The effect of ecotype and season on the production and reproductive performance of Nguni cattle in Limpopo province of South Africa

By

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Submitted in partial fulfilment of the requirements for the degree

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Declaration

I, Mmboniseni Mulaudzi declare that this dissertation which I hereby submit for the degree MSc (Agric) Animal Science is my own work conducted under the supervision of Prof E.C. Webb and co-supervision of Mr. M.L. Mashiloane. Approval to conduct this study was granted by the University of Pretoria and Limpopo Department of Agriculture and Rural Development. This work has never been submitted to any other university or Institution for degree purposes.

Signature Date

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Abstract

Nguni cattle have been a source of interest for several decades for researchers, breeders and farmers alike. The production efficiency potential, reproduction potential and adaptation of Nguni cattle are some of the most desired traits of the breed. The Nguni cattle breed has several ecotypes that are similar in other respects, and different in other characteristics. The production and reproduction characteristics among the three Nguni cattle breed ecotypes raised at Mara Research Station in Limpopo Province were investigated in this study.

Data of these three Nguni cattle ecotypes (Pedi, Venda and Shangaan) calf births collected from 2009 to 2013 were used in the study. Data contained records of cow identities, monthly cow weights, shoulder heights, calf birth dates, calf birth weights, weaning weights and yearling weights. Data were used to derive the following parameters: inter calving period, weight of cow at breeding, weight of cow at weaning, days to reconceive and weaning efficiency. Data were edited to remove all calves that were born out of season and cattle that died within the first year of study. Only cows that were present in all the breeding seasons during the period of this study were included in the data set. The final data set amounted to 644 calf births with 264, 142 and 65 representing Pedi, Venda and Shangaan ecotypes respectively.

Mixed models procedure of SAS was used to analyse for variance in production and reproduction parameters due to ecotype and season. Least square means were separated using PDIFF function for mixed models procedure and the Bonferroni multiple range test was used to compensate for the unbalanced nature of the data set. GPLOT procedure of SAS was used to generate a schematic representation of the

distribution of reconception data for cows of each Nguni ecotype. The relationship between live weight and body measurements was explored using Procedure of Correlation and GPLOT procedure in SAS. A scatter plot for body measurements for all ecotypes was also done using GPLOT procedure of SAS to demonstrate the size distribution of the three ecotypes.

No differences ($p>0.05$) were observed with regards to cow size variation among the three Nguni ecotypes. The Pedi ecotype had a higher ($p<0.05$) birth weight at 25.46 (0.26)kg and a higher ($p<0.05$) weaning weight at 156.87 (1.84)kg, the Venda ecotype had a lower ($p<0.05$) birth weight at 24.08 (0.38)kg and a higher ($p<0.05$) weaning weight at 144.04 (2.78)kg and the Shangaan ecotype had a higher ($p<0.05$) birth weight at 25.01 (0.70)kg and a lower ($p<0.05$) weaning weight at 136.36 (4.56)kg. Season 2012 had the highest ($p<0.05$) birth weight and weaning weight at 27.67 (0.47)kg and 159.78 (3.23)kg respectively. Season 2010 and 2011 experienced the lowest precipitation, however Shangaan ecotype in subsequent seasons 2011 and 2012 respectively, had the highest ($p<0.05$) birth weight at 26.93 (0.84)kg and 27.05 (1.11)kg respectively, of the three ecotypes. This high performance of the Shangaan ecotype was expected because a smaller framed animal allows for efficient utilization of energy during periods of scarce feed.

The Pedi and Shangaan ecotypes had higher ($p<0.05$) weaning efficiency) at 0.407 (0.01) and 0.439 (0.01) respectively, and differed significantly ($p<0.05$) with the Venda ecotype which had a lower ($p<0.05$) weaning efficiency at 0.381 (0.01). The Pedi and Venda ecotypes had the highest ($p<0.05$) weights at breeding at 355.50 (3.55)kg and 349.68 (4.47)kg respectively which differed ($p<0.05$) from Shangaan ecotype at 328.28 (7.09)kg. Pedi and Venda ecotypes also had the highest ($p<0.05$) weights at weaning across all the years included in the model at 385.44 (7.38)kg and 377.79

(4.89)kg respectively; and were not statistically different ($p>0.05$) from each other but they were both statistically different ($p<0.05$) from the Shangaan ecotype at 341.35 (8.06)kg, which is generally smaller. No differences ($p>0.05$) were observed among the three ecotypes with regards to inter calving period and days to reconception. There were no differences ($p>0.05$) between seasons 2009, 2010 and 2013 for weaning efficiency but all these seasons differed ($p<0.05$) significantly from both seasons 2011 and 2012 at 0.33 (0.01) and 0.47 (0.01) respectively. The lowest ($p<0.05$) weaning efficiency 0.33 (0.01) and highest ($p<0.05$) inter calving period 545.08 (26.30) days were observed in season 2011; and the highest ($p<0.05$) weaning efficiency was observed in season 2012 at 0.47 (0.01). A reduction in cow weight at weaning and cow weight at breeding was observed in season 2012. The observed lack of statistical differences ($p>0.05$) between the Pedi, Shangaan and Venda ecotypes in terms of reproduction is important for Nguni cattle farmers, because either of the ecotypes would fare well in beef production systems in subtropical regions. The implication is that no differences are required in the management of these ecotypes for optimal production; thus farmers can choose either of the ecotypes, and if well managed they should be able to produce a calf each year. The lack of meaningful differences between the ecotypes indicates that there is no need to manage the Nguni ecotypes differently at Mara Research Station in Limpopo Province.

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Table of contents

List of Abbreviations

AD	-	Anno Domini
AI	-	Artificial Insemination
BCS	-	Body conditioning score
CM	-	Centimetres
GLM	-	Generalized Linear Models
GnRH	-	Gonadotropin releasing hormone
GPLOT	-	General Plotting programme
ICP	-	Inter calving period
INTERGIS	-	Integrated Registration and Genetic Information System
KG	-	Kilograms
LH	-	Luteinizing hormone
LHRH	-	Luteinizing hormone-releasing hormone
LSMEANS	-	Least Squared Means
MM	-	Millimetres
N	-	Total number
NBCIS	-	National Beef Cattle Improvement Scheme
NEg	-	Net Energy for gain
Pdiff	-	Pairwise Differences
SAWS	-	South African Weather Service
SAS	-	Statistical Analysis Software
SD	-	Standard Deviation
SE	-	Standard error

List of Tables

List of Figures

Chapter 1

Introduction

South Africa has only just above 10% of arable land (Tainton, 1999); the rest is most suitable for extensive livestock farming, due to high temperatures, low and erratic rainfalls and drought susceptibility. Limpopo is the rule rather than the exception to all these climatological variations (Maponya and Mpandeli, 2012) and as a consequence, the Nguni breed (which is the most popular breed in Limpopo) is the most suitable breed for farming in such harsh conditions. Climate, being a major component of the physical surroundings, has an impact on people's lifestyles and largely, agricultural production systems (Maree & Casey, 1993). Adaptation in livestock comprises the collaboration between the total environment and the genetic constitution of an animal (Scholtz, 2010). The Nguni breed is highly adaptable to these harsh environmental conditions through years of natural selection and survivability to diseases and tick-borne diseases (Collins-Lusweti, 2000; Nowers and Welgemoed, 2010).

Although different literature cites different migratory routes for the arrival of Nguni cattle in South Africa, they all agree that the Nguni cattle settled with different tribes of Nguni people, who are the black people of South Africa, in different bioregions (Schoeman, 1989; Oosthuizen, 1996; Ramsey et al. 2000; Bester et al. 2003; The Nguni Cattle Breeders Society, 2008). Bioregion is also known as agro-climatological region and has a significant impact on the phenotypical differences of Nguni cattle (Botsime, 2005). These are mostly defined as biomes which are classified according to dominating plant life as well as prevalent climatic factors. Due to moisture and temperature having such a strong influence on plant establishment and survival, biomes largely correspond to climatic regions, and each biome has a distinct assortment of plant and animal species as well as a distinct general appearance. This physical environment is very pivotal to the management of beef cattle in extensive feeding systems (Mucina and Rutherford, 2006). The settlement of these tribes in different bioregions and the apparent selection of different phenotypical preferential traits like coat colour patterns, body conformation, horn shape and size has led to distinctive Nguni cattle ecotypes which developed, evolved and adapted into different bioregions (Bester et al. 2003) but still maintained the actual adaptation traits of the original Sanga breed (Schoeman,1989). According to the Nguni Cattle Breeders Society (2008) this occurrence is believed to have ensured genetic variability within the breed and adaptation to different ecological areas within Southern Africa.

Nguni cattle are small to medium in frame size (bulls weigh between 500 kg and 600 kg, while cows weigh between 300 kg and 400 kg) hardy, highly fertile, resistant to diseases, require low inputs, flourish on poor pastures and are well-matched with the communal areas (Tada et al. 2013; Scholtz et al. 2008; The Nguni Breeders Society, 2008). Cow frame size and reproductive performance of the Nguni breed has exhibited it to be the most fertile beef breed in South Africa (Bester et al. 2003) and this is the reason why it is so popular in the Limpopo Province of South Africa in both the commercial and subsistence farming systems.

There are three different Nguni cattle ecotypes that exist in Limpopo Province which differ in size, mature weight, coat colour patterns, body conformation, head and horn shape. The ecotypes are Venda, Pedi and Shangaan ecotypes named after the tribes with which they are found dominant, Vhavenda, Bapedi and Vachangana respectively. According to Mansvelt and Skinner (1962) the then Department of Bantu administration and development played a huge role in realising the value of these indigenous breeds and herds were established for breeding, selection and observation purposes. In 1948, the Department of Agriculture even established a committee that emphasised the value of these breeds in the native areas.

The apparent phenotypical differences in size, body conformation and colour patterns amongst the three Nguni cattle breed ecotypes in Limpopo Province as well as the genetic variability within the breed resulting from the adaptation of the Nguni cattle breed in different bioregions lead us to postulate that these ecotypes may also differ with regards to production and reproductive performance. This supposition consequently suggests that there should be different management strategies applied to these types for optimal production and reproduction efficiency. Therefore, it is absolutely necessary to conduct this study, so that proper scientific facts on the implication of presence or absence of differences can be disseminated or presented to the farmers of the Limpopo province, most of which are resource poor communal farmers with little or no knowledge about these types.

1.2 Aim of the study

The aim of this study was to investigate the effect of ecotype and season on the production and reproductive performance of three ecotypes of Nguni cattle breed in the Limpopo province of South Africa.

1.3. Objectives:

1. To investigate the effect of ecotype on cow size in Nguni cattle present at Mara Research Station.
2. To determine the effect of ecotype and season on the production characteristics of Nguni cattle at Mara Research Station.
3. To determine the effect of ecotype and season on the reproduction characteristics of Nguni cattle at Mara Research Station.

1.4. Hypotheses

1. $H_{O:}$ Ecotype has no significant effect on cow size in Nguni cattle present at Mara Research Station.

$H_{A:}$ Ecotype has a significant effect on cow size in Nguni cattle present at Mara Research Station.

2. $H_{O:}$ Ecotype and season have no significant effect on the production characteristics of Nguni cattle at Mara Research Station.

$H_{A:}$ Ecotype and season have a significant effect on the production characteristics of Nguni cattle at Mara Research Station

3. $H_{O:}$ Ecotype and season have no significant effect on the reproduction characteristics of Nguni cattle at Mara Research Station.

$H_{A:}$ Ecotype and season have a significant effect on the reproduction characteristics of Nguni cattle at Mara Research Station.

Chapter 2

Literature review

2.1. Introduction

Nguni cattle have been a source of interest for decades, for scientists, researchers, breeders and farmers alike. The reproduction potential, production efficiency potential and adaptation of Nguni cattle are some of the most desired traits of the breed. This review will cover the origins of the Nguni cattle and the ecotypes, their description, adaptation, growth performance as well as their reproductive performance. The Nguni breed has several ecotypes that looks similar in colour patterns, stature, length and height and yet so different in other respects. These differences will be explored in this study and in this review.

2.2. The origin of Nguni cattle

The origin of olden and modern African cattle is still a matter of much discussion among researchers (Magnavita, 2006). According to their size, modern African cattle are traditionally sub-divided into at least three major groups: taurine, zebu and taurine-zebu crosses, known as Sanga (Rege et al. 1994; Magnavita, 2006). The Nguni group of cattle truly represent Sanga cattle of Southern Africa according to The Nguni Cattle Breeders Society (2008), maintained by the black people of South Africa who were collectively known as Nguni people. It is also one of the most popular indigenous cattle breed in South Africa (The Nguni Breeders Society, 2008; Schoeman, 1989). The cattle have descended from original Sanga that were introduced into Eastern and Southern Africa when the nomadic people and their Sanga cattle first crossed the Zambezi River about 700 AD. Migration due to wars, trade as well as environmental pressures (Bester et al. 2003) has led to the arrival of Nguni cattle in South Africa approximately 2000 years ago via the banks of the Limpopo River (Ramsey et al. 2000). The Nguni cattle then settled with different tribes who selected these cattle according to their phenotypical traits of preferences, which include horn shape, horn size, body conformation, coat colour and pattern amongst others (Oosthuizen, 1996). These tribes continued to migrate and split up due to tribal dissensions and cattle raids and settle in different bioregions and geographic areas of South Africa, which is why the different breeds of Sanga cattle today are related. A number of ecotypes for this breed evolved under different geographical zones which are believed to have ensured genetic variability within the breed and adaptation to different ecological areas (The Nguni Cattle Breeders Society, 2008).

Ramsey (1988) however, indicates that Nguni cattle, within the Sanga group, descended from the following three main migration routes through southern Africa: the first one from Ethiopia southwest to Ovamboland and Botswana; the second route from Ethiopia south to Zimbabwe, the northern and eastern parts of South Africa; and the third route from Ethiopia southeast to Mozambique, Zululand and Swaziland. The interaction between the environment and the genotype over a period of 1,200 years was reported to have resulted in different Sanga cattle ecotypes, which probably led to different Nguni ecotypes found in South Africa, Swaziland, Namibia and Zimbabwe sharing a common genetic background (Ramsey, 1988). These Nguni ecotypes differ in size, mature weight and colour patterns among others.

2.3. Nguni ecotypes of Limpopo Province

Most scientists agree that Nguni cattle ended up in South Africa through migratory routes of the people of old and that adaptations to the various climate of the areas which the breed was exposed to have resulted in the development of different ecotypes. Bester (2003) indicated that both Nguni ecotypes and landrace breeds such as the Afrikaner can be separated on the basis of their genetic distancing. The settlement of these Nguni ecotypes in different bioregions with different environmental factors such as soil type, veld type, temperatures, humidity and rainfall as well as differentiation over a period of time through selection and different management practices has further led to these recognized subtypes within the Nguni breed.

In Limpopo Province there are three ecotypes of the Nguni cattle breed. These ecotypes are Venda, Pedi, and Shangaan as named after the tribes from which they were found, Vhavenda, Bapedi and Vachangana respectively. According to Mansvelt and Skinner (1962) the then Department of Bantu administration and development played a huge role in realising the value of these indigenous breeds, which were previously regarded as inferior breeds, and herds were established for breeding, selection and observation purposes. In 1948, the Department of Agriculture even established a committee that emphasised the value of these breeds in the native areas.

According to Mara Research Station (unpublished report), The Venda ecotype herd was kept at the Doppie farm in Musina Municipality since 1996, the Shangaan ecotype herd was kept at Hartebees, Mashawa and Magwena farms since 1976 and the Pedi ecotype herd was kept at Stellenbosch farm in Sekhukhune area since 1956 to preserve and ensure purity of the gene pool. All these three Nguni ecotypes have now settled at Mara Research Station west of Makhado town, under the custodianship of the Limpopo Department of Agriculture and Rural Development for conservation and purity maintenance. The performance of these three ecotypes with regard to production and reproduction is not documented.

