resistant host animals. Resistance is considered to be the ability of an animal to suppress the establishment of a parasite infection. In contrast, resilience or tolerance is the ability of an animal to maintain the same level of production even when exposed to parasitism (Bisset and Morris, 1996; Van Zyl, 2014).

Substantial evidence exists that certain sheep breeds are more resistant to internal parasites than others, i.e., the Red Masaai sheep, an indigenous African breed, have been found to be more resistant than several other breeds, such as the Dorper, Blockheaded Somali and Romney Marsh (Mugambi *et al.*, 1997; Correa *et al.*, 2016). Regarding South Africa's own indigenous sheep breeds, claims of both resistance and resilience to internal parasites have been made in popular and semi-scientific

literature. The Blinkhaar Ronderib Afrikaner sheep is described as “tolerant of diseases and parasites”, the Damara breed as “having a high resistance level to parasites” and the Nguni (Zulu) sheep as “tolerant of internal and external parasites” (Ramsey *et al.*, 1998; Du Toit, 2008). However, in a survey of 76 indigenous farmers, when asked to identify livestock production constraints, 58 mentioned parasites and predators as a constraint (Kunene and Fossey, 2006; Kunene *et al.*, 2007). It seemed that even resilient breeds, to a lesser or greater degree, are affected by parasites. Other factors influencing resistance or susceptibility of sheep to GIN need to be considered. Individual sheep within a breed differ regarding their resistance and/or resilience to internal parasites. Hence, it is possible to breed for enhanced resilience within susceptible breeds (Marshall *et al.*, 2013).

The level of nutrition affects the ability of animals to tolerate infection with internal parasites (Coop and Kyriazakis, 1999), and animals in good condition seem to tolerate GIN better than less well-fed animals. Sheep are most susceptible to parasitism at the time of weaning and parturition. An experiment was therefore conducted to investigate the relative resistance or susceptibility of Nguni weaner lambs against GIN infections under a range of conditions. Merino weaners were used as a comparative breed. The animals had finished winter on two different nutritional levels, either grazing maize (a high nutritive level fodder [H]) or veld (a low nutritive level fodder [L]). They were weaned at the end of the winter-feeding experiments. After weaning, the lambs were then moved to summer grazing, which was either Kikuyu pasture (a high nutritive level fodder [H]) or veld, (a low nutritive level fodder [L]), for the summer. Faecal analysis was used to determine the level of GIN infections. Animals with resistance to internal parasites will usually have low nematode eggs gram⁻¹ (EPG) of faeces (Bisset and Morris, 1996; Colditz, 2008).

6.3 MATERIAL AND METHODS

6.3.1 Site

The field experiments were conducted at the Dundee Research Station, Department of Agriculture and Rural Development, KwaZulu-Natal. The Research Station is situated about 10 km east of Dundee (latitude 28°10'S and longitude 30°31'E), at an altitude of 1219 m (2830AB). The long-term mean rainfall is 782.8 mm a⁻¹ and the

distribution is a typical summer rainfall pattern with convectional rainfall from October to March. The veld type is Sandy Sour veld (Bio resource group [BRG]14).

6.3.2 Animals

A total of 42 post-weaned lambs were used for the experiment, 20 of the Nguni breed and 22 of the Merino breed. The lambs were used in a crossover experiment (Chapter 5), comparing the performance of the breeds on different winter feeding regimes pre-weaning, namely grazing maize as the high (H) level feed, and veld as the low (L) level feed, followed by two summer feeding regimes, with Kikuyu as the high (H) level grazing, and veld as the low (L) level grazing, generating four treatments in summer: High-High (HH), Low-High (LH), High-Low (HL) and Low-Low (LL). The current experiment ran together with the summer feeding experiment (Chapter 5 – Experiment 2) with lambs on different nutritional level treatments (HH, LH, HL and LL), with emphasis on measuring resistance to gastrointestinal nematodes under these conditions. The experiment was done in the summer of 2016 to 2017.

The animals were blocked according to live weight (Chapter 5 – Experiment 2). Treatments were replicated twice.

6.3.2.1 Animal health

All the trial animals were vaccinated using Multivax P[®], prior to the trial, to immunize against Enterotoxaemia, Malignant oedema, Black quarter, Tetanus and Pasteurellosis. Any animal with a positive number of oocytes per gram (OPG >0) was treated using an injectable product Norotrim 24[®]. This product has no effect on the infestation of roundworms. Any animal with an infection of *Moniezia* and *Thysanitiesia spp.* was treated with Ex-a-lint[®]. The active ingredient, niclosamide, is very specific against tapeworms, and will not affect the roundworm infestation levels of the animal.

Attention was immediately given to any individual animal that had an FEC of ≥ 5000 EPG for two consecutive FEC tests, as stated in the animal ethics agreement. Such cases were recorded and treated using dosing material with Rafoxinide as the active ingredient. Rafoxinide was identified in earlier studies on DRS to be the most effective active ingredient against roundworm infestations, other than Derquantel (Van Zyl, 2014).