2.4. Phenotypic description of Nguni cattle

Nguni cattle have a well pigmented, motile hide of medium thickness and a short, fine glossy coat with a wide variety of colour patterns. White, black, brown, red, dun, and yellow are common; and they are found whole or multi-coloured (black and tan or brindle), or in several specific patterns. Nguni cattle are humped, the hump is situated cervico-thoracially and it is muscular in structure. The size and structure of the hump is well developed in bulls 3 years of age, but in females it is only visible in individual cows in really good condition (The Nguni Cattle Breeders Society, 2008). It is a horned breed with crescent shaped horns in bulls and characteristically lyre shaped, thinner and longer horns in mature females (The Nguni Cattle Breeders Society, 2008). The horns are round in cross section and dark at the tips (The Nguni Cattle Breeders Society, 2008). Nguni cattle require low inputs, flourish on poor pastures and are compatible with communal farming (Tada et al. 2013; Scholtz et al. 2010).

2.4.1 Pedi Ecotype

Pedi ecotype herd was preserved and kept at Stellenbosch farm in Sekhukhune district since 1956, however they are now kept at Mara Research Station in Makhado. The Pedi ecotype herd was established around Nguni cattle that were found with the Pedi speaking tribe of Sekhukhune and were selected according to the tribe’s coat colour preference. It is the largest of the three ecotypes at Mara Research Station. The coat colour patterns ranges between grey and white, grey and black as well as grey, white and black. It has a long head with medium lyre shaped horns and large ears (Mara Research Station, unpublished report).

2.4.2 Venda ecotype

The Venda ecotype herd was kept and preserved at the Doppie farm in Musina Municipality of Vhembe district since 1996. Due to land claims the herd was also moved to Mara Research Station for preservation. The Venda ecotype was established around Nguni cattle that were found amongst the Tshivenda speaking people of Venda, who also selected their animals according to their coat colour preferences. It is medium framed and has a short head with lyre shaped horns and medium ears. The coat colour patterns range from black to black and white (Mara Research Station, unpublished report).

2.4.3 Shangaan ecotype

The Shangaan ecotype herd was kept and preserved at Hartbees, Mashawa as well as Magwena farms in Giyani, in Mopani district. The herd was also established around Nguni cattle that were found with the Xitsonga speaking people of Giyani. The Shangaan ecotype cattle were also selected according to the coat colour patterns preferred by the tribe. It is small framed and has a long head with lyre shaped horns and large ears. The coat colours range from red, red and white and white with black patches (Mara Research Station, unpublished report).

2.5. Adaptability and regional differentiation of Nguni cattle

Scholtz (2010) reported that adaptation in livestock comprises the collaboration between the total environment and the genetic constitution of an animal. Having survived many years of exposure to climatic and other environmental extremes such as internal and external parasites, sub-optimal grazing conditions and subsistence management practices; the Nguni cattle breed has developed as a small, hardy, and highly fertile breed which has a higher tolerance for climatic stressors, especially heat, due to their adaptability to harsh subtropical environments and survivability to diseases including tick-borne diseases (Collins-Lusweti, 2000; Nowers and Welgemoed, 2010; Norris et al. 2004; Bester et al. 2003; Nguni Breeders Society, 2008). They are highly fertile, have high reconception rates, remain long in the breeding herd, and they can also calve up to the age of 16 years or more and the mortality rates from birth to weaning are very low (Nguni Breeders Society, 2008). Scholtz (2010) demonstrated another adaptive quality of the Nguni breed where during winter, it modifies its conduct to improve its energy economy by spending less time grazing, grazing while walking, resting longer and walking slower. Nguni cattle do not just sniff the urine as other animals urinate, they also drink the urine, which would result in higher plasma urea levels which may be beneficial on intake and fermentation (Scholtz, 2010). Maree and Casey (1993) indicated that the climate is a major component of the physical environment and thus to a large extent influences lifestyles and also determines agricultural production systems. Botsime (2005) also described bioregion as a very important role player in the phenotypical differences of our cattle, which is especially visible with the Nguni breed. The migratory routes that were taken by the people who owned Nguni cattle toward southern Africa, mentioned by Ramsey (1988), did not only expose the animals to the harsh extremes of the climate and the tropical diseases of Africa, but led to the settlement of these cattle in different bioregions. Natural selection favoured those animals that were genetically suited to the hostile environment. Phenotypical trait selection and management strategies has led to adaptations of Nguni cattle to the different climates of the areas that these Nguni cattle settled in. It is this adaptation that led to the differentiation over a period of time which ensured genetic variability within the breed and the development of different ecotypes that perform differently in different environments (The Nguni Cattle Breeders Society, 2008).

2.6. Growth performance of Nguni cattle compared to other beef breeds

2.6.1. Birth weight

Birth weight (BW) of a calf is a consequence of genetic make-up of the calf and the maternal environment of the cow (Anderson &Plum, 1965). BW echoes the effects of several crucial factors influencing the economic value of the calf during its lifespan, and expresses the vigour and size of the calf at birth (Dawson et al. 1947). It is preferably measured within 72 hours of a calf's birth. A lower BW is preferable than a higher BW for calving ease, although this may affect the growth rate of that calf. Calves with lower BW do not usually reach market weight on time, therefore there has to be a balance between BW and growth rate. The Nguni animal is distinct in that it can physiologically restrict or limit the growth of a foetus in utero in order to prevent accelerated foetus growth that leads to dystocia (The Nguni Breeders Society, 2008). However, growth rate of Nguni calves is not affected by their small BW (Nguni Breeders society, 2008). Nguni calves are usually born weighing 20kg for females and 21-25 kg for males, whereas composite breeds like the Bonsmara and Simbra are born at an average birth weight of 35-36kg.

2.6.2. Weaning weight

Weaning weight refers to the weight of the calf at the moment it stops suckling. It was described by Olthoff et al. (1990) as the sum of birth weight and pre-weaning gains. Weaning in beef cattle occurs at about 6-7 months of age. The weaning weight of the calf is the consequence of the milk production and mothering ability of the dam as well as the type of cattle breed (du Plessis et al. 2006; Schoeman 1996). It is a highly heritable trait that is greatly affected by the environment. A study by Wasike et al. (2009) revealed that at weaning maternal effects are more prominent and that permanent maternal environment effects tend to be greater than direct and maternal genetic effects. All these indicates that gaining vigorous calves at weaning is highly dependent on the post-natal environment provided by the dam (Wasike et al. 2009). Calves with lower birth weights are expected to also have lower weaning weights. Gbangboche (2011) showed that calves with large birth weights are also expected to keep this superiority for daily gain until weaning. Large, vigorous calves have a larger capacity for milk consumption and tend to maintain lactation persistency of the dam, resulting in heavier weaning weights (Dawson et al. 1947). Meyer (1992) indicated that the genotype of the dam influences the phenotype of her calf through a sample of her direct additive effect for growth as well as through her genotype for maternal effects on growth; however, Lombard (1971) reported that changes in the environmental conditions such as climate, management and nutrition may be the main cause of the variation in growth traits. Lubout (1987) and Kars et al. (1994) reported significant influence of year effects on weaning weight.

In a weaner production system, the dam consumes approximately 94% of the total digestible nutrients of the dam/calf unit until weaning. Even if the calf is marketed after feedlot finishing, the dam still consumes up to 72% of the total digestible energy of the dam/calf unit (Skrypzeck et al. 2000; Van der Westhuizen & Matjuda, 1999). Several studies have been conducted to explore the cost effective techniques to increase weaning mass in a weaner production system. Cows that deliver calves with lower birth weights but higher weaning weights are favourable and selected for in a breeding herd. A study by Doren et al. (1986) found that weaning weight of the previous calf was positively correlated with postpartum conception and calving interval, however the extent of the relationship can only be determined by adjusting for differences in breed type, condition, parity, early management, age, weight and weight change of the dam. Weaning weights are usually corrected or adjusted to a 205-day weight to limit variation (Nowers et al. 2013) since the calves are not of the same age at weaning. The formula for correcting weaning weight is as follows:

$$\text{Adjusted 205day weight} = \frac{\text{actual weaning weight} - \text{birth weight}}{\text{actual age in days}} \times 205 + \text{birth weight.}$$

2.6.3. Yearling weight

The 12-month weight of a calf is called the yearling weight. Olthoff et al. (1990) described yearling weight as the sum of weaning weight and post-weaning gains. A calf with a higher birth weight is expected to have a higher yearling weight as well, since there is a positive correlation between birth weight and yearling weight. Olthof et al. (1990) indicated that yearling weight is a highly heritable trait and that selecting for it in beef cattle may lead to a significant response in a short period of time. According to Banga (2002) yearling weight can be used to evaluate adaptability and post weaning growth of calves.

2.6.4. Cow efficiency

Dickerson (1970) defined an efficient cow as early maturing with a high reproduction rate, low dystocia rate, longevity, minimum maintenance requirements and with the ability to convert available energy into highest weaned calves. Some scientists further indicate that an efficient cow must be able to reproduce within a given feeding environment. Productive life of a cow is the result of its health, reproductive performance, maternal ability, survivability, and that of the calf. Therefore, productive life of a cow expresses its fitness in the herd (Aranda-Avila et al. 2010; Martnez et al. 2004; Szabo and Dakay, 2009). The latter studies further indicated that a longer productive life significantly reduces replacement costs and enables the attainment of maximum performance in the herd by having more adult cows which increases the total amount of meat produced.

Reproduction rate of a cow herd and the calves' survival rate are the most important aspects determining cowherd efficiency according to du Plessis et al. (2006). It is however the inherent qualities of an animal such as maintenance requirements, resistance to diseases and parasites (du Plessis et al. 2006) that renders an animal adapted to its environment and thus productively efficient. Susceptibility to diseases and parasites influences the frequency at which livestock have to be treated medically, which is a cost that can be reduced when farming with extensive environment adapted animals. Lamb and Maddock (2009) highlighted just how complicated optimizing the efficiency of beef cattle production can be, due to the many variables going into the equations that attempt to effectively represent breeding herd efficiency. They further indicated that efficiency fundamentally measures the inputs needed to create a desired output.

2.7. Biological and Economical efficiency of beef cattle

Johnson et al. (2010) indicated that defining optimum efficiency in cattle production is complicated. Overall efficiency of a cattle production system is a combination of both biological efficiency (feed consumed to beef produced) and economic efficiency (input costs to output returned). Though the two concepts are related, biological and economic efficiency are not identical. Achieving both simultaneously can be a complicated process which requires understanding and managing the genetic potential of cattle, the environment in which cattle are asked to perform, and decisions about when and what product a producer is marketing (Johnson et al. 2010). He went further on to explain that the reason biological and economic efficiency in cattle production are not always positively correlated, is that the beef cattle industry is subdivided into three highly competitive segments which are the farm, where cattle must be efficient in a limited energy, forage-based, high investment per unit business; the feedlot, where cattle must be efficient in a high energy, grain-based, low investment per unit, margin based business and the market segment, which has the lowest investment per unit and is also a margin based business. Notter (2002) indicated that biological traits supporting efficient use of grazed forages in the first segment of the industry are not similar to those biological traits supporting efficient use of harvested concentrates in the second segment.

Dickerson (1970) noted that in an extensive system an efficient cowherd displays early sexual maturity, a high rate of reproduction, low rates of dystocia, longevity, minimum maintenance requirements, and the ability to convert available energy into the greatest possible kilograms of weaned calves. He further stated that to make the most of efficiency in the cow calf context, the objective is earlier sexual maturity and lean growth with minimum increase in mature weight. The ability to reproduce is by far the most important contributor towards efficiency, and the ability to reproduce in a given feed environment is related to its mature size. Nguni cattle are known as the world's most profitable cows according to The Nguni Cattle Breeders Society (2008). Due to its small to medium frame size the Nguni animal requires low inputs but still performs very well reproductively. It is shown to be the most fertile beef breed in South Africa (Bester et al. 2003; Tada et al. 2013; Scholtz et al. 2008).

2.7.1 Factors influencing biological efficiency of a beef cattle

2.7.1.1. Effect of nutrition on biological efficiency

According to Johnson et al. (2010), biological efficiency depends upon the interaction between genetic potential and the environment with specificity to the availability and variability of feed resources. Johnson et al. (2010) also indicated that maintenance requirements of an animal should not be confused with efficiency since high maintenance cows tend to have high visceral organ weight, low body fat mass, high body lean mass and high milk production. High maintenance cattle are also late maturing, which means they reach puberty late. In contrast low maintenance cows tend to have low visceral organ weight, high body fat mass, low body lean mass and in low milk production (Johnson et al. 2010). Efficiency is a ratio of input to output, and maintenance energy is an input, but not an indication of output. Jenkins and Ferrell (1994) indicate that indigenous feed resources vary radically by geographic location; the natural variation of animals of the same species around the world speaks to the fact that nature defines the right genetics for efficiency differently in different environments. According to de Waal et al. (1990), variation in dry matter yield of veld due to variation in rainfall occurs between years at any specific site and is reflected in animal performance. Forage production in arid and semi-arid lands is very different than tropical areas with high annual precipitation, not only in amount but also in frequency and reliability (Johnson et al. 2010). In a study by Vargas (1999), efficiency was studied in three calving events of small, medium, and large framed Brahman cattle where the small and medium framed cattle were more efficient for the first two calving events, but by the third, when the large framed cattle had reached their full growth potential, the large framed cattle were more biologically efficient. These results reiterate that in both between and within breeds, maximum efficiency occurs at a level of feed intake that does not limit reproduction but also provides adequate energy for milk production to meet the growth potential of the breed as expressed in the calf (Jenkins and Ferrell, 2002).

2.7.1.2 Effect of reproduction rate on biological efficiency

Nguni cattle breed have been used successfully as dam lines in a number of crossbreeding systems as well as the establishment of new composite breeds like the PinZ^{2}yl, (a cross between the Pinzgauer and Nguni), Sanganer (a cross between Afrikaner and Nguni) and Borguni (a cross between Boran and Nguni) in South Africa. This has been achieved by exploiting its ability to physiologically restrict the growth of a fetus in-utero to prevent dystocia, as well as its fertility and potential to produce a calf each year (The Nguni Breeders Society, 2008; Bester, 2003; Scholtz, 2013). This breed of cattle and its crosses have further been proven to maintain their high reproductive performance with ease in both extensive farming conditions and feedlot conditions (Scholtz, 2013). Because of their small frame, Nguni cattle farmers produce more LSU per carrying capacity than a farmer who is farming with cattle of larger frames. It is this efficiency that makes Nguni cattle one of the most popular breeds in South Africa in both commercial and subsistence farming systems.

2.7.1.3. Effect of survival rate on biological efficiency

Du Plessis et al. (2006), reported that reproduction rate and calf survival rate are the most crucial factors determining the efficiency of a cow herd; whereas calving to conception interval, breeding to conception interval, reconception rates, calving percentage, weaning weight and weaning percentages are some of the traits that are also used to measure cow efficiency (Schoeman and Jordaan, 1999). The most efficient cow is one with the highest milk production potential that can repeatedly produce a calf without reducing the percentage of calves weaned.

2.7.1.4. Effect of adaptability on biological efficiency

Hot environments impair production (growth, meat, milk yield and quality), reproductive performance, metabolic status, health status, and immune response in animals (Ames and Ray, 1983). Livestock that are exposed to adverse environments experience reduced rate and efficiency of performance. Acclimation is a phenotypic response developed by an animal to an individual source of stress within the environment (Fregley, 1996, Nardone et al. 2010). Ames and Ray (1983) indicate that animal environment has evolved as an integral part of total animal management systems. When these environmental extremes are eliminated and animals are protected from environmental stressors, both reproduction and rate of growth increase. Cattle partition food energy in the following order: maintenance, growth, lactation, and reproduction. As a selective grazer and browser, the Nguni breed is able to obtain optimal nutritional value from the available natural vegetation, thus enabling it to survive under conditions that bulk grazers such as the European cattle breeds would find extremely testing. It has also adapted to the harsh climate of tropical and sub-tropical areas.

2.8. Reproduction and reproductive efficiency of Nguni cattle

According to Van Zyl (1990) reproductive performance remains the most key factor influencing the productivity of the cow/calf enterprise. Cow herd reproduction rate and calf survival rate are the most crucial factors determining the efficiency of a cow herd. Simmentaler, Bonsmara and Nguni cattle, maintained satisfactory productivity levels while grazing natural sweet veld pastures without any supplements in a study by du

Plessis et al. (2006). Maree & Casey (1993) have indicated that the climate is a major element of the physical environment and also determines which production system will be practiced in that particular region. Over 50% of the bovine population is located in the tropics (Wolfenson et al. 2000). Nardone et al. (2010) indicates that high temperatures may compromise reproductive efficiency of farm animals in both sexes. Heat stress, which is associated with tropical climate compromises oocyte growth in cows by altering progesterone, the secretion of the luteinizing hormone and follicle stimulating hormone and dynamics during the oestrus cycle (Ronchi et al. 2001; Nardone et al. 2010). An animal is adapted when it can thrive and reproduce well in its given environment. The reproductive performance of smaller framed animals in extensive arid sweet veld conditions at Mara Research Station, has been shown to be higher than that of larger framed animals (du Plessis et al. 2006). In the latter study the Nguni breed was observed to have a higher pregnancy rate as well as a higher calving rate than Simmentaler crosses, Bonsmara crosses and Afrikaner breed compared with it in the study.

2.8.1 Factors affecting reproduction efficiency

2.8.1.1 Inter calving period

Inter calving period or calving interval is the period between two successive calving events in a cow's reproductive life. It can be divided into three stages, postpartum anoestrus, gestation and the service period (Diskin and Kenny, 2014). Many authors believe that calving interval is a biased measure of assessing reproductive performance in beef cows mated during a restricted breeding season, due to the large negative influence of prior calving date on calving interval (Bourdon & Brinks, 1983; MacGregor, 1997; MacGregor and Casey, 1999; MacGregor and Casey, 2000). Inter calving period is calculated as an index for the herd but may not provide a full picture of reproductive efficiency if significant numbers of cows do not calve for a second time and are thus not included in the calculation. It has also been demonstrated by (Hetzel et al. 1989; Swanepoel et al. 1992; Swanepoel and Hoogenboezem, 1994; MacGregor and Casey, 2000) that cows with the shortest calving intervals produce the lightest calves at weaning. Calving interval in cows is influenced by interval between calving and the recommencement of ovarian activity in the postpartum period (Shrestha et al. 2004). It is more, profitable to have one calf yearly in beef cattle; therefore (Peters, 1984) advised that it is not recommended for the postpartum anestrous period to exceed 80-85 days.

Postpartum anoestrus is more pronounced in beef than in dairy cattle (Montiel and Ahuja, 2005) and the two main factors that affect its duration are nutrition, measured by body condition score and suckling (Randel, 1990; Montiel and Ahuja, 2005). However, other factors such as breed, age, number of calving events, milk yield, calving season, presence or absence of a bull may also play a role (Montiel and Ahuja, 2005); although they mostly just give impetus to the effects of nutrition and suckling. Scientists agree that the exact mode of action with which suckling causes prolonged postpartum anoestrus is not certain (Escruvao et al. 2012; Crowe et al. 1998; Perez-Hernandez et al. 2002), however it is assumed that it could possibly be that elevated levels of prolactin in a nursing cow are depressing the secretion and release of Gonadotropin Releasing Hormone (GnRH), or that the pituitary gland may be less reactive to GnRH during nursing (Vandeplassche ,1982); or it could be through a neural-mediated inhibition of Luteinizing Hormone Releasing Hormone (LHRH), or due to the inhibitory effect of Luteinizing Hormone (LH) on gonadotrophins, or its action on the ovary (Convey et al. 1983; Pérez-Hernández et al. 2002) or even due to suckling action in a chronic manner to inhibit LH secretion during the postpartum period, (Crowe et al. 1998; Pérez-Hernández et al. 2002). Several studies suggest that separation of a calf from its dam for 12 hours each day may shorten the interval to first oestrus postpartum and also increase the conception rate of *Bos taurus* beef cows in intensive production systems (Escruvao et al. 2012; Stewart et al. 1993; Gazal et al. 1999) however Escruvao et al. (2012) went on further to demonstrate there were no statistical differences between treatment groups on neither conception rates nor length of postpartum interval when the experiment was performed on Bos Indicus cattle under extensive production systems. A higher calving interval results in the reduction of the total number of calving events in the lifetime production of the cow. Montiel and Ahuja (2005) reported the ideal ICP that has been accepted by many scientists is generally shorter than 365 days, however Nguni cows registered at the Namibian Stud Breeders Association obtained an average inter calving period of 402 days despite the severe drought conditions experienced during the nineties (Nguni Breeders society, 2008). This further propagates the idea that Nguni cattle are indeed one of the most adapted and reproductive efficient breeds in South Africa and the world.

2.8.1.2. Conception rate

Conception rate greatly influences both cow efficiency and herd productivity according to Corah and Lusby (1999). Since conception rate influences the percent of cows weaning calves, lower conception rates greatly reduce the productivity of the total herd. Maintaining conception rates will ensure that a high percentage of cows calve down early in the calving season. Heifers that are mated for the first time tend to have a higher rate of conception than repeat cows, because they do not have the added stress of cycling while nursing a calf (Corah and Lusby, 1999). Diskin and Kenny

(2014) however indicated that heifers that are calving for the first time took longer to display oestrus signs than mature cows due to their high energy needs for growth as well as maintenance and milk production, while mature cows only require energy for maintenance and suckling. This phenomenon leads to lower reconception rates in heifers than in mature cows; hence heifers should be mated 2-3 weeks earlier than mature cows to lower the calving to conception interval. Jochle (1972) found direct linear correlations between conception rate in Brahman cows and precipitation, atmospheric pressure and temperature.

The formula for calculating conception rate is as follows:

$$\text{Conception rate} = \frac{\text{Number of cows pregnant}}{\text{Number of cows mated}} \times 100$$

2.8.1.3. Age at puberty

Age at puberty is largely determined by frame size, breed type, climate, management and nutrition of the herd (du Plessis et al. 2006; Lepen et al. 1993; Van der Merwe and Schoeman, 1995). It is an integral part of the animal's life time production. Due to increased production costs, producers are inclined to mate heifers as soon as they are physiologically mature. This practice of early mating may increase lifetime productivity of cows; however, dystocia, decreased reconception rates and lower weaning weight of calves may result as a consequence. Diskin and Kenny (2014) indicated that beef heifers that became pregnant early during their first breeding season and calved as two year olds had greater prospects of becoming pregnant as primiparous cows, have greater lifetime production reflected in greater weaning weights, and tend to calve down earlier in subsequent years compared to heifers that conceived later in their first breeding season. They also indicated that age at which puberty occurs impacts the time of conception in the first breeding season, lifetime productivity and economic efficiency of beef production. According to Lepen et al. (1993), the age at which puberty was attained varied from 11 months to 13.5 months, whereas Vargas *et al.* (1999) gives the age at puberty at 21 months to 22 months. Although there is a large difference between the latter studies, both indicate that puberty was reached during or after the mating season if the heifers were mated at 13 to 15 months of age. However, in most cases puberty was reached before mating at two years of age (du Plessis et al. 2006).

Heritability of age at puberty, age at first conception and age at first calving is normally low indicating that these traits are highly affected by environmental factors. Brown (1956) reported that Nguni heifers may be mated successfully between the ages of 13 to 18 since they reach puberty at an early age, which reduces the age at first calving. According to the Nguni Breeders Society (2008) and INTERGIS the average age at first calving for Nguni cattle is 28 months. A study by Lepen et al. (1993) suggested that, with effective herd and pasture management under extensive sweet pasture conditions, the Nguni has the potential to calve successfully before or at the age of 24 months. They also observed that initial reproduction, body mass and reconception, were not repressed by mating Nguni heifers at approximately 15 months of age on veld.

2.8.1.4. Calving percentage

Calving percentage is a number of calves born per number of female cattle exposed to a bull expressed as a percentage. It is also referred to as effective calving percentage. Calving percentage does not relate to the date of births or when the calves were born during calving season. All full-term calves are included in the number of calves born even if born dead. Calving percentage is a good indicator of breeding performance and herd fertility hence it is used as an estimate of reproductive efficiency in cows (Mokantla et al. 2004; Chenoweth, 1994; Mossman, 1984). Although a low calving percentage can highlight the existence of a problem in a herd, it does not point where the problem lies or the cause of the problem. Herd genetics and environment mismatch e.g. feed resources and management style, bull fertility and fitness, nutritional programme and disease could all affect calving percentage. Usually under extensive production systems there is only one breeding season (Diskin and Kenny, 2014), in circumstances where a single sire is used on a herd of cows the fertility of the bull is very important. Utilization of a sterile bull will result in a great loss, since there will not be any conception, and therefore no calves born that year.

Variation in calving percentage occurs year by year due to environmental stresses such as drought, severe winters and high environmental temperatures. Several studies have recorded different calving rates for different breeds in different environments. Rennie et al. (1976) projected the calving rate of conventionally raised Tswana cattle in Botswana as 46.4%, compared with 74.0% for similar animals on a farm. Calving percentage in the communal areas is estimated at 41% (Bembridge and Tapson, 1993). The higher calving rate on the farm is attributed to the animals being better fed and managed than those under traditional or communal management. Nuru and Dennis (1976) calculated a calving rate of 67% for White Fulani cattle raised on government farms in Nigeria, compared with about 34-55% for similar animals raised by local herders.

The effect of season on calving rate was investigated and significant effects of year on calving rate was attributed to differences between years in the quantity and quality of forage available (Thorpe and Cruickshank, 1980). Bishop (1978) found that calving percentage of Afrikaner cross cows in South Africa was positively correlated with rainfall in the previous year, as did Butterworth (1983) in an analysis of 18 272 births from Nguni cattle in Swaziland. Monthly calving frequency was correlated with previous monthly rainfall records but most of the variation was accounted for by rainfall 10 months earlier in both the highveld (79%) and middle veld (50%). The Nguni Breeders Society (2008) estimates calving percentage of reproductive females at 89.24%. The formula for calculating calving percentage is as follows:

$$\text{Calving percentage} = \frac{\textit{Number of cows calved}}{\textit{Number of cows mated}} \times 100$$

2.8.1.5 Weaning efficiency

Weaning efficiency measures how efficient a cow is at converting feed into kilograms calf weaned. It is calculated as the ratio between the weaning weight of the calf and the weight of the dam at weaning. A study by Comerford et al. (1987) indicated that weaning efficiency depends on several factors like birth weight, calving ease or calf survival. Although heavier birth weight leads to heavier weaning weight (Gbangboche, 2011) and a higher weaning efficiency, it may present problems such as dystocia. Calving difficulty has a devastating effect on calf survival. Lower birth weight has also been shown to have a negative effect on calf survival (Comerford et al. 1987). The latter study also found that correlations were generally positive and significant for birth weight and calving ease, but were more variable for birth weight and calf survival. Lower calf survival leads to reduced weaning rates which affect weaning efficiency negatively. In a beef production enterprise, the aim should be to produce animals with heavier birth weight, no calving difficulties and a higher calf survival rate and a heavier weaning weight.

2.8.1.6 Nutrition

The differences in nutrition probably account for most variation in reproductive performance between and within herds (Wiltbank et al. 1964; McDowell, 1972; Holness et al. 1978). Level of feeding (Wiltbank et al. 1962) and live weight (Ward, 1968; McClure, 1970; Lamond, 1970) affect cow fertility. Nutritional status of the cow, as measured by body condition score (BCS) in the pre- and postpartum periods, highly influences subsequent reproductive performance. BCS has been associated with pregnancy rate, calving interval and weaning weight (Renquist et al. 2006). Richards et al. (1986), Selk et al. (1988) and Houghton et al. (1990) have found a relationship between pregnancy rate and BCS at calving. Morrison et al. (1999) has shown that pregnancy rate is related to both pre- and postpartum changes in body condition score.

Pre-calving nutrition as reflected by BCS of a cow at calving is important because it determines when cows commence oestrus cycles again after calving. Low live weight and poor body condition, compounded with lactation stress, has been observed to further extend the postpartum anoestrus period (Edmonson et al. 1989). It is recommended that body condition scoring takes precedence in regular management strategies of the breeding herd to prevent longer postpartum anoestrus periods, although low BCS negative effects can be partially remediated by putting the cows at a higher nutritional plane after calving.

Nutritional stress has the largest indirect effect on the grazing animal. Basha et al. (2009) indicates that in Africa, natural vegetation makes up a major part of the diet of ruminant livestock. An understanding of these natural pastures can enhance livestock production. High feed costs are a major constraint in profitability of a livestock production enterprise (Van der Westhuizen et al. 2004). Edmonson et al. (1989) indicated that when cows have low body energy reserves, they may have a greater probability of suffering from diseases, metabolic disorders, reproductive failure and reduced milk production, and heifers tend to reach puberty at an older age. The low body energy reserves may also lead to reduced conception rates and increased pregnancy losses.

Steenkamp et al. (1975) who compared conception rates of cows of similar weight that differed in body condition score also found that body condition score at mating is more important than weight and the results of Van Niekerk (1982) also agree where a calving rate of 78% for cows in optimum condition compared to only 8% in animals of the poorest condition were observed. Conception rates are also mostly affected by nutrition of the cow before and after calving. Nutrition will determine how soon the cow would display oestral activity, and how soon it can be exposed to a bull or mated (Corah and Lusby, 1999; BEEFLAMB, 2009). A study by du Plessis et al. (2006) found that nutritional fluctuations between years also increases the variation in the pregnancy rate of the young heifers. A study by Klosterman (1981) suggested that if heifers are to be mated young, sufficient supplementary feeding should be given to maintain acceptable reproductive levels. The low pregnancy rate observed for the Afrikaner breed herd was accounted to an innate characteristic of the breed, as various reports also indicated low reproduction rates in Afrikaner cattle under extensive production environments, at the Omatjene Research Station in Namibia (Schoeman, 1989), Potchefstroom in the Northwest Province of South Africa (De Brouwer et al. 1993) and in Zimbabwe (Tawonezvi et al. 1988).

The plane of nutrition as well as the dietary chemical composition during the breeding season has been shown to affect conception and pregnancy rates (Ciccioli et al. 2003). Ciccioli et al. (2003) reported improved pregnancy rates in beef cows maintained on a moderate plane of nutrition for 10 weeks postpartum as compared to those on a lower plane of nutrition. Jenkins and Ferrell (1994) study indicates that indigenous feed resources vary dramatically by geographic location. Dunne et al. (1999) reported a 50% reduction in conception rates when beef heifers maintained on a high plane of nutrition on pasture were subsequently given a lower plane of nutrition post artificial insemination. However, there was no evidence in the study to indicate that systemic concentrations of progesterone were implicated in the conception rates recorded.

Cattle in the tropics are usually dependent on natural pastures and crop byproducts for feed with a crude protein content that is often below 7.5%, which reduces rumen efficiency and reduces the true digestibility of the feed. Therefore, lactating cows are unable to meet their nutritional requirements and lose weight and condition during lactation. This phenomenon prolongs the lactation anoestrus period, and cows tend to calve in alternate years (Ward, 1968). Forage legumes are mostly preferred as a means of improving animal nutrition in the tropics. Some however contain substances such as phytoestrogens; which are plant derived compounds capable of estrogenic or antiestrogenic effects on the animals consuming them. High concentrations of phytoestrogens can cause long-term disruption in reproduction due to their structural similarities with mammalian estrogen and their propensity to bind estrogen receptors. These compounds may lead to reduction in the fertility of animals (Wyse et al. 2021).

Feeding cows on clover, lucerne or other plants rich in phytoestrogens may also lead to cystic ovaries. Little (1976) assessed several pasture species, particularly tropical legumes, for oestrogenic activity and found that lucerne (*Medicago sativa*) had a slight oestrogenic potential. Care must be exercised where these tropical legumes form part of the pasture that is used as the sole source of the nutritional requirements of the animals

2.9. The effect of frame size on production and reproduction of beef cattle

Taylor (1971) highlighted the difficulty of inter breed relationships or comparisons. He found that when inter breed relationships between mean birth weight and mean mature maternal weight were examined, the birth weight of a breed did not seem to increase in proportion to dam weight but more slowly which means heavier breeds tended to give birth to lighter calves. He also indicated that if allowance is made for differences in body size in different breeds of cattle, performance and productive efficiency would be similar; therefore, a conclusion can be made that breeds are very similar in their optimal performance, with marginal superiority in a few cases which vary with conditions and type of rearing. Nguni cows also have this unique quality to be able to restrict the growth of the foetus in-utero regardless of the size of the sire either in pure breeding or crossbreeding programs which together with the sloping rump conformation of the cow results in calving ease and less incidents of dystocia (The Nguni Cattle Breeders Society, 2008).