6.3.2.2 Grazing treatments

Kikuyu and veld were used as grazing treatments. All treatments were supplemented with Voermol Maxiwool™, aiming for an intake of 400g animal⁻¹ day⁻¹. Fresh running drinking water was always available.

Full feed analysis was done on samples from both Kikuyu and veld. The samples were taken monthly (January, February and March), using the methods described in Chapter 5 under Paragraph 5.3.2.2.1.1.

Kikuyu pasture

Four small rain-fed Kikuyu pasture camps, (< 1 ha each) were made available for the experiment, and ample feed was available at all time for the animals. The Kikuyu pasture was regarded as the high nutritional level (H) pasture for the summer period and was grazed by weaner lambs from both breeds, coming from either grazing maize as the high nutritional level (H) or veld, regarded as the low nutritional level (L) during winter.

Veld

Six veld grazing camps were available for the weaned lambs. The total area consists of approximately 10 ha and as the experiment was done over the growing season, ample food was available for the animals. Predominant grass species were described in Chapter 4, (BRG 14). The veld was regarded as the low nutritional level (L) pasture for the summer period and was grazed by weaner lambs from both breeds, coming from either grazing maize as the high nutritional level (H) or veld, regarded as the low nutritional level (L) grazing during winter.

6.3.3 Data collected

6.3.3.1 Faecal egg count (FEC)

Approximately 10 to 20 g of faeces were taken directly from the rectum of each sheep on a weekly basis. The samples were individually placed in numbered sterile plastic bags, then transported to the laboratory on the same day in a cool bag containing ice packs.

FEC analyses were done by KZN Departmental Veterinary Laboratories, using the modified McMaster method (Hansen and Perry, 1994), to count *Strongyle* worm eggs

in faeces. Three grams of faeces were diluted into 30 ml of a saturated 40% sugar solution. After mixing the solution, a sample was taken with a pipette and dropped into a McMaster slide chambers. Using a microscope, helminth eggs were counted on both sides of the chamber and multiplied by 50 to estimate the total number of eggs in the sample as EPG of faeces.

The laboratories used did not differentiate between species, and results need only be seen as an indication of the level of infection by mixed GIN species. Colditz (2008) stated that it is generally not possible to differentiate between the species of *Trichostrongylid* eggs on species level with this method.

6.3.3.2 Famacha®

Visual estimation of GIN infestation levels was done using the Famacha® technique, which uses an estimate of the level of anaemia caused by a possible infestation of nematodes. The Famacha® score per individual animal is determined by comparing the colour of the mucosa of the eye, with a chart in the operator's hand that displays five different shades from red to very light pink. The scores range from 1 for red, which indicates healthy animal with no anaemia, to 5 for very light pink, which indicates an animal that is highly anaemic (Bath and Van Wyk, 2001).

6.4 STATISTICAL ANALYSIS

Genstat 18.1 software was used in the analysis of the data. An analysis of variance (ANOVA) was done, with Fisher's least significant difference test conducted to separate means, at a 5% level of significance. For greater accuracy of data analysis, the area under the curve (AUC) by using the following formula:

$$Area = \int_a^b f(x)dx$$

Area under curve (2017).

For the second part of the assessment, the FEC data was transformed by a Log_e transformation, and doing an ANOVA using Genstat 18.1 software (VSN Int., 2015).

6.5 RESULTS

6.5.1 Climatic conditions

The first good rains for the summer season, were recorded in November. November was characterized by intermittent rain with heavy downpours. Above normal rain also fell during January, February and March, creating moist conditions during these months (Figure 6.1).

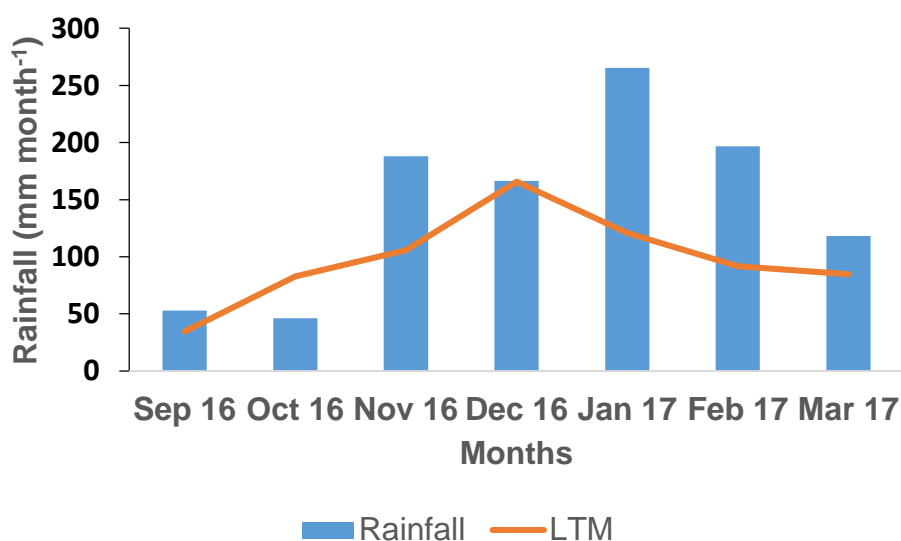


Figure 6.1: Mean monthly rainfall (mm) for September 2016 till March 2017, compared to the Long-term mean (Agricultural Research Council, 2016/17)