The reproductive performance of smaller framed animals in extensive arid sweet veld conditions has been shown to be higher than that of larger framed animals. In a study conducted by du Plessis et al. (2006) at Mara Research Station the Nguni breed was observed to have a higher pregnancy rate as well as a higher calving rate than other breeds compared with it in the study. He also found that under extensive arid sweet veld conditions smaller framed animals had greater reproductive rates than larger framed animals. However, conflicting results concerning the reproduction rates of cattle from different frame sizes also exist, due to not only between breeds variation but within breed variations as well. Rate of gain is usually higher for larger framed cattle; however, large differences in rate and efficiency of gain exist in cattle of similar size (Dhuyvetter, 1995). No one frame size will be best for all feed resources, breeding systems, and markets. Many scientists have always wondered which type and size of cattle are most efficient; between the larger framed ones or smaller framed ones and also between fast growing ones and slow growing ones. Steenkamp and Van der Horst (1974) reported that large- and medium-framed Afrikaner cows grazing natural pastures had significantly higher calving rates than small-framed Afrikaner cows. A study by Taylor et al. (2008) found that frame size of heifers significantly influenced conception rate in second, third and greater parity animals. He also found that large framed multiparous cattle had lower reproductive efficiency due to later calving dates.

The results of Vargas et al. (1999) however reinforced the more prevalent view that small-framed cows have higher calving rates than medium- or large-framed Brahman cows on cultivated pastures and nutritional supplementation in winter. The results from the study of (du Plessis et al. 2006) suggest that the innate reproductive traits of the breed may play a more prominent role in the expression of the reproduction rate than frame size. Johnson et al. (2010) however, indicated that the appropriate question to ask should be linked to the animal’s natural environment and production system since in nature, different breeds of the same species can appear widely different because they have adapted differently to best fit their specific environment. Similarly, different cattle are efficient in different environments and production systems.

2.10. Effect of genetics on reproduction of Nguni cows

The Nguni Cattle Breeders Society (2008) alleged that there is genetic variation among the Nguni cattle breed ecotypes which could have resulted from evolution of the breed during migration and settlement in different bioregions which is believed to have ensured genetic variability within the breed. A study conducted in Mozambique by Maciel et al. (2012) found there were significant genotype by environment interaction effects regarding reproductive traits for the different Nguni ecotypes where age at first calving, calving interval and calving rate where affected by herd of origin. A study by Sanarana (2015) demonstrates that the population differentiation (F_{ST}) and AMOVA analysis of Nguni cattle breed ecotypes revealed that 4.8% of the total variation was due to differences between populations, while 95.2% accounted for the differences within population individuals. The study also found that there was a short genetic distance between the Pedi and the Shangaan ecotype; and even though the Venda ecotype differentiated from the Pedi ecotype, it was genetically closer to the Shangaan ecotype.

2.11. Conclusion

Nguni cattle breed ecotypes developed through migration of African tribes as cattle were adapting to different environments and selection for different traits of importance to those tribes over a long period of time. With further development of the breed, there was a clear emergence of ecotypes within the breed. Evidence from literature show that there are phenotypic and genotypic differences amongst these Nguni cattle breed ecotypes. Though the ecotypes differ phenotypically and genotypically, the difference in performance with regards to production and reproduction is not evident in literature.

Chapter 3

Materials and methods

3.1. Description of study site

3.1.1. Location

The study was conducted at Mara Research Station. The station is located approximately 54 km west of Makhado (23^0 08'04" S and 29^{0}33'24" E) at an altitude of 961 meters above sea level in the Limpopo Province.

3.1.2. Climate

The study location is a hot area with mean daily maximum temperatures ranging from 22.6^{0}C in winter months to 30.4^{0}C in summer months. The long term mean annual rainfall recorded at Mara Research Station is 452mm per annum, 80% of which precipitates in the summer months (between November and March). The mean annual rainfall recorded at Mara Research Station for the study period (2009 to 2013) was 521mm, ranging from 310mm per annum (in 2011) to 620mm per annum (in 2009) as per records of the South African Weather Service (SAWS) for station [0722099 1] - MARA -23.1500 29.5700 extracted on the 23rd January 2015 at 08:31am. Table 3.1 presents the mean annual rainfall for the period of the study.

Table 3.1. Annual rainfall during the study period

Season/year	2008	2009	2010	2011	2012	2013
Annual Rainfall (mm)	590	620	470	310	600	540

3.1.3. Vegetation and Veld type of study site

Mara Research Station is found in the Arid Sweet Bushveld (Acocks, 1998). Figure 3.1 presents the location of the station within the country and province with clear borders by veld type. The vegetation in this area is characterised by woody species such as *Acacia tortilis, Boscia albitrunca, Commiphora pyracanthoides, Combretum apiculatum,* as well as *Grewia species* and grass species like *Eragrostis rigidor, Panicum maximum*, *Panicum coloratum, Urochloa mosambicensis* and *Digitaria eriantha* (Dekker *et al.* 2001).

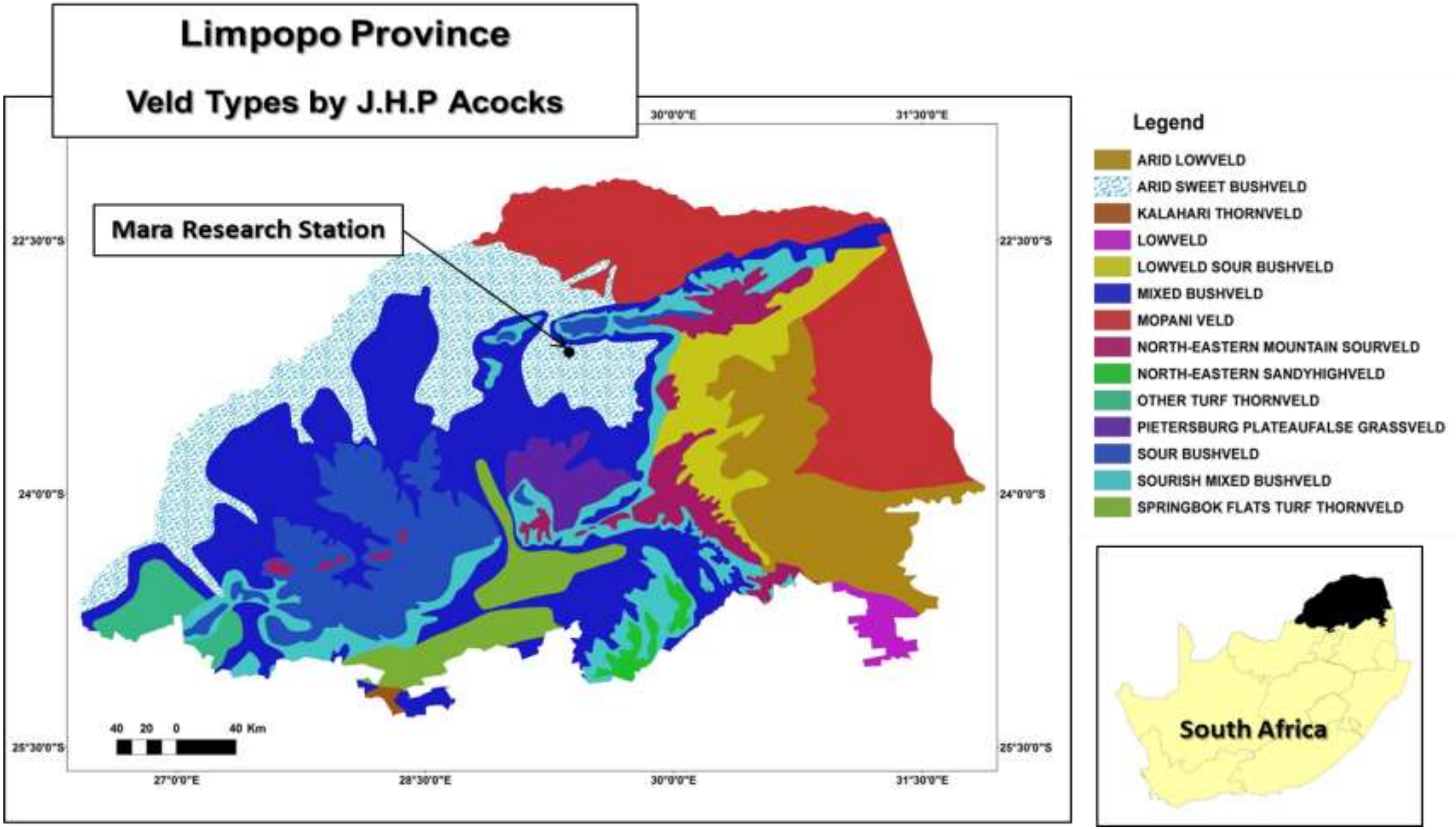

Figure 3.1. The map of the Limpopo province showing the study site and the Veld types

3.2. Management of study animals

The Nguni cattle used in the study were managed in accordance with norms of stud cattle. Management and performance recording was also conducted in line with the requirements of the Nguni Cattle Breeders Society. Records that were kept include birth date, birth weight, weaning weight, yearling weight, monthly weight, health records and pedigree records.

3.2.1. Grazing management

All cattle were kept under extensive grazing system with no supplementary feed or lick provided. The grazing capacity on station can accommodate the nutritional requirements of the animals all year round. A tailor-made Mara grazing system was applied, where emphasis was on rotational resting of the natural pasture instead of the rotational grazing of the pasture. Two types of rests are built into the Mara grazing system, where summer rest encourages seed production, and full season rest which enables the grass plant to complete all its physiological processes and to regain its vigour (du Plessis et al. 2006; Dekker, 1996)

3.2.2. Breeding management

The three different ecotypes (Pedi, Venda and Shangaan) were kept and bred separately at all times to maintain genetic purity. Bulls and cows were also kept separate, except during the breeding season, which was from January to mid-March of every year. Selected bulls of the same ecotype as cows ran with cows for the duration of breeding. The calving season was from October to December and planned to coincide with the onset of summer rains in order to ensure that there was adequate feed to meet the nutritional requirements of the lactating cows.

3.2.3. Health management

All cattle were dipped once per month in an Acaricide solution plunge dip to control external parasites and diseases caused by external parasites. The study area has a high prevalence of diseases like heartwater (Ehrlichia ruminantium; cowdriosis) and redwater (babesiosis) caused by these ticks. Vaccinations against economically important diseases like brucellosis were done on heifer calves at 4-8 months, and at weaning all calves were vaccinated against lumpy skin disease, black quarter, botulism and anthrax. Treatment of sick animals was done by either the Animal Health Technician on site or by the State Veterinarian on call.

3.2.4. Performance recording

Performance recording was done in accordance with the South African National Beef Cattle Improvement Scheme (NBCIS) guidelines for growth and reproductive traits (NBCIS, 1959).

The NBCIS comprises of seven phases:

Phase A is the evaluation of the cow herd which is divided into Phase A1, the reproduction phase and Phase A2 which is the suckling phase. Records kept in Phase A include: identification number, the date of birth, the sire identification number, cow performance, mating records, conception/ pregnancy diagnosis, ease of calving, calving date, sex of the calf, weight of the calf at birth and weight of the calf at weaning, cow weight and reproduction rate.

Phase B is the on farm recording phase of stud heifers and bulls, where post weaning growth rate of young heifers, bulls and oxen is evaluated under normal farming conditions. Traits recorded include yearling weight, 18-month weight, and scrotum circumference.

Phase C is the standard growth tests or central performance test phase where the following traits are evaluated: average daily gain, growth per day of age, feed conversion ratio, body measurements, functional appearance and scrotal circumference.

Phase D is the on-farm growth tests phase for bulls. Post weaning growth rate of young bulls is evaluated by means of performance tests under controlled conditions on the farm of a member or a private organization. Average daily gain, growth per day of age, efficiency ratio, body measurements, functional appearance and scrotum circumference are evaluated.

Phase E is divided into phase E1 feedlot data phase which is optional and phase E2 which is the slaughter phase, where carcass weights, dressing percentage, fat, muscle and bone percentage, tenderness and marbling are evaluated

3.3. Description of secondary data

Production and reproduction records for the years 2009 to 2013 were analysed to determine the differences in production and reproduction parameters of the three Nguni ecotypes at Mara Research Station. Secondary data of 702 calf births with 397, 211 and 94 representing Pedi, Venda and Shangaan respectively, collected from 2009 to 2013 were used. Data contained records of calf birth weights, calf weaning weights and monthly cow weights.

This basic data was used to derive the following parameters: inter calving period, cow breeding weight, cow weight at weaning, days to reconception and weaning efficiency. Shoulder height was measured on the dorsal midline at the highest point on the withers in centimetres, using a tape attached to a wooden stick in the working area where the animal was restrained by a neck clamp. It represents the vertical distance from the highest point on the withers to ground level.

The derived parameters were constructed and calculated as follows:

Birth weight: The birth weights of the calves were taken within 3 days of their birth and was used in the analysis as is.

Weaning weight: Weaning occurred in June during the monthly weighing when the calves were between 6-8 months old depending on when, during the calving season, they were born. The weaners were between 6-8 months old at the time of weaning, therefore the weaning weights were adjusted to a 205-day weaning weight to limit the variation using the following formula:

Adjusted 205-day weight = (actual weaning weight–birth weight/actual age in days) x 205 + birth weight.

Cow weights: All cows were weighed once every month as part of the animal management procedure of Mara Research Station

Cow breeding weight: This is the weight of the cow during the breeding season; it was derived by adding the weight of the cow measured during the three months that the bulls ran with the females and diving that by three to get an average.

Cow weight at weaning: This is the weight of the cow when the calf is weaned. It was used in the analysis as is.

Inter calving period: It was calculated as the number of days between consecutive calving for a particular cow.

Days to reconception: This is the period it took for a cow to conceive again and it was calculated as the date of birth minus the gestation period.

Calving percentage: Calving percentage was calculated using the following formula

Equation 1 Calving percentage = 100-((average ICP per year-365) / 365*100)

Cow efficiency: Cow efficiency was calculated using the formula:

Cow efficiency =Adjusted wean weight/ LSU

The LSU in cow efficiency was calculated as follows

LSU = Cow weight at weaning / 450

Weaning efficiency: This trait measures how efficient a cow is in converting feed into kilograms calf weaned. It was calculated as the weaning weight of the calf divided by the weight of the dam at weaning.

Seasonal classification: Years were classified into seasons. Season 2009 represents year 2009, season 2010 represents year 2010, season 2011 represents year 2011, season 2012 represents year 2012 and season 2013 represents year 2013.

3.4. Data editing

The initial data set consisted of 702 records of calf births of which 397 were Pedi, 211 were Venda and 94 were Shangaan. Data of all calves that were born out of season were removed. Cattle that died in first and second year of the study were also removed. The remaining data amounted to 644 calf births with 264, 142, and 65 representing Pedi, Venda and Shangaan respectively.

3.5. Data analysis

Mixed models procedure of SAS (2015) was used to analyse for variance in production parameters due to ecotype and season. Least square means were separated using PDIFF function for mixed models procedure by employing the Bonferroni multiple range test method due to the unbalanced nature of the data set. The variance in reproduction parameters due to ecotype and season was also analysed using the Mixed models procedure of SAS (2015). Least square means were separated using PDIFF function for mixed models procedure. Bonferroni multiple range test was also employed to compensate for the unbalanced nature of the data set. GPLOT procedure of SAS (2015) was used to generate a schematic representation of the distribution of reconception data for cows of each ecotype. The relationship between live weight and body measurements was explored using Procedure of Correlation and GPLOT procedure in SAS (2015). A scatter plot for body measurements for all ecotypes was also done using GPLOT procedures of SAS (2015) to demonstrate the size distribution of the three ecotypes.

Chapter 4

Results and discussion

4.1. Size variation in Pedi, Venda and Shangaan ecotypes of Nguni cattle

Variation in the physical environment from which cattle originate may affect their morphology. Given the different geographical origins of the Nguni cattle ecotypes, it is expected that these differences will be exhibited in the three Nguni ecotypes at the Mara Research Station at Makhado in the Limpopo province of South Africa. A 180 Nguni cattle were monitored and measured to determine the effect of ecotype on the morphological, growth and reproductive characteristics of Nguni cattle. The average shoulder height of Nguni cows was observed to range from 110cm to 170cm, while body length ranged from 118cm to 167cm. On average a Nguni cow weighed 350.61kg ranging from 220kg to 550kg. The mean body compactness ratios in terms of weight per body length and weight per shoulder height were 2.79kg/cm and 2.53kg/cm respectively. The descriptive statistics of these body measurements are represented in Table 4.1

Table 4.1 Descriptive statistics for anthropometric body measurements of Nguni cattle ecotypes (pooled data) at the Mara Research Station from 2009 to 2013.

Variable	N	Mean	SD	Min	Max
Shoulder height (cm)	180	127.97	7.13	110	170
Body length (cm)	180	141.16	7.79	118	167
Weight (kg)	180	350.61	50.11	220	550
Shoulder height ratio (kg/cm)	180	2.79	0.34	2	3.87
Body length ratio (kg/cm)	180	2.53	0.31	1.69	3.46

N: Number of observations, SD: Standard Deviation, Min: Minimum, Max: maximum.

For the sample of Nguni cattle used, the body measurements were acceptable and within range, because according to the Nguni Cattle Breeders Society (2008), shoulder height of Nguni cows ranges from 110cm to 120cm at an average body length of about 133.7cm. Therefore, the Nguni cows sampled in this study can be regarded as typical and an acceptable cohort representative of Nguni cattle (*Bos taurus africanus)*.

The analysis of variance for body measurements gave unanticipated results. Phenotypical visual appraisal of these three Nguni cattle ecotypes indicates that the Pedi is the largest of the three ecotypes in terms of shoulder height, body length and mature weight, followed by the Venda ecotype while the Shangaan ecotype is the smallest of the three ecotypes. Table 4.2 shows least square means and standard errors for body measurements of the three ecotypes. The results of this study indicate that there were no significant differences ($p>0.05$) observed in weight between the Pedi and Venda ecotypes at 354.94 (5.60)kg and 359.32 (6.40)kg respectively, but they both differed ($p<0.05$) with the Shangaan ecotype which was smaller at 331.36 (7.41)kg in weight. The shoulder height of the Pedi and Shangaan ecotypes were similar ($p>0.05$) at 129.68 (0.79)cm and 127.98 (1.05)cm respectively, but they were both significantly taller ($p<0.05$) than the Venda ecotype at 125.75 (0.90)cm. There were no significant differences ($p>0.05$) in body length between the Shangaan and Venda ecotypes which were both long at 143.43 (1.16)cm and 141.08 (1.00)cm respectively; but the two differed ($p<0.05$) from the Pedi ecotype which was shorter than all the ecotypes in the study at 139.92 (0.88)cm. Ecotype had no significant effect ($p>0.05$) on either the mature weight/shoulder height ratio or the mature weight/body length ratio of these Nguni cattle ecotypes. The body compactness of all these Nguni ecotypes was similar. An animal with a high body compactness is believed to be more productive and reproductive efficient than a less compact animal, therefore these three ecotypes are expected to be similarly efficient.

Table 4.2 Least square means and (standard errors) for the effect of ecotype on body measurements for the three Nguni ecotypes.

Variable	**Pedi**	**Shangaan**	**Venda**
Weight	354.94 (5.60)[a]	331.36 (7.41)[b]	359.32 (6.40)[a]
Shoulder height	129.68 (0.79)[a]	127.98 (1.05)[a]	125.75 (0.90)[b]
Body length	139.92 (0.88)[b]	143.43 (1.16)[a]	141.08 (1.00)[a]
Weight/Shoulder height ratio	2.74 (0.04)[a]	2.82 (0.05)[a]	2.84 (0.04)[a]
Weight/Body length ratio	2.53 (0.04)[a]	2.51(0.05)[a]	2.54 (0.04)[a]

Means in rows with different superscripts differ $p< 0.05$

These results are similar to those obtained by Sanarana et al. (2015) who observed a closer genetic distance between the Pedi and Shangaan ecotype. Sanarana et al. (2015) also observed that the Venda ecotype is genetically distant from the Pedi ecotype, but genetically closer to the Shangaan ecotype.

The Shangaan ecotype is similar (p>0.05) to the Pedi ecotype in shoulder height, but it is also similar (p>0.05) to the Venda ecotype in terms of body length, which indicates a lack of consistency in the Shangaan ecotype. The inconsistency of the Shangaan ecotype can be corroborated by the results of the study of Sanarana et al. (2015), which exposed that the Shangaan ecotype lacks the unique alleles that are required both in conservation and in measurement of population genetic distinctiveness described by Szpiech and Rosenburg (2011). Sanarana et al. (2015) indicated that the absence of these unique alleles in the Shangaan ecotype can be observed by the ecotype's tendency to resemble other ecotypes. However, the Venda ecotype is also similar (p>0.05) in weight to the Pedi ecotype. These results contradict Sanarana et al. (2015) who indicated that the two ecotypes (Venda and Pedi) are very distant to each other by the Principal Component Analysis employed in the study. There is not a single consistent superior ecotype with regards to weight, length and shoulder height; among these three ecotypes. These inconsistencies observed in the results of this study indicate that these three ecotypes are not that different with regards to size.

4.2. Relationship between live weight and body measurements

The relationship between live weight and body measurements was explored using Procedure of Correlation and GPLOT procedure in SAS (2015). Table 4.3 below represents the correlations between live weight and body measurements for all ecotypes combined. There are strong positive correlations (p<0.05) between live weight and the weight/body length ratio (r=0.85) and between live weight and weight/shoulder height ratio (r= 0.81) as well as between live weight and shoulder height (r=0.54). A change in live weight will lead to a positive change in weight/body length ratio, weight/shoulder height ratio as well as shoulder height. Weight/body length ratio is positively correlated (p<0.05) with weight/shoulder height ratio (r=0.85) as well as shoulder height (r=0.54). Weigh/shoulder height ratio is also positively correlated (p<0.05) with body length (r=0.54). These results indicate that a change in one variable will also lead to a positive change in correlated variables. Within the Pedi ecotype, in Table 4.4, the correlations are similar to those of the entire herd of Nguni cattle. There are strong positive correlations (p<0.05) between live weight and the weight/body length ratio (r=0.93), between live weight and weight/shoulder height ratio (r=0.94) as well as between weight/shoulder height ratio and weight/body length ratio (r=0.93). The relationship between live weight and body length is positive (p<0.05), but not very strong (r=0.59). Within the Shangaan ecotype, Table 4.5, there are negative correlations (p>0.05) between shoulder height and body length (r=-0.08) and between shoulder height and weight/shoulder height ratio (r=-0.06). This means that as shoulder height increases, body length as well as weight/shoulder height ratio decrease. There are strong positive correlations (p<0.05) between weight/shoulder height ratio and weight/body length ratio (r=0.69), between live weight and weight/body length ratio (r=0.57) as well as between shoulder height and weight/body length ratio (r=0.57) but the relationship between body length and live weight is not strong (r=0.21). Within the Venda ecotype, Table 4.6, the correlations also mimic that of the entire herd, as well as that of the Pedi ecotype, however the relationship between live weight and shoulder height (r=0.81) as well as the relationship between live weight and body length (r=0.64) are very strong (p<0.05). Change in live weight will lead to a positive change in both shoulder height and body length in the Venda ecotype.

Table 4.3 Pearson correlation coefficients between live weight and body measurements for all ecotypes (pooled data)

	Live weight	**Shoulder height**	**Body length**	**Weight/Shoulder height ratio**	**Weight/Body length ratio**
Live Weight	1.00000	**0.54** p<0.01	0.45 p>0.01	**0.81** p<0.01	**0.85** p<0.01
Shoulder height		1.00000	0.27 p>0.01	0.21151 p>0.01	**0.54** p<0.01
Body length			1.00000	**0.54** p<0.01	0.20 p>0.01
Weight/Shoulder height ratio				1.00000	**0.84** p<0.01
Weight/Body length ratio					1.00000

Significant correlations are indicated in in bold

Table 4.4 Pearson correlation coefficients between live weight and body measurements for the Pedi ecotype (pooled data)

	Live weight	Shoulder height	Body length	Weight/Shoulder height ratio	Weight/Body length ratio
Live Weight	1.00000	0.47 p>0.01	0.50 p>0.01	**0.94** p<0.01	**0.93** p<0.01
Shoulder height		1.00000	**0.59** p<0.01	0.15 p>0.01	0.29 p>0.01
Body length			1.00000	0.34 p>0.01	0.14 p>0.01
Weight/Shoulder height ratio				1.00000	**0.93** p<0.01
Weight/Body length ratio					1.00000

Significant correlations are indicated in bold

Table 4.5 Pearson correlation coefficients between live weight and body measurements for the Shangaan ecotype (pooled data)

	Live weight	Shoulder height	Body length	Weight/Shoulder height ratio	Weight/ Body length ratio
Live weight	1.00000	0.49 p>0.01	0.21 p>0.01	0.38 p>0.01	**0.57** p<0.01
Shoulder height		1.00000	-0.08 p>0.01	-0.06 p>0.01	**0.57** p<0.01
Body length			1.00000	**0.59** p<0.01	0.06 p>0.01
Weight/Shoulder height ratio				1.00000	**0.69** p<0.01
Weight/ Body length ratio					1.00000

Significant correlations are indicated in bold

Table 4.6 Pearson correlation coefficients between live weight and body measurements for the Venda Ecotype (pooled data)

	Live weight	**Shoulder height**	**Body length**	**Weight/shoulder height Ratio**	**Weight/body length Ratio**
Live weight	1.00000	**0.81** p<0.01	**0.64** p<0.01	**0.97** p<0.01	**0.94** p<0.01
Shoulder height		1.00000	0.42 p>0.01	**0.66** p<0.01	**0.81** p<0.01
Body length			1.00000	**0.67** p<0.01	0.34 p>0.01
Weight/shoulder height Ratio				1.00000	**0.89** p<0.01
Weight/body length ratio					1.00000

Significant correlations are indicated in bold

The relationship between live weight and body measurements was also explored using the GPLOT procedure of SAS (2015). Figure 4.1 represents the relationship between body length and live weight. A linear relationship was observed between body length and live weight, where body length is increasing with the increase in weight for all ecotypes. This linear relationship was observed in all three ecotypes. The Venda and Shangaan ecotypes are longer ($p<0.05$) than the Pedi ecotype, whereas Venda and Pedi ecotypes are heavier ($p<0.05$) than the Shangaan ecotype. Figure 4.2 represents the relationship between live weight and shoulder height for the three ecotypes. A linear relationship was also observed where shoulder height was increasing with the increase in weight of cows. The tallest ($p<0.05$) animals were found in the Shangaan ecotype, which is also the smallest ($p<0.05$) of the three ecotypes in weight, followed by the Venda ecotype. The Venda ecotype is the only ecotype which is more compact that the rest of the ecotypes, which makes it more desirable according to Vargas et al. (1998) and Riley et al. (2007);

who indicated that a smaller framed animal which is heavier is preferable since it has a higher reproductive efficiency and overall efficiency than a larger framed heavier animal.

Figure 4.4 represents the relationship between the weight/shoulder height ratio and the weight/body length ratio. This is where a linear relationship can be observed. There is a positive correlation between the weight/ shoulder height ratio and the weight /body length ratio, where one variable increases as the other increases as well. The results are corroborated by Klosterman et al. (1968) as quoted by Riley et al. (2007) who also found a strong positive correlation between live weight/hip height ratio and body condition score. Riley et al. (2007) also observed positive correlations between live weight/hip height ratio and live weight.