The mean daily maximum temperatures for the spring were slightly higher than the long-term means (LTM), possibly as result of the relative low rainfall. These climatic conditions prolonged the normal winter drought. However, this trend changed in December, when rainfall was above normal. The trend changed from January to March, possible due to the abundant rainfall, with less sunshine during these months.

Minimum temperatures did not divert significantly from LTM, although the mean daily minimum temperature in January was slightly below the long-term mean (Figure 6.2).

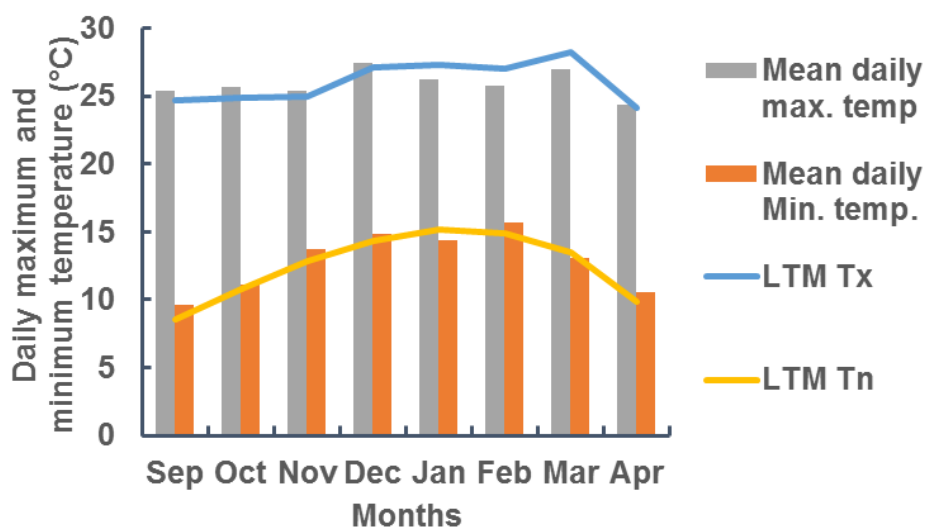


Figure 6.2: Mean daily maximum and minimum temperatures in relation to the Long term means (Tx and Tn), (Agricultural Research Council, 2016/17)

Relative humidity's (RHx and RHn) were below the LTM means for the dry spring months, but were above normal during November when above normal rain was measured. This trend was also visible in February, but not in January and March (Figure 6.3).

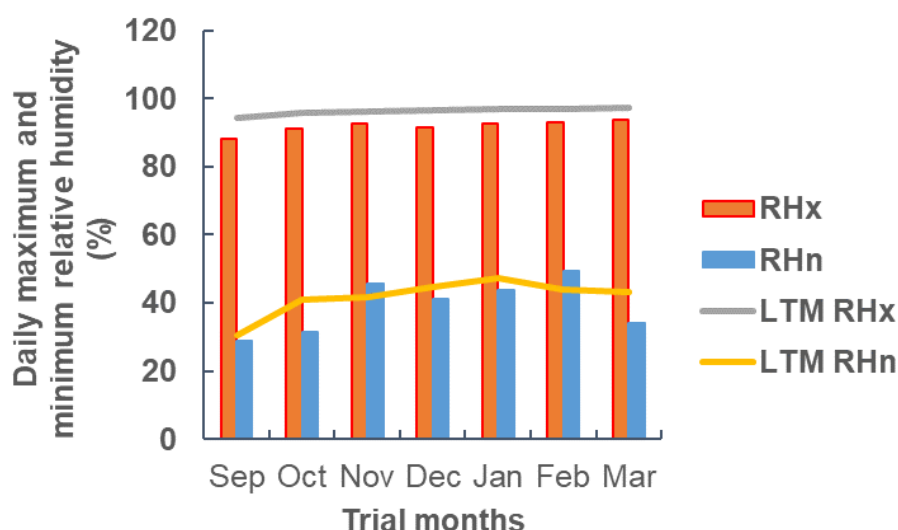


Figure 6.3: Maximum and minimum relative humidity (RHx and RHn) - (%) recorded during the trial months compared to the long term means for humidity (LTM, RHx and RHn), (Agricultural Research Council, 2016/17)

6.5.2 Chemical analyses of pastures

The chemical feed value of the samples in terms of acid detergent fibre (ADF), neutral detergent fibre (NDF) and crude protein (CP), in both Kikuyu and veld, are displayed in Figures 5.3, 5.4 and 5.5 in Chapter 5. The ADF ranged between 39.08 up to 54.49% in the Kikuyu samples and it ranged between 50.54 to 60.35% in the veld samples.

NDF for the pastures ranged between 67.16 to 76.76% for the Kikuyu and 62.57 to 88.52% for the veld. The difference in CP content indicated bigger differences of 14.61 to 22.07% for the Kikuyu and 4.45 to 6.88% for the veld.

Considering the explanation furnished in Chapter 5 (section 5.5.1.2) regarding ADF, NDF and CP, these pastures (both veld and Kikuyu) were not of prime quality.

6.5.3 Faecal egg count

6.5.3.1 Effect of summer grazing (Kikuyu and veld) on FEC of weaner lambs

When the mean weekly FEC of lambs (both breeds) on the two forage treatments over the trial period was analysed. However, no significant difference ($P>0.05$) in the FEC counts resulted from the forage treatments. A significant difference ($P<0.05$) in FEC was found between the FEC of the Nguni and Merino breeds, with the Nguni sheep displaying the lower FEC. The interaction between breed and treatment were found to be not significant ($P>0.05$). In this analysis, the effect of reduced FEC levels were included as result of drenching when the FEC of individual lambs exceeded the critical level of 5000 EPG in two consecutive weeks, as set by the Animal Ethics Agreement. (Table 6.1).

Table 6.1: Mean FEC of Nguni and Merino weaner lambs on either Kikuyu or Veld grazing for the trial period (AUC) - effects of drenching on FEC included

| Breed (B) | Treatment forage | | Means for Breed |
|------------------|----------------------|--------------------|--------------------|
| | Kikuyu | Veld | |
| Merino | 38640 | 39712 | 39176 ^a |
| Nguni | 27831 | 22844 | 25338 ^b |
| Means for Forage | 33236 ^a | 31278 ^a | |
| LSD (5%) | Breed (B) | 13662.1 | |
| | Treatment forage (F) | NS | |
| | Interaction B X F | NS | |
| | CV% = 21.6% | | |

FEC = faecal egg count per gram of faeces

LSD = Least Significant Difference;

Values with different superscripts within the column or row differ significantly.

6.5.3.2 Effect of nutritional levels (HH, HL, LH and LL) on FEC of weaner lambs

The effect of nutritional levels, with resulting differences in body conditions of the lambs, on the mean weekly FEC of lambs (both breeds) on the HH, HL, LH and LL treatments over the trial period was analysed. The differences in the start and end live weights of the lambs are displayed in Figure 6.4, showing that higher feeding levels in summer did not eliminate winter nutritional stress (Chapter 5).

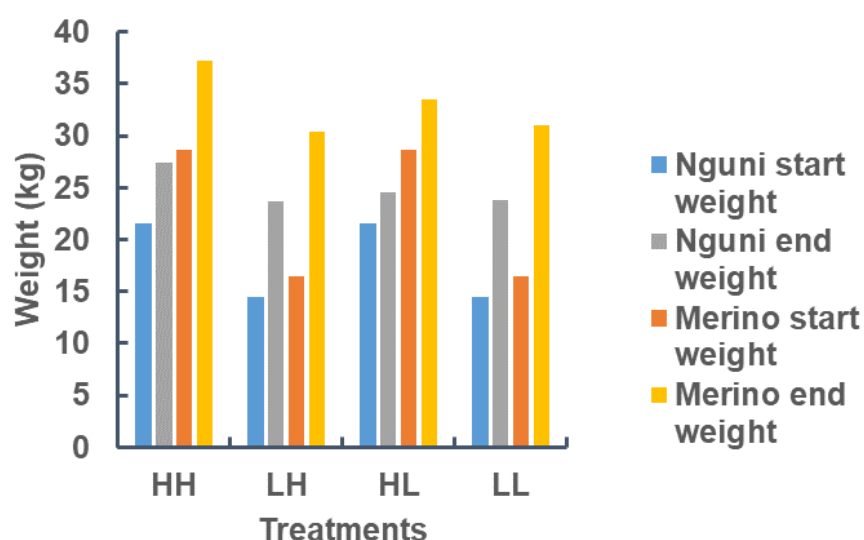


Figure 6.4: Start and end live weight of the weaners from both breeds on the HH, HL, LH and LL treatments

No significant difference ($P>0.05$) was found between the breeds and nutritional treatments regarding FEC (Table 6.2).

Table 6.2: Mean FEC of Nguni and Merino weaner lambs in treatments, HH, HL, LH and LL (AUC)

| Breed (B) | Treatments (F) | | | | Means for B |
|-------------|-------------------|---------|----------|-------|-------------|
| | HH | LH | HL | LL | |
| Merino | 30429 | 47233 | 29123 | 51788 | 39643 |
| Nguni | 35671 | 26963 | 25308 | 27880 | 27880 |
| Means for F | 33050 | 37098 | 27216 | 37683 | |
| LSD (5%) | Breed (B) | 13195.7 | $P>0.05$ | NS | CV % 33.9 |
| | Treatment (T) | 18661.5 | $P>0.05$ | NS | |
| | Breed x Treatment | 26391.3 | $P>0.05$ | NS | |
| | | | | | |

LSD=Least Significant Difference.