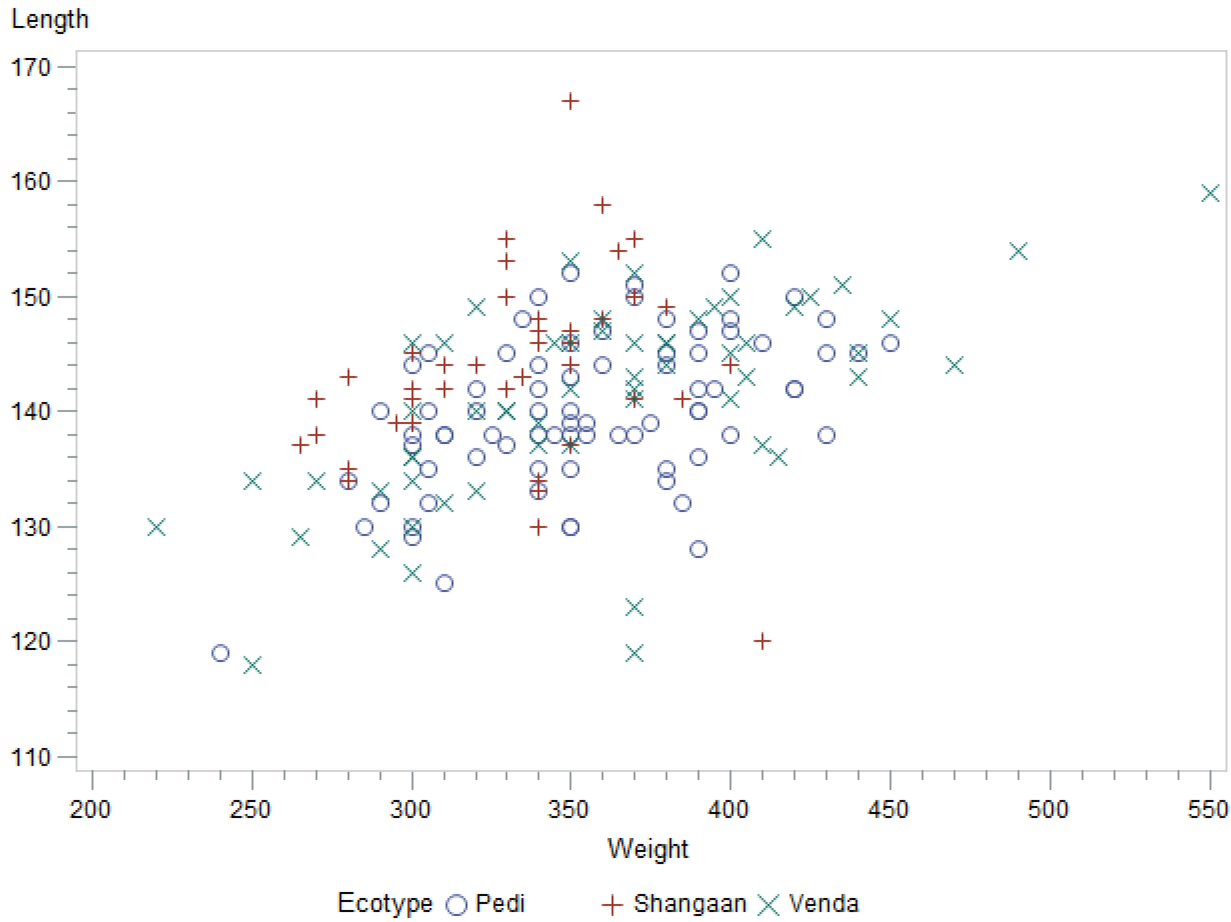

Figure 4.1 Relationship between live weight and body length of Nguni cattle

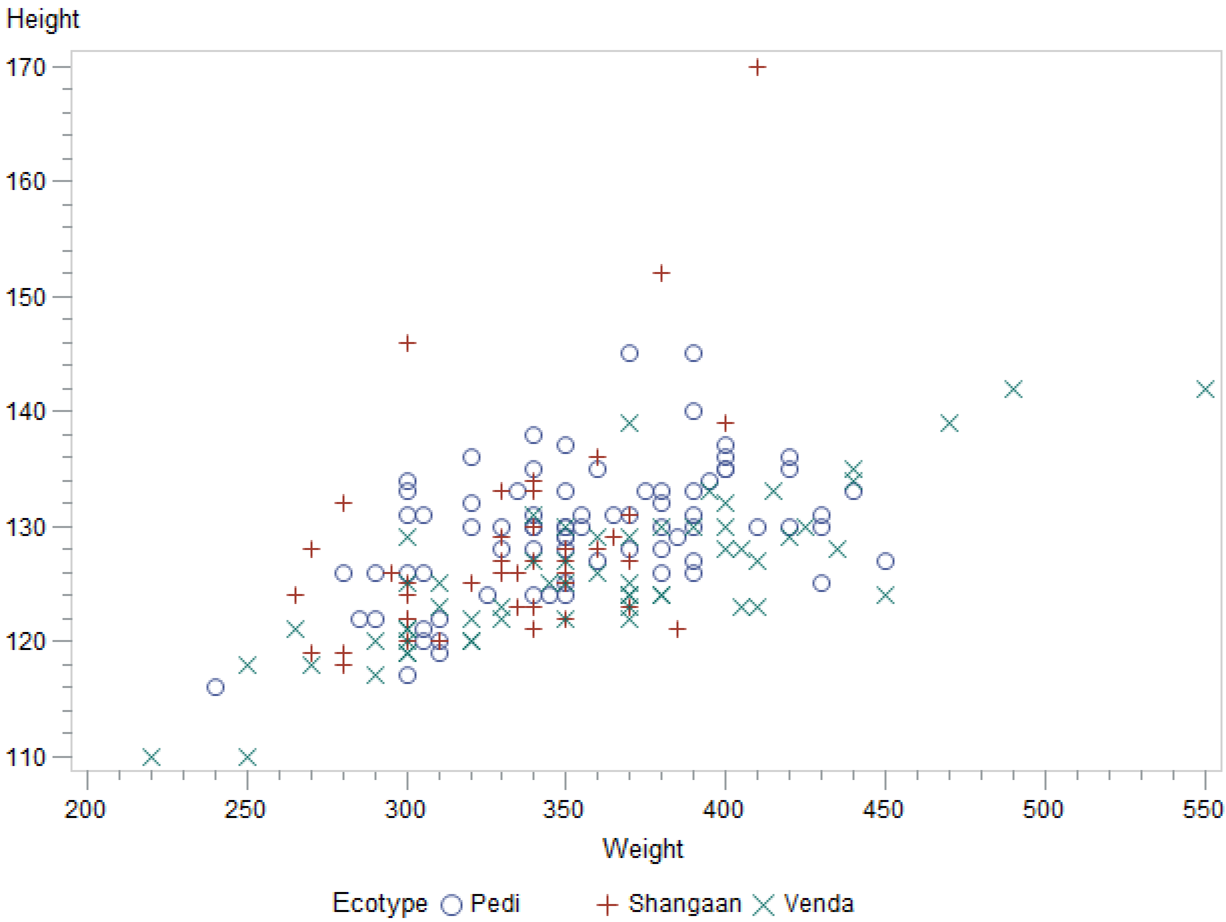

Figure 4.2 Relationship between live weight and shoulder height of Nguni cattle

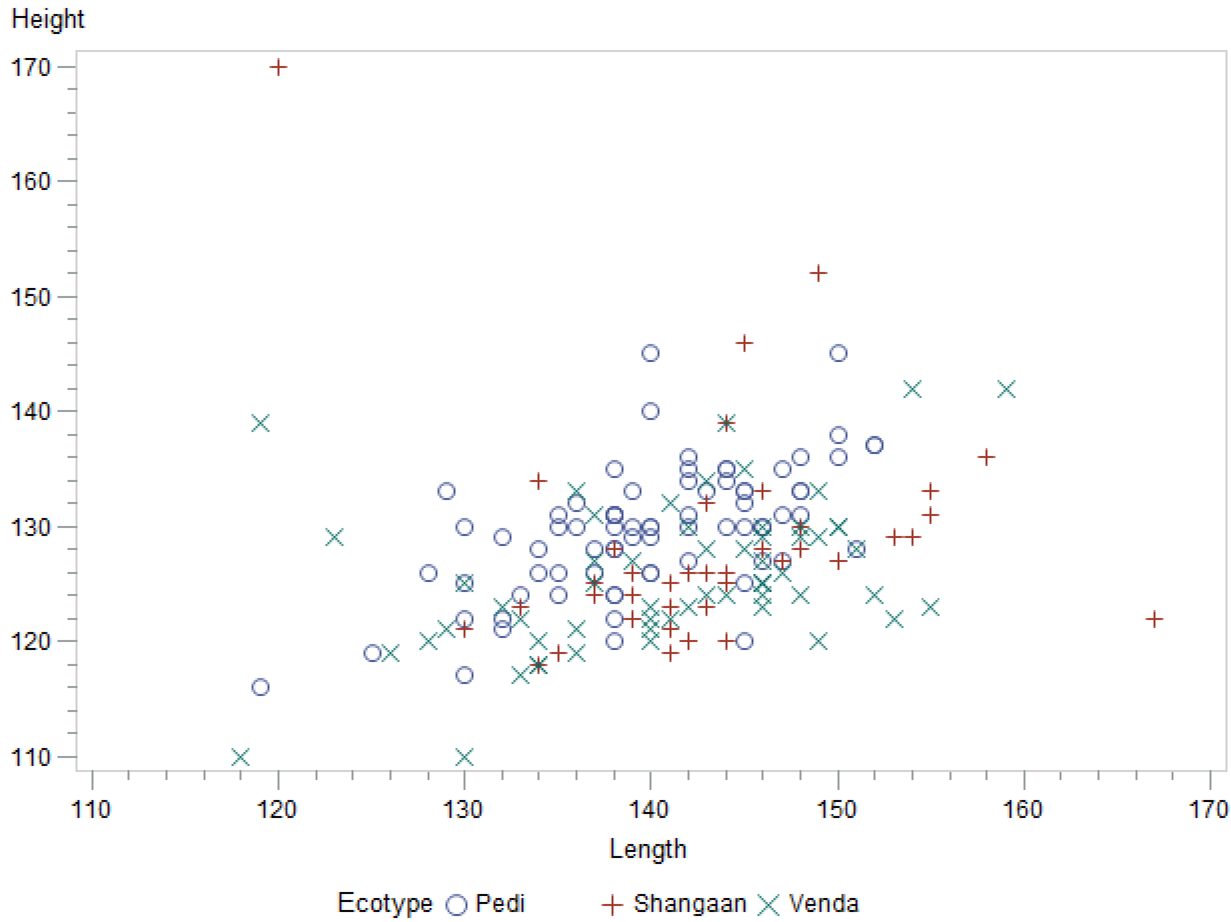

Figure 4.3 Relationship between shoulder height and body length of Nguni cattle

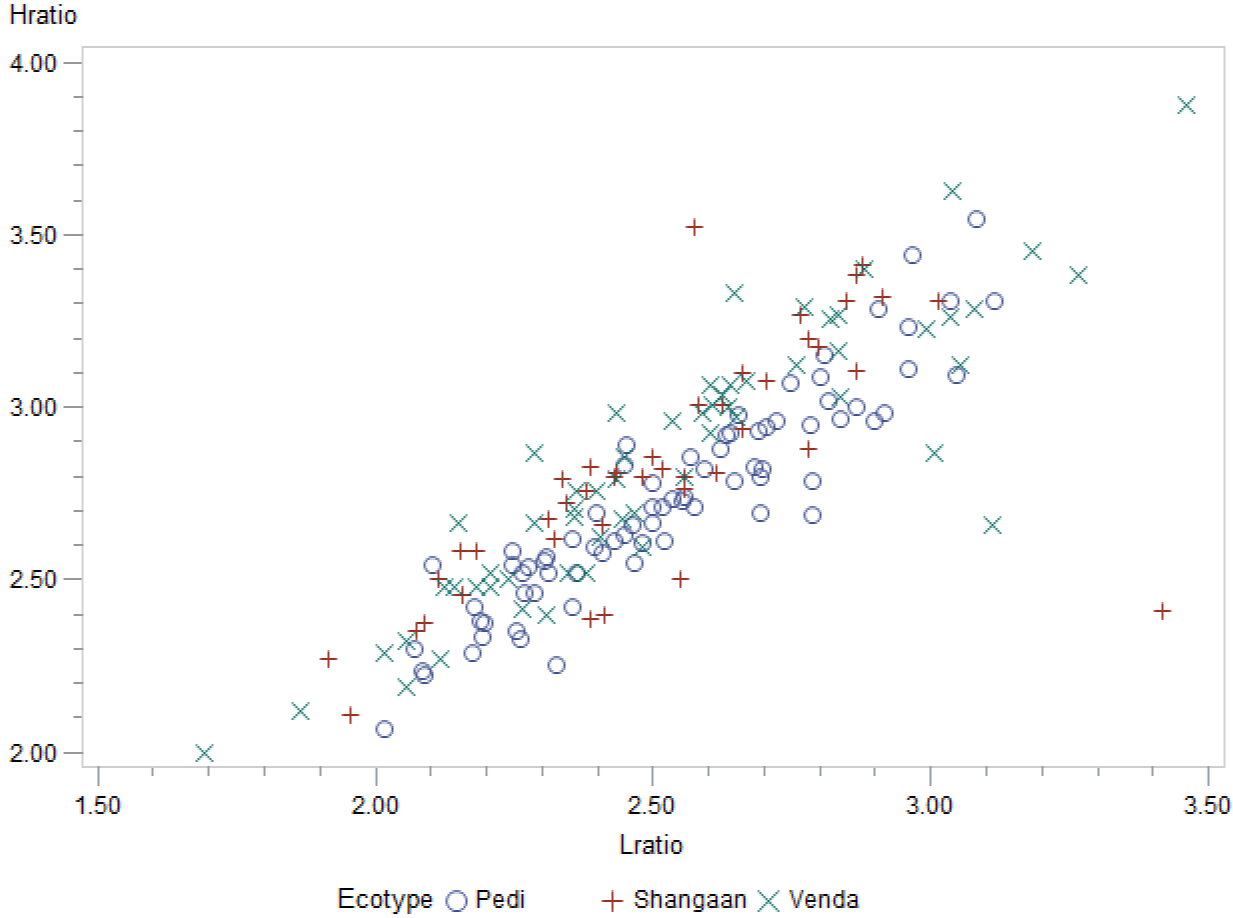

Figure 4.4 Relationship between live weight/shoulder height ratio and live weight/body length ratio of Nguni cattle

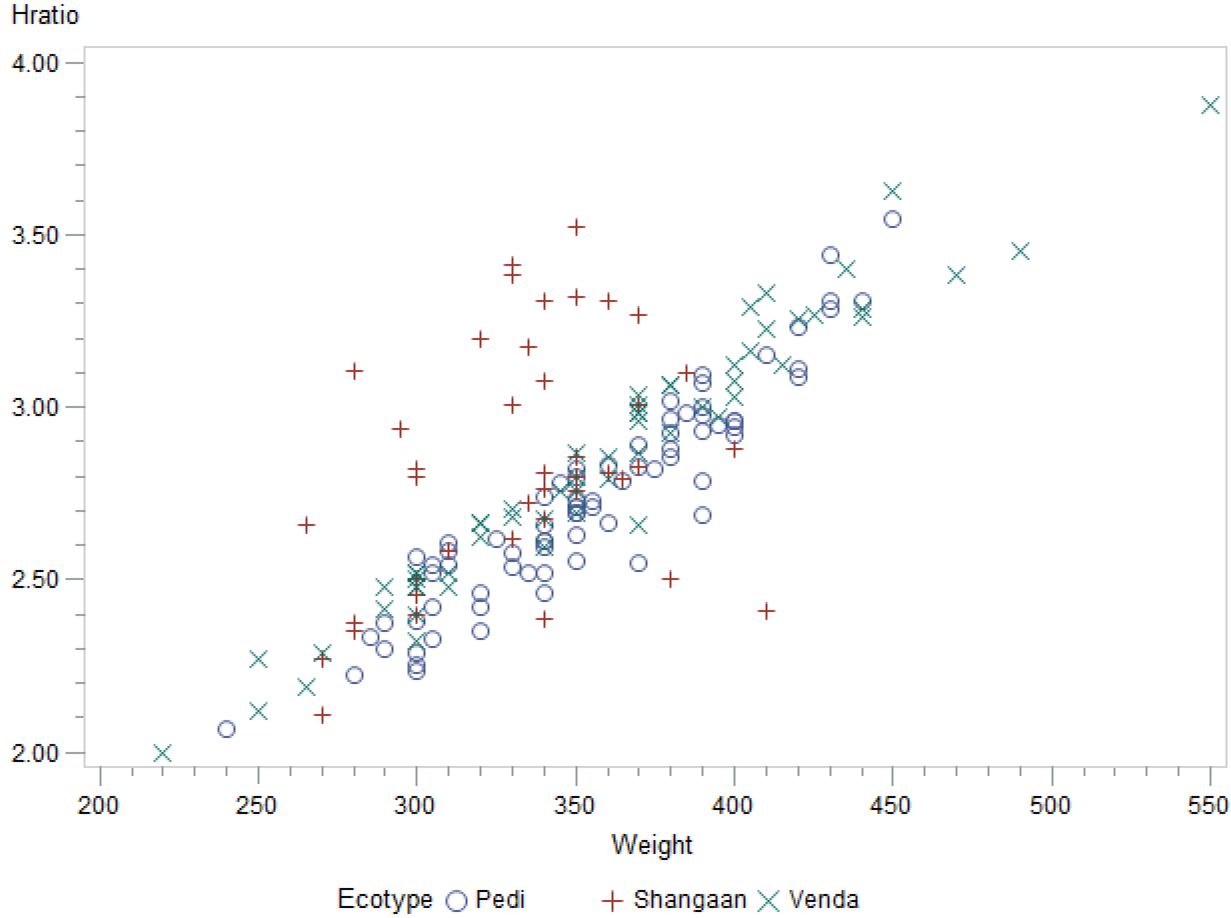

Figure 4.5 Relationship between live weight/shoulder height ratio and live weight of Nguni cattle

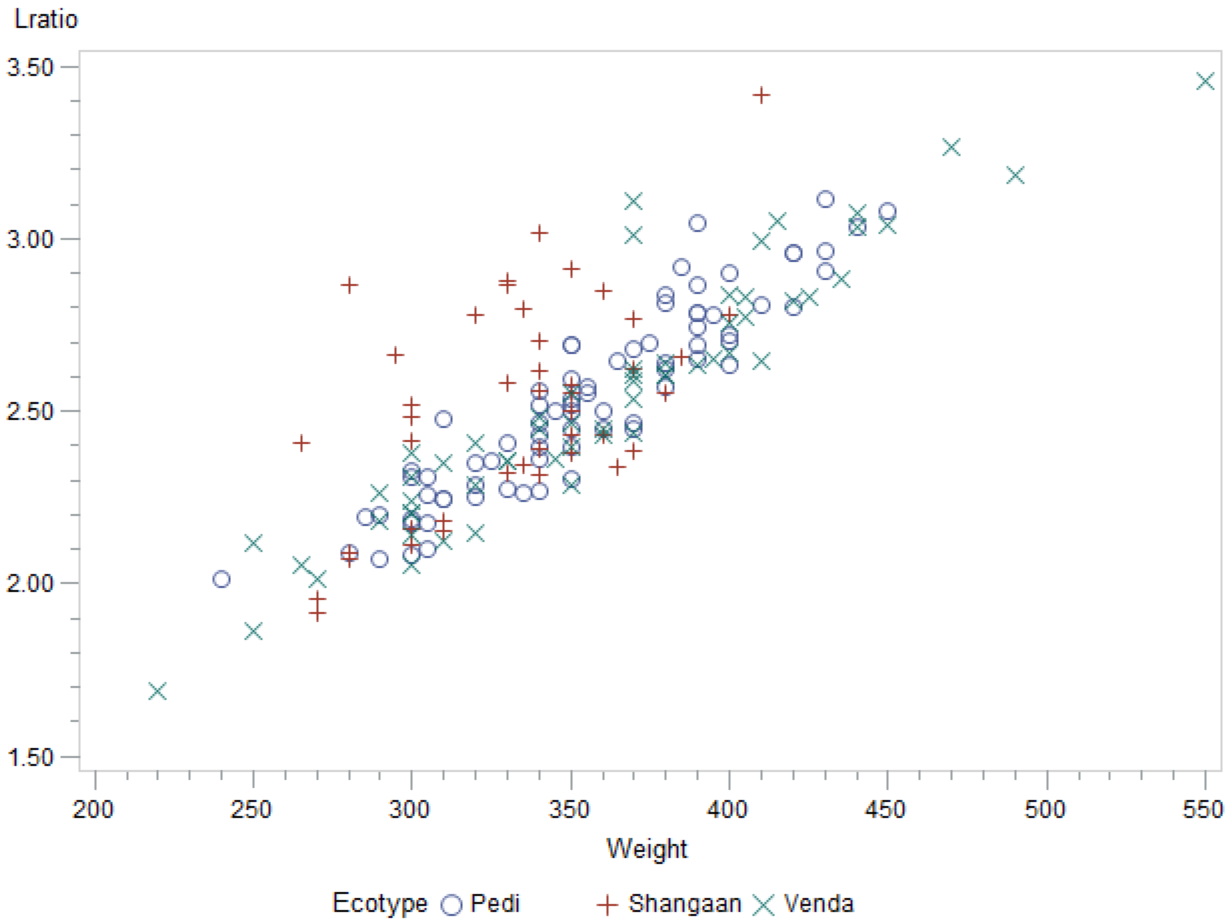

Figure 4.6 Relationship between live weight/body length ratio and live weight of Nguni cattle