6.5.3.3 Resistance or susceptibility of Lambs to GIN

Resistance or susceptibility to GIN infections were concealed due to compulsory drenching, which occurred once the FEC levels exceeded 5000 EPG in two consecutive weeks. To counteract this concealment, the number of weaner lambs of both breeds on the two grazing treatments, Kikuyu and veld, that never exceeded the 5000 EPG level, and therefore needed no drenching during the trial period, were used as a measure of resistant animals (Table 6.3 and Figure 6.4).

Regarding the summer treatments only, all the Nguni weaner lambs on the Kikuyu needed drenching, while 43% of the Merino's on the Kikuyu had FEC that stayed below the critical level over the trial period and were not drenched. On the veld grazing, 40% of Nguni weaner lambs and 34% of Merino weaners lambs had FEC levels below the critical EPG level over the trial period indicating a trend. Statistics was not done as the numbers were relatively small (Table 6.3).

Table 6.3: Weaner lambs (Nguni and Merino) that did not need treatment on the summer forage (%)

| Forage | Breed | Weaner lambs not drenched (%) |
|---------------|--------------|--|
| Kikuyu | Nguni | 0 |
| | Merino | 43 |
| Veld | Nguni | 40 |
| | Merino | 34 |

When the effects of the HH, LH, HL and LL treatments were considered, all Nguni lambs, either in a better condition (coming from H treatment in winter) or lambs in a poorer condition (coming from the L treatment in winter), needed treatment on Kikuyu. Regarding the Merino lambs, 43% of the lambs in better condition (coming from the H treatment in winter) were able to withstand severe GIN infections. The Merino lambs in poorer body condition (coming from the L treatment in winter) all needed drenching (Figure 6.4).

A trend was noticed as no statistics was done because of small numbers. On the veld, 34% of the Merinos from the H winter treatment withstood severe GIN infections, as did 20% of the Nguni lambs. In the group of lambs coming from the L winter treatment, all Merino were susceptible to severe GIN infections and needed drenching, whereas 20% of Nguni lambs did not need drenching.

Table 6.4. Nguni and Merino weaner lambs (%) that needed no drenching treatment for the whole of the trial period (i.e., FEC stayed below 5000)

| Forage | Treatment | Breed | Weaner lambs not drenched (%) |
|------------|-----------|--------|-------------------------------|
| Kikuyu (H) | HH | Nguni | 0 |
| | | Merino | 43 |
| | LH | Nguni | 0 |
| | | Merino | 0 |
| Veld (L) | HL | Nguni | 20 |
| | | Merino | 34 |
| | LL | Nguni | 20 |
| | | Merino | 0 |

6.5.3.4 Relationship between the recorded Famacha[®] scores and FEC

The recorded Famacha[®] scores taken per animal during faeces collection per individual faecal sample, were compared with the FEC resulting from the laboratory analyses. A weak relationship resulted. This data is displayed in Figure 6.5.

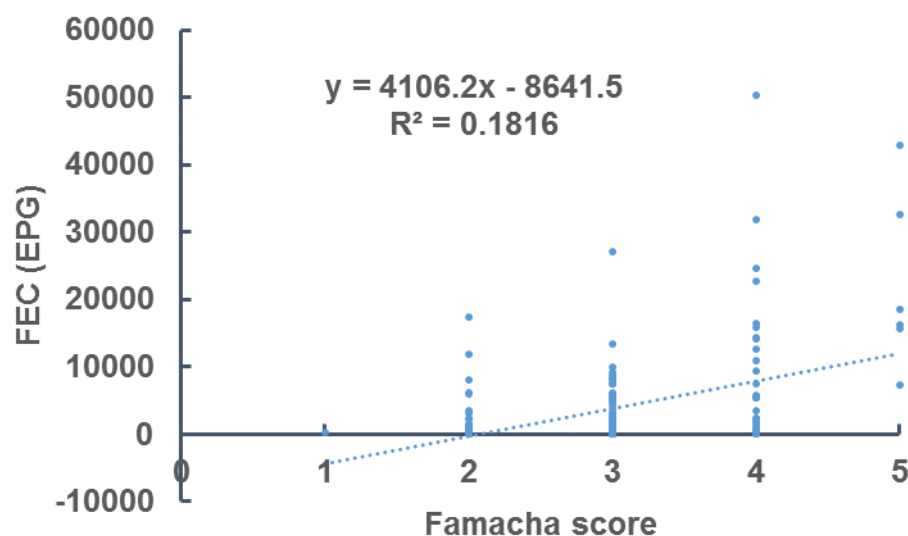


Figure 6.5: Linear Regression between Famacha[®] score (observed) and the FEC (EPG) as analysed by the veterinary laboratory

6.6 DISCUSSION

The spring months of September and October were relatively dry, resulting in low FEC's in the weaner lambs on trial. The first elevated FEC's were found in January 2017 after above normal precipitation from November onwards. According to Hansen and Perry (1994), temperatures between 22°C and 26°C, plus sufficient moisture, provide ideal conditions for GIN larval development. Under favourable climatic conditions eggs can hatch and develop into the infectious L₃ stage within seven to ten days. Krecek *et al.*, (1995) showed that air temperature and soil moisture have strong positive effect on the numbers of L₃ larvae, whereas relative humidity has a weaker positive effect, especially in the lower vegetation layers of pastures.

Due to compulsory drenching to control FEC levels (according to set norms in the Animal Ethics Agreement weaner lambs with FEC exceeding 5000 EPG in two consecutive weeks), the mean FEC under these management procedures showed that no significant difference ($P>0.05$) in FEC levels was found between the Nguni and Merino breeds. There were also no significant effects of the grazing on FEC numbers ($P>0.05$).

These results were in contrast with the fact that the Kikuyu pasture, with its dense growth habit, is believed to create an ideal microclimate for GIN larvae to develop to the infectious stage (L₃), and therefore to promote re-infection of grazing sheep (Van Zyl, 2014). They are prone to become highly contaminated with GIN. In contrast, veld is less dense with more uncovered soil areas, allowing the sun to penetrate to ground level, and reduce moisture levels in the veld. The numbers of L₃ larvae of *H. contortus* that become infective has been correlated with the moisture levels in the pastures (Krecek *et al.*, 1992; Krecek *et al.*, 1995; Van Zyl *et al.*, 2016).

However, the actual resistance or susceptibility to GIN infections were concealed by the practice of compulsory drenching once the FEC exceeded 5000 EPG in two consecutive weeks. To counteract this concealment, the number of weaner lambs of both breeds on the two grazing treatments, Kikuyu and veld, that never exceeded the 5000 EPG level gave a truer reflection of resistance or susceptibility to GIN infection. On the Kikuyu pasture, all the Nguni weaner lambs needed drenching, while 43% of

the Merino weaner lambs did not need drenching. On the veld grazing, both breeds were less badly infected; with 40% of Nguni weaner lambs and 43% of Merino weaners lambs not requiring drenching. These figures supported the premise that Kikuyu pastures poses the higher GIN challenge to grazing sheep, but the Nguni sheep proved to be more susceptible to GIN infections on Kikuyu grazing than Merino sheep.

Regarding the HH, HL, LH and LL treatments, all concerning the body condition of the weaner lambs, it is well documented that the condition of the host influences susceptibility to parasitic infections within a flock. Animals in good condition seem to tolerate GIN better (Coop and Kyriazakis, 1999), probably due to their ability to better tolerate the protein and iron losses induced by the parasites than poorly fed animals, especially those on low protein diets. Lambs under the age of six months are known to be highly susceptible to GIN infection (Van Houtert and Sykes, 1996). The lambs used in this study were weaned at the end of the winter period when the challenge of GIN during the cold winter months are very low, and therefore the lambs were all naïve to GIN. Their first exposure to GIN was in the subsequent summer during the experiment.

Nutrition high in protein, energy, or a combination of both, appears to be effective in enhancing specific immune responses to withstand parasitism (Brown *et al.*, 1991; Coop and Kyriazakis, 1999; Hoste *et al.*, 2008). Both the summer forages used in this experiment were relatively low quality for growing lambs. However, the Kikuyu pasture had better CP values, which could have improved the performance of infected lambs.

The lambs on the HH treatment, due to their superior body condition, were expected develop fewer GIN infections than the lambs on the other treatments. This was what occurred with the Merino weaner lambs. Nearly half of the Merino weaners did not need treatment on the Kikuyu, where GIN challenge was expected to be high. However, the Nguni lambs, despite their good body condition, could not withstand the GIN challenge, and all needed drenching. In the case of the LH treatment, all weaners entered the summer grazing on Kikuyu were in a much worse body condition after winter, and all lambs of both breeds needed treatment.

The weaner lambs in the HL treatments ended winter with good body conditions, and then spent the summer on veld where the GIN challenge was assumed to be lower. As a result, 40% of the Nguni weaners and 43% of the Merino weaners needed no drenching. In contrast, the weaners that ended winter in a poorer body condition and also spend the summer on veld (LL) were more susceptible. As a result, all the Merinos lambs need drenching and 20% of the Nguni lambs needed no drenching.

Body condition, breed and type of grazing all appeared to play a role in the susceptibility of both Nguni and Merino weaner lambs to GIN infections. Further research is needed to confirm these preliminary findings. A change in trial design may be needed to deal with the masking effect that compulsory drenching creates.