4.3. Effect of ecotype and season on production of Nguni cows

Calf birth weights ranged from 12kg to 45kg while adjusted weaning weight ranged from 67kg to 237kg. According to the Nguni Cattle Breeders Association the average birth weight for a Nguni female calf is 20kg while that of a Nguni male calf is 21-25kg. The average weaning weight reported for the Nguni breed is 153kg by Studbook SA (2014). Descriptive statistics of the sample are presented in Table 4.7

Table 4.7 Descriptive statistics for adjusted weaning weight and calf birth weight of Nguni ecotypes (pooled data)

Variable	N	Mean	SD	Min	Max
Birth weight	415	24.98	4.49	12*	45
Adj. Weaning weight	415	152.00	29.39	67	237

N: Number of observations, SD: Standard Deviation, Min: Minimum, Max: maximum,
*One Shangaan calf was born alive weighing 12kg, survived and was sold at an auction on 20 January 2015

Least square means and standard errors for the effect of ecotype on birth weight and weaning weight are presented in Table 4.8 below. Ecotype had a significant effect ($p<0.05$) on birth weight of Nguni calves across all seasons. The Pedi ecotype had the highest ($p<0.05$) birth weight at 25.46 (0.26)kg of all three ecotypes, but was statistically similar ($p<0.05$) to the Shangaan ecotype at 25.01 (0.70)kg that also obtained a higher birth weight; however, the two ecotypes were significantly different ($p<0.05$) from the Venda ecotype at 24.08 (0.38)kg, which had a lower birth weight than the two ecotypes. Large framed animals are expected to give birth to bigger calves as compared to those born from medium and smaller framed cows. This statement is true with regards to the Pedi ecotype, which is a large framed animal; but unexpectedly, the Shangaan calves were statistically ($p<0.05$) as big as the Pedi calves, and even bigger than the Venda calves. The Shangaan is the smallest of the three ecotypes with regards to weight; and compares very well with the Pedi ecotype with regards to shoulder height. It is not advisable for a smaller framed animal to have bigger calves, due to the risk of dystocia.

Table 4.8 Least square means and (standard errors) for the effect of ecotype on birth weight and weaning weight across all seasons (pooled data)

Variable	Pedi	Shangaan	Venda
Birth weight	25.46 (0.26)[a]	25.01 (0.70)[a]	24.08 (0.38)[b]
Adjusted Weaning weight	156.87 (1.84)[a]	136.36 (4.56)[b]	144.04 (2.78)[b]

Means in rows with different superscripts differ ($p< 0.05$)

Ecotype also had a significant effect ($p<0.05$) on weaning weight of the Nguni calves across all seasons. The Pedi ecotype had the highest weaning weight at 156.87 (1.84)kg of the three ecotypes, and it was significantly different ($p<0.05$) from both the Shangaan and the Venda ecotype. There were no significant differences ($p>0.05$) between the Venda 144.04 (2.78)kg and the Shangaan 136.36 (4.56)kg ecotypes. The inconsistencies of the Shangaan ecotype observed by Sanarana et al. (2015) can also be observed in this study, wherein the Shangaan ecotype resembles the Pedi ecotype for birth weight, and the Venda ecotype for weaning weight. The Venda ecotype has a lower birth weight and a higher weaning weight, which makes it a preferable ecotype according to The Nguni Cattle Breeders Society (2008) and Skrypzeck et al. (2000) who both indicated that a lower birth weight means calving ease while a higher weaning weight means a higher growth rate. The Pedi ecotype had both a higher birth weight and a higher weaning weight.

Apart from the effects of ecotype on birth weight and weaning weight of the calves, an analysis for the effect of season of birth on birth weight and weaning weight was also performed with the help of mixed procedures of SAS (2015). Season affected cow production as measured by birth weight and weaning weight. Least square means for effect of season on birth and weaning weight of Nguni calves are presented in Table 4.9

Table 4.9 Least square means and standard errors for the effect of season on birth weight and weaning weight across all seasons

Variable	**Birth weight**	**Weaning weight**
2009	23.08 (0.75)^{a}	149.26 (4.87)^{a}
2010	23.72 (0.86)^{a}	144.91 (6.43)^{a}
2011	25.80 (0.40)^{b}	126.22 (3.01)^{b}
2012	27.67 (0.47)^{c}	159.78 (3.23)^{c}
2013	23.97 (0.42)^{a}	148.62 (3.39)^{a}

Means in columns with different superscripts differ (p<0.05)

Season had a significant effect (p<0.05) on the performance of all ecotypes for birth weight. Season 2012 had the highest birth weight at 27.67 (0.47)kg of all seasons and it was significantly different (p<0.05) from 2011 which had the second highest birth weight25.80 (0.40)kg. 2011 was significantly different (p<0.05) from 2009, 2010 and 2013 which had much lower birth weights at 23.08 (0.75)kg, 23.72 (0.86)kg and 23.97 (0.42)kg respectively. These results differ from the results of Tawonezvi et al. (1988) who reported non-significant effects of year/season on birth weight. Season also had a significant effect (p<0.05) on the performance of all ecotypes for weaning weight. Calves born in season 2012 had the highest average weaning weight at 159.78 (3.23)kg than in any other season. In season 2011, the lowest ($p<0.05$) weaning weight 126.22 (3.01)kg was observed. Although Season 2009 had the highest precipitation of all seasons, its weaning weight 149.26 (4.87)kg was not different ($p>0.05$) from the weaning weight of seasons 2010 and 2013 at 144.91 (6.43)kg and 148.62 (3.39)kg respectively. Significant influence of year effects on weaning weight have been reported by Lubout (1987) and Kars et al. (1994). A similar trend can be observed with season 2012 on both birth weight and weaning weight where the performance was highest ($p<0.05$), however performance in season 2009, 2010 and 2013 were also similar in that the seasons are not significantly different ($p>0.05$) for both weaning weight and birth weight. Lombard (1971) indicated that changes in the environmental conditions such as climate, management and nutrition may be the main cause of the variation in growth traits.

The interaction between season and ecotype was also explored to determine if certain ecotypes could have been performing better in certain seasons. Least square means and standard errors for the effect of ecotype by season interactions are presented in Table 4.10 below. The Pedi ecotype performed exceptionally well ($p<0.05$) in the season 2012 for both birth weight at 30.02 (0.56)kg and weaning weight at 175.83 (3.71)kg; the same trend can be observed for the performance of the Shangaan ecotype which also performed well for both birth weight and weaning weight at 27.05 (1.11)kg and 149.01 (6.97)kg respectively in season 2012. The Venda ecotype had the lowest ($p<0.05$) birth weight in 2012. Season 2009 was the season with the lowest performance for birth weight in the Pedi ecotype. Both the Pedi ecotype and Shangaan ecotype experienced the lowest ($p<0.05$) weaning weight at 122.36 (3.89)kg and 123.02 (6.01)kg respectively in season 2011. The Pedi ecotype had the lowest birth weight 22.00 (0.45)kg in season

2009. These results are substantiated by de Waal et al. (1990) who reported that variation in dry matter yield of veld due to variation in rainfall occurs between years at any specific site and is reflected in animal performance. The Shangaan ecotype performed better ($p<0.05$) than all the ecotypes in the season 2011, which is the season with the lowest precipitation with a birth weight of 26.93 (0.84)kg. Even though the ecotypes were exposed to the same environment, there were differences observed with regards to their response to seasonal effects. The Shangaan ecotype has a small live weight with less nutritional requirements than the large framed animals, which allows efficient utilization of energy during periods of scarce feed, hence it performed better ($p<0.05$) than the Pedi ecotype, a larger framed ecotype of the three, in seasons of lower precipitation. These results are corroborated by findings of Du Plessis et al. (2006) and Scholtz (2013) who agree that a smaller framed animal has a competitive advantage over a bigger framed animal. The diversity in the response of the ecotypes shows that others can indeed respond positively to the composing negative elements of season, which expresses the vigour of the Nguni breed in general. These results are corroborated by many scientists who explained thoroughly the adaptation to harsh subtropical conditions and tolerance to harsh climatic stressors of Nguni cattle breed (Collins-Lusweti, 2000; Nowers and Welgemoed, 2010; Norris et al. 2004; Bester et al. 2003; Nguni Breeders Society, 2008; Scholtz, 2010). Table 4.3.4 represents the interactions between ecotype and season for birth weight and weaning weight.

Table 4.10 Least square means and (standard errors) for the interaction effects of ecotype and season on birth weight and weaning weight

Ecotype	Season	Birth weight	Weaning weight
Pedi	2009	22.00 (0.45)[a]	161.84 (3.53)[a]
	2010	24.41 (0.71)[b]	174.83 (5.19)[b]
	2011	25.88 (0.59)[b]	122.36 (3.89)[c]
	2012	30.02 (0.56)[c]	175.83 (3.71)[b]
	2013	24.98 (0.52)[b]	149.52 (3.89)[d]
Shangaan	2009	23.83 (2.06)[a]	127.16 (12.91)[a]
	2010	23.51 (2.20)[a]	135.56 (14.77)[b]
	2011	26.93 (0.84)[b]	123.02 (6.01)[c]
	2012	27.05 (1.11)[b]	149.01 (6.97)[d]
	2013	23.72 (0.93)[a]	147.04 (6.46)[e]
Venda	2009	23.40 (0.82)[a]	158.78 (5.16)[a]
	2010	23.25 (1.15)[a]	124.34 (9.38)[b]
	2011	24.60 (0.68)[b]	133.29 (4.70)[b]
	2012	25.94 (0.68)[b]	154.50 (4.78)[a]
	2013	23.20 (0.69)[a]	149.30 (4.82)[a]

Means in columns with different superscripts within the same Nguni ecotype differ ($p<0.05$)

4.4. Effect of ecotype and season on reproduction of Nguni cows

Table 4.11 below represents the descriptive statistics of the reproductive traits that were included in the analysis. Varying number of observations were recorded for each trait. There were 316 observations recorded for weaning efficiency which averaged at an acceptable value of 0.4 with a minimum weaning efficiency of 0.06 and a maximum weaning efficiency of 0.83. There were about 157 observations for days to conception. This number is considerably smaller than the rest of the traits measured because only animals that were present in the breeding cycle for two selected consecutive years were measured. The number of days it took the animals to reconceive averaged at 85 days, however there is a cow that took only 20 days to reconceive, while the maximum number of days it took for an animal to reconceive was 162. It should be noted that although the 162 day exceed the 90 day breeding season, this value also includes the number of days after the cow calved down, before it was exposed to the bull during the breeding season. 337 observations were recorded for cow weight at breeding, where the range was observed to be between 212kg and 510kg. On average, at breeding cows were weighing 351kg. 342 observations were recorded for cow weight at breeding where cows were weighing 380kg on average, with a minimum weight of 210kg and a maximum weight of 590kg. Observations for inter calving period were 214 where the maximum period it took for animals to reconceive was 1031 days and the minimum period was 305. On average the ICP for Nguni cattle at Mara Research Station was 458 days. These observations are supported by findings from other studies which generally accepts the ideal ICP to be shorter than 365 days (Montiel & Ahuja, 2005). The Namibian Stud Breeders Association also obtained an average inter calving period of 402 days (The Nguni Breeders Society, 2008).

Table 4.11 Descriptive statistics for reproduction traits of all ecotypes

Variable	N	Mean	SD	Min	Max
Weaning efficiency	316	0.402	0.105	0.06	0.828
Days to conception	157	85.55	25.76	20	162
Cow weight @ breeding	337	351.62	55.9	212	510
Cow weight @ weaning	342	380.92	60.74	210	590
ICP	214	458.51	158.47	305	1031

N: Number of observations, SD: Standard Deviation, Min: Minimum, Max: maximum, According to du Plessis et al. (2006) a smaller framed animal would perform fundamentally better than a larger framed animal with regards to reproduction. The expectation in this study was that the Shangaan ecotype, which was smaller in weight than the rest of the ecotypes would outperform all ecotypes involved, which are the Venda ecotype and the Pedi ecotype. However, results obtained from this study differ with that rationale.

Least square means and standard errors for the effect of ecotype on reproduction of Nguni cattle are presented in Table 4.12 below. Ecotype had a significant effect ($p<0.05$) on weaning efficiency of Nguni cows across all seasons. There was no significant difference ($p>0.05$) observed between Pedi ecotype and Shangaan ecotype at 0.407 (0.01) and 0.439 (0.01), however they were both significantly different ($p<0.05$) from Venda ecotype at 0.381 (0.01). The Shangaan ecotype obtained the highest ($p<0.05$) weaning efficiency of all three ecotypes which is consistent with the rationale of du Plessis et al. (2006) that small framed animals perform better than large framed animals with regards to reproduction. These results also resemble those obtained in Table 4.8 for the effect of ecotype on birth weight, where both Shangaan and Pedi ecotypes were not significantly different, but were significantly different from the Venda ecotype.

Table 4.12 Least square means and (standard errors) for the effect of ecotype on reproduction of Nguni animals across all seasons.

Variable	Pedi	Shangaan	Venda
Weaning efficiency	0.407 (0.01)^{a}	0.439 (0.01)^{a}	0.381 (0.01)^{b}
Days to reconception	87.46 (3.23)^{a}	88.02 (5.87)^{a}	81.99 (3.73)^{a}
Cow weight @ breeding	355.50 (3.55)^{a}	328.28 (7.09)^{b}	349.68 (4.47)^{a}
Cow weight @ weaning	385.44 (7.38)^{a}	341.35 (8.06)^{b}	377.79 (4.89)^{a}
Inter calving period	454.73 (22.96)^{a}	465.20 (43.63)^{a}	451.48 (24.86)^{a}

Means in rows with different superscripts differ ($p<0.05$)

There were no significant differences ($p>0.05$) among the three ecotypes for the number of days it took for the cows to reconceive. All ecotypes reconceived on average within the breeding season of 3 months. These results uphold the same observations as that of Peters (1984) who advised that it is not recommended for the postpartum anestrous period to exceed 80-85 days if the rationale is for cows to have one calf each year in order to have a more profitable herd. The Shangaan ecotype took longer than the rest of the ecotypes to conceive again at 88 days, followed by the Pedi ecotype at 87 days. The ecotype with the lowest number of days it took to reconceive is the Venda ecotype at 82 days even though there is no statistical difference ($p>0.05$) among the three ecotypes.

Figures 4.7 is a schematic representation of the distribution of number of Pedi ecotype cows coming into reconception at a certain period. A greater number of Pedi ecotype cows managed to reconceive on the 9th week; another surge can be observed on the 13th week where another majority of Pedi ecotype managed to reconceive. Figure 4.8 is a schematic representation of the distribution of number of Shangaan ecotype cows coming into reconception at a certain period. Two surges can be observed where a majority of cows managed to reconceive at 12 weeks as well as at 15 weeks. Figure 4.9 is a schematic representation of the distribution of number of Venda ecotype cows coming into reconception at a certain period where the majority of cows managed to reconceive at 14 weeks.