The Famacha system was developed as a visual evaluation of the colour of the mucosa of eyes of sheep to estimate the level of anaemia in each animal. Drenching is recommended for sheep that have a Famacha[®] score of ≥ 3 (4-5) (Bath and Van Wyk, 2001). However, the Famacha[®] scores taken in this study had a weak relationship with the actual FEC numbers, which are a direct measure of GIN infection levels. Again, this potentially important outcome requires further studies to confirm this preliminary finding.

6.7 CONCLUSIONS

Under conditions of good nutrition (grazing maize) in winter and Kikuyu pasture in summer (HH), with high levels of GIN inoculum, Merino lambs were less susceptible to GIN infection than the Nguni sheep. Under conditions of good nutrition (grazing maize) in winter and poor veld in summer (HL), the two breeds were equally susceptible to GIN. Under conditions of poor veld in winter, and good Kikuyu pastures in summer (LH) with high inoculum levels, both breeds were equally heavily infected. Under conditions of poor veld in winter and in summer (LL), but with lower inoculum levels, the Nguni lambs were slightly less susceptible than the Merino lambs. Overall, there is little evidence of Nguni lambs being less susceptible to GIN infections than Merino lambs.

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CHAPTER 7

DISSERTATION OVERVIEW AND CONCLUSION

7.1 OVERVIEW

The Nguni sheep of KZN, also known as the Indigenous Zulu sheep, or just Zulu sheep, are today only found in relatively small flocks, scattered throughout the northern and north-eastern parts of KwaZulu-Natal where they are primarily owned by small scale farmers using communal grazing. The first part of the study was dedicated to identifying the distribution of Nguni sheep in KwaZulu-Natal, to understand local sheep production constraints and management practises, and the ways that sheep are utilized in the rural Zulu communities.

Fifty-two owners with 1184 sheep were located. The distribution of sheep was separated into four main areas: Nongoma with 30.8% of the sheep, Nkandla with 28.8% of the sheep, Ingwavuma with 21.2% of the sheep and Msinga with 19.2% of the sheep. The distribution of sheep was spread over several agro-ecological zones, including sweetveld, mixed veld and sourveld. The agro-ecological zones determined the need for supplementary feed and tick control practices. The mean flock size was 24.5 sheep per flock, with a ratio of rams to ewes of 1: 14. Kraaling at night was a popular method used by the majority of owners to ensure the security of their sheep. Regarding animal health, most of the farmers did not have access to veterinarians. Breeding happened year round and the majority of owners did not practise castration. Crossbreeding with Merino or Dorper sheep was being practised, with the aim to improve mutton production. Home consumption and income generation were given as the main reasons for keeping sheep.

The next part of the study focussed on the phenotype of the Nguni sheep. Two purebred flocks, based at the Dundee and Makhathini Research Stations (DRS and MRS, respectively), originated from the same original genepool, but were separated in 2009, and subsequently exposed to different agro-ecologies and management practices. The Dundee flock was intensively managed and feed on summer sourveld and winter pastures, with a defined breeding season. The Makhathini flock was kept free-ranging, feeding solely on sweetveld and managed extensively, with uncontrolled,

year-round breeding. These two flocks were assessed and compared regarding different qualitative and quantitative phenotypic characteristics. Qualitative traits such as tail type and coat pattern and colour did not differ between the sheep at the two assessment sites, with an overall mean of 59% of sheep having thin tails. The predominant coat colouring and pattern was plain light brown in both flocks. However, some notable differences were measured. The majority of sheep at MRS (87%) displayed straight facial profiles, compared to slightly more than half (57%) at DRS. The majority of MRS sheep displayed straight backs (49%) but at DRS there was a greater inconsistency in the appearance of the back profiles, with only 27% having straight backs. In qualitative traits, pelvis width and heart girth, which can probably be related to the better nutritional and more intensive managerial conditions at DRS, showed highly significant differences ($P<0.001$) between the two flocks. Head width was also significantly larger in the DRS group. Differences in head and ear length and shoulder heights, body length, tail length and width were not significant.

The performance of Nguni sheep under different nutritional levels was tested in a winter-summer forage trial. Merino sheep was used as a comparative breed. Lactating ewes were exposed to either a low nutritional level (L, sourveld) or a high nutritional level (H, grazing maize) during winter. In a crossover trial, post-weaned lambs were fed with either a low nutritional level (L, sourveld) or a higher nutritional level ((H, planted Kikuyu pasture). Live weights were recorded during the next summer, resulting in four treatments: HH, HL, LH and LL. There were highly significant ($P<0.001$) differences in live weight changes on the different feeding treatments, but no significant difference was found between the changes in live weight over the trial period between the two breeds. Analysing ewe efficiency, significant differences ($P<0.05$) were found between the feeding treatments and breeds, which showed that the Nguni ewes were more efficient. The reaction of lambs to the treatments showed that, in terms of weight change pre-weaning, the Nguni sheep were comparable to Merino lambs, although a high level of significance was found between the treatments ($P<0.001$).

Post-weaned results for the lambs showed compensatory growth in lambs of both breeds that were under nutritional stress during winter. The chemical feed analysis of the summer pastures showed that, in terms of ADF and NDF, the quality was not very

different, except for the crude protein content of Kikuyu pastures, which was higher than the crude protein content in veld grasses. At the termination of the trial, the Nguni lambs had an end weight (% of summer start weight) of 63.74% in the LH and 64.43% in the LL treatment, compared to the Merino lambs, which had end weights of 84.46% in the LH treatment and 88.41% in the LL treatment. The differences between breeds were highly significant ($P < 0.001$). The differences between the treatments were also highly significant ($P < 0.001$), but the interactions between breed and treatments were insignificant.

The final part of the study was dedicated to a comparison of Nguni and Merino sheep regarding their resistance to gastrointestinal nematodes (GINs). The data for the investigation were sourced from the faecal egg counts (FEC) of the weaned lambs in the summer trial. Significant differences ($P < 0.05$) were found in the FEC's of the two breeds of lambs, with the Nguni sheep developing lower FEC values than the Merino lambs. The interaction between treatment and breed was found to be insignificant. On the veld, 34% of the Merino from the H winter treatment withstood severe GIN infections, as did 20% of the Nguni lambs. In the group of lambs coming from the L winter treatment, all Merino lambs were susceptible to severe GIN infections and needed drenching, whereas 20% of Nguni lambs did not need drenching.

7.2 CONCLUSIONS

Relatively few Nguni sheep remain in the communal areas of KZN. As such, it has become a critically endangered breed. A PRA conducted in this study showed that the Nguni sheep is a poorly valued breed, and that farmers are taking a fast route to 'improve' their stock by doing uncontrolled crossbreeding. However, this study confirmed that in the presence of regular droughts, causing nutritional stress, Nguni sheep can survive hostile conditions on veld better than Merino sheep. It is important that the problems encountered by resource poor farmers are addressed. Without proper feed, prophylaxis, medicines, information and veterinary assistance, the current challenges experienced will continue and will escalate.

Governmental research stations or colleges could become nucleus collection and distribution points for Nguni sheep. Farmers have identified the availability of Nguni sheep for purchase as a constraint, especially rams from different areas, to ensure genetic diversity and to obviate inbreeding. Another constraint identified was the regular occurrence of a high mortality among weaned lambs. Internal parasites and disease probably play a major role in these deaths. Therefore, it would be advantageous to have veterinary supply points in rural areas where farmers could go to purchase dosing material, feeds such as licks, and vaccines and medicines. At these centres the farmers could also obtain information to their specific requirements.

Before new (relatively unknown and untested) forage plants are to be cultivated in rural areas, maize can be grown as a winter fodder crop to supplement feed for the animals in winter. It has the advantage of being a well-known crop, with established agronomic practices.

This study identified positive traits in the Nguni sheep that make it superior to Merino sheep in some agro ecological zones, and with low input management systems. It would be valuable, even vital for the survival of the indigenous breeds, to disseminate the concept that locally adapted, indigenous animal breeds may have some superior traits to commercial breeds in local agro-ecologies, such as the Nguni sheep and cattle.

7.3 FURTHER RESEARCH

- Further DNA sampling could be done to determine the ancestry of the Nguni sheep and to ascertain how pure the current breed in KwaZulu-Natal is. This must be done in conjunction with phenotypic studies, building upon the current knowledge on Nguni sheep. This is an urgent task because uncontrolled cross-breeding will systematically eliminate pure bred Nguni sheep in the long-term.
- A scientific back-cross programme could be undertaken to breed Nguni sheep selected for superior mutton production (more meat on the legs), sourced from a Dorper donor parent, but with the progeny backcrossed to Nguni parents for seven generations to ensure that the progeny carried more than 99% Nguni genes. This could be confirmed using DNA marker maps of pure Nguni sheep, compared with DNA of the progeny of the breeding programme.

- The relationship between animal condition and susceptibility to GIN needs further investigation, as well as breeding GIN resistant animals in the Nguni sheep.
- Greater emphasis could be placed upon the reduction of weaning stressors on the farm, starting with an effective internal parasite management program and supplemental feeding in winter.
- More research is needed on the unknown qualities of the Nguni sheep, such as:
 - Mothering abilities
 - Ability to survive harsh environments
 - Performance in a feedlot system (high protein supplementation)
 - Meat quality
 - Browsing ability.
 - Effect of cold stress on Nguni sheep.
- Maize as fodder crop in rural areas is a limited resource because farmers will normally harvest the grain, leaving crop residue only. Research could evaluate what portion of the crop can be harvested that would still provide a nutritionally valuable residue for animals. Strategic incorporation of alternative forages to meet key nutritional deficiencies could also enhance sheep production.
- One hypothesis to test is that weaner lambs of Nguni sheep are more resilient to internal parasites when they have fed on higher levels of crude protein.
- A second hypothesis to test is that there is a 'bounce back' effect of GIN populations after dosing with GIN medications, and re-infection from cultivated pastures may then exceed the levels that occur in untreated sheep.