The weight of the cow at breeding is indicative of the cow's body condition score, and determines whether the animal is at an optimum weight for conception, however Wiltbank et al. (1964); Wiltbank et al. (1977) and Haresign (1984) highlighted that it is also indicative of the likelihood of subsequent reproductive performance. Emaciated cows do not conceive, as well as cows that are over conditioned or overweight. There was no significant differences ($p>0.05$) observed between Pedi ecotype and Venda ecotype at 355.50 (3.55)kg and 349.68 (4.47)kg respectively. Both the Pedi and Venda ecotype however differed significantly ($p<0.05$) from the Shangaan ecotype at 328.28 (7.09)kg. The weight of the cow at weaning is also indicative of the cow's reproductive efficiency, and a similar trend that was observed with the weight of the cow at breeding, was also observed with the weight of the cow at weaning. There was no significant difference ($p>0.05$) observed between Pedi ecotype and Venda ecotype at 385.44 (7.38)kg and 377.79 (4.89)kg respectively but both the Pedi ecotype and Venda ecotype differed ($p<0.05$) significantly from the Shangaan ecotype at 341.35 (8.06)kg. These results were expected, considering the smaller frame of the Shangaan ecotype compared to the larger frames of both Pedi ecotype and Venda ecotype. The animals did not lose condition at weaning, even though they had been suckling a calf for 6 months and it was dry season. This is only evidence of the tenacity of the Nguni breed.

There were no significant differences (p>0.05) observed among the ecotypes for inter calving period. The Shangaan ecotype had the longest period between two successive calving events, among the three at 465.20 (43.63) days, followed by the Venda ecotype at 451.48 (24.86) days and the Pedi ecotype at 454.73 (22.96) days with the shortest period albeit not statistically different (p>0.05). The Shangaan ecotype was expected to have the shortest period between two successive calving events as per the rationale of du Plessis et al. (2006); that smaller framed animals perform better than larger framed animals with regards to reproduction, however the larger framed animals had the shorter inter calving periods.

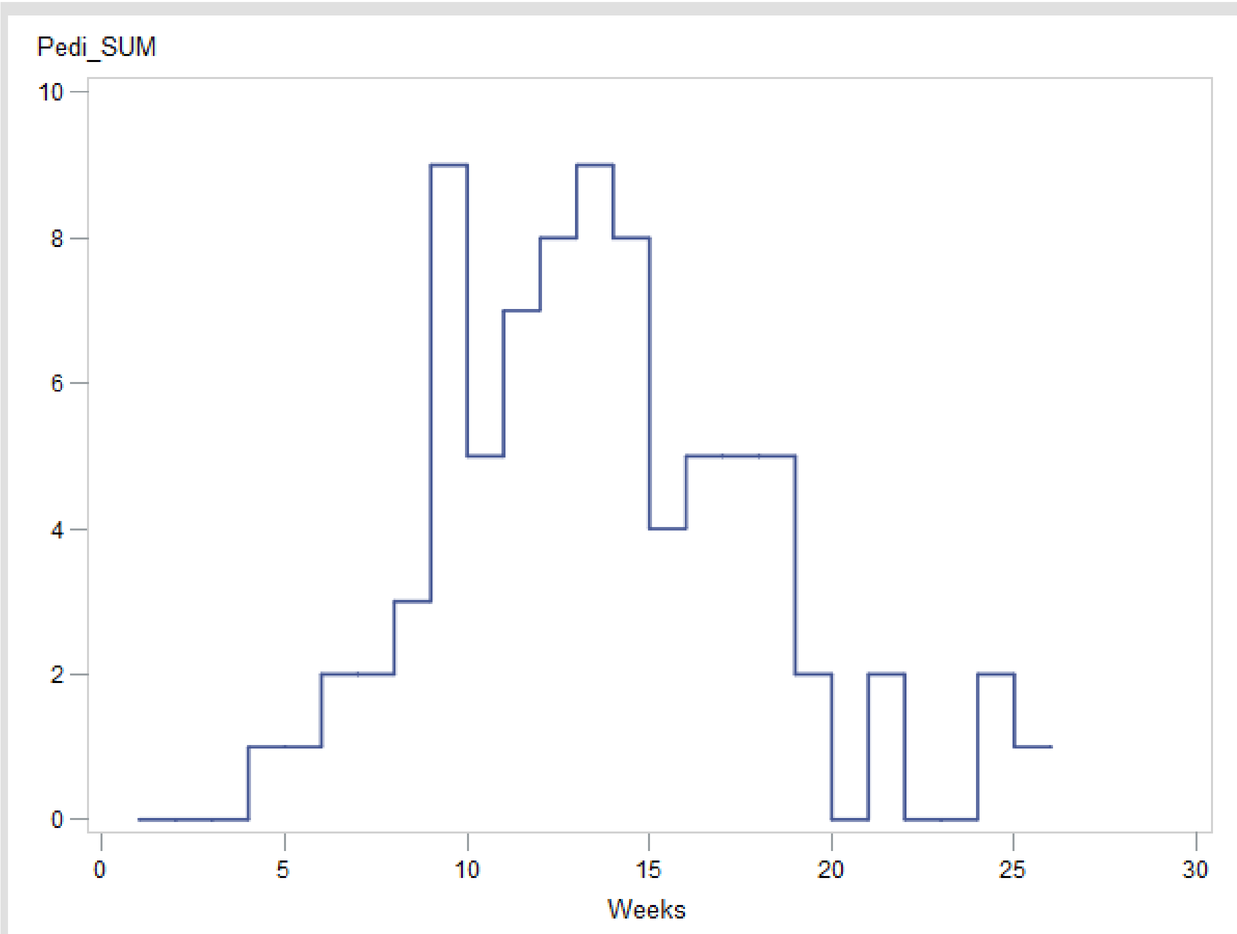

Figure 4.7 Schematic representation of the distribution of reconception data for Pedi ecotype cows

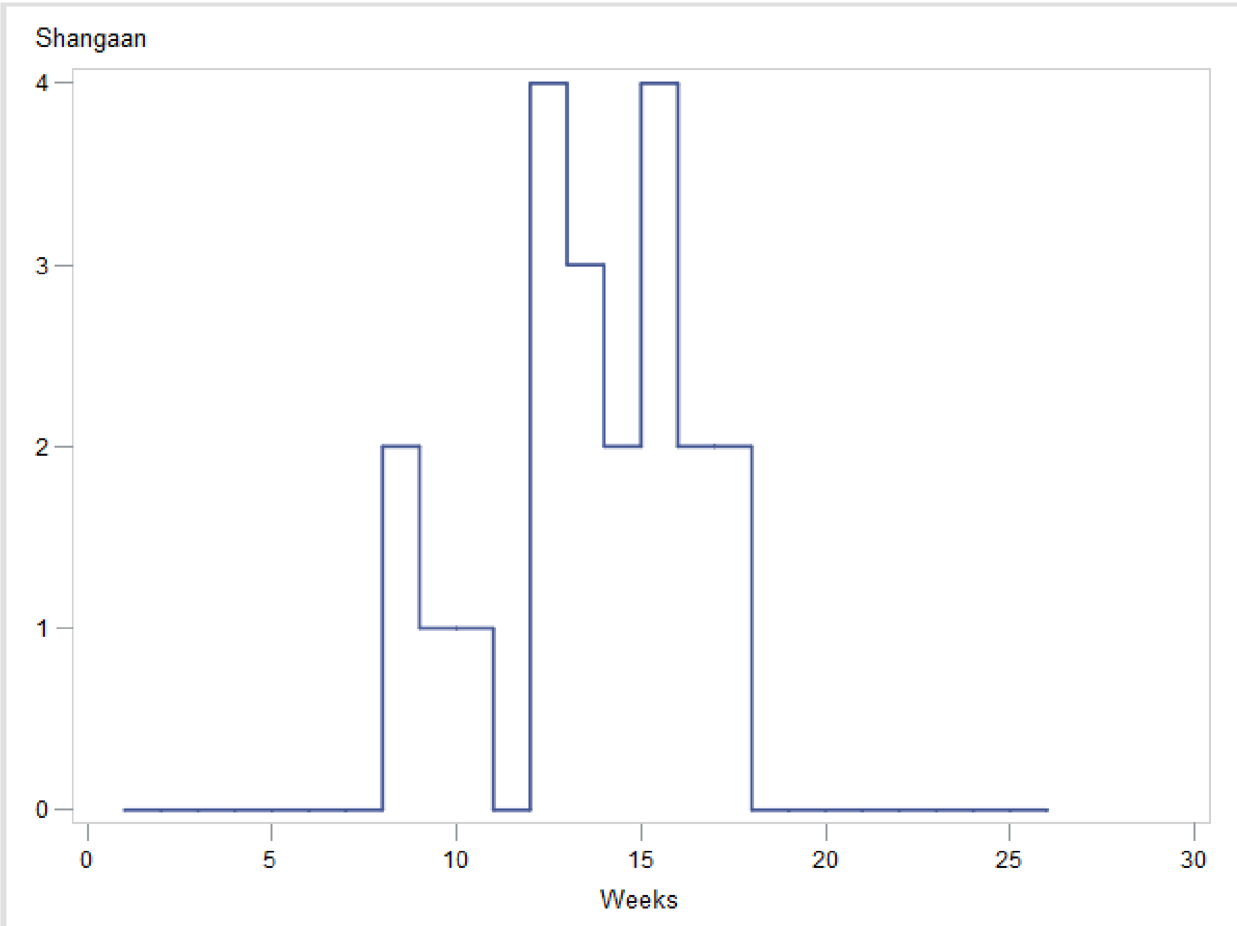

Figure 4.8 Schematic representation of the distribution of reconception data for Shangaan ecotype cows

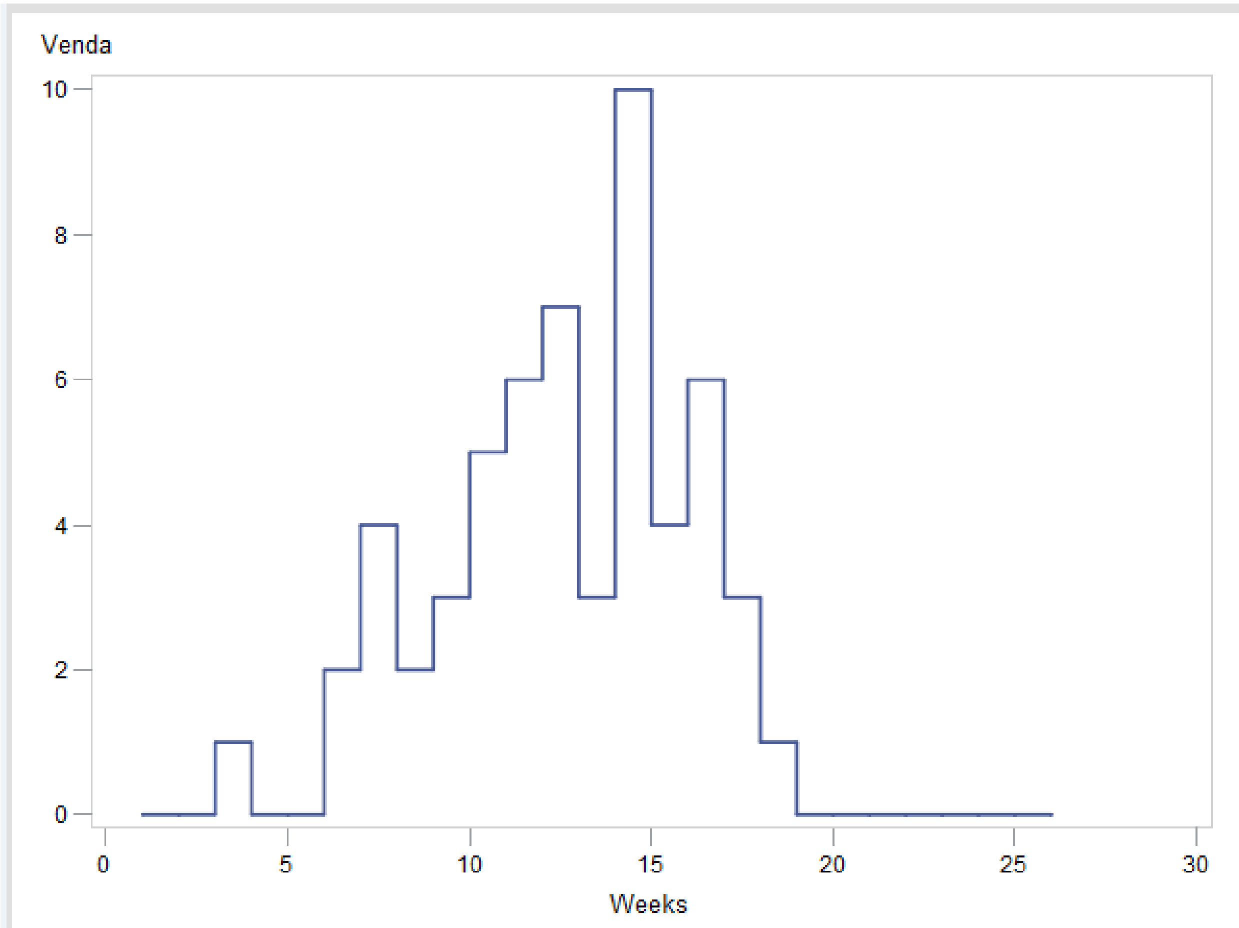

Figure 4.9 Schematic representation of the distribution of reconception data for Venda ecotype cows

Season was also observed to have a tremendous effect on the reproduction of Nguni animals. Least square means and standard errors for the effect of season on reproduction of Nguni animals are presented in Table 4.13 below. The rainfall pattern illustrated in Figure 3.1 depicts a very low precipitation in season 2011, followed by a huge increase in precipitation in the following season 2012. Much of the statistical difference observed for seasonal effect on reproduction of Nguni cows can be attributed to the varying and unstable climatic conditions for the seasons 2009 through to 2013. Weaning efficiency was affected ($p<0.05$) by season, with the highest weaning efficiency in 2012 at 0.47 (0.01) and the lowest weaning efficiency in 2011 at 0.33 (0.01). There were no observed differences ($p>0.05$) among seasons 2009, 2010, and 2013 for weaning efficiency.

Maciel et al. (2016) indicated that season has an effect on calving interval and this is observed with the results of this study where inter calving period was longest in season 2011 at 545.08 (26.30) days, the year of lowest precipitation and significantly different ($p<0.05$) from the rest of the seasons. Cow weight at breeding in 2013 was the highest at 356.58 (6.12)kg and significantly different ($p<0.05$) from all the seasons while cow weight at weaning in 2012 was the lowest 344.19 (6.19)kg and differed ($p<0.05$) significantly from all seasons; cows were weaning calves born the previous year, 2011, which had the lowest precipitation. The results of this study are corroborated by Montiel and Ahuja (2005) who observed that inadequate protein and energy intake during pregnancy or early lactation results in low body condition score at calving and a longer inter calving period in beef cows. There were no observed significant differences ($p<0.05$) in the time it took for cows to reconceive in all seasons.

Table 4.13 Least square means (standard errors) for the effect of season on reproduction of Nguni animals across all ecotypes.

Season	Weaning efficiency	Days to Reconception	Cow weight @ breeding	Cow weight @ weaning	Inter calving period
2009	0.431 (0.01)[a]		331.37 (8.45)[a]	374.14 (6.92)[a]	
2010	0.41 (0.02)[a]	87.77 (7.27)[a]	332.95 (12.08)[a]	377.29 (13.53)[a]	419.38 (47.89)[a]
2011	0.33 (0.01)[b]	82.29 (5.33)[a]	350.70 (5.56)[a]	387.03 (5.85)[a]	545.08 (26.30)[b]
2012	0.47 (0.01)[c]	88.94 (3.74)[a]	335.50 (6.68)[a]	344.19 (6.19)[b]	415.85 (25.10)[a]
2013	0.40 (0.01)[a]	84.29 (3.45)[a]	356.58 (6.12)[b]	376.24 (6.19)[a]	477.72 (20.65)[a]

Means in columns with different superscripts differ ($p<0.05$)

The interaction effect of season and ecotype was also explored to determine if certain ecotypes could have been performing better with regards to reproduction in certain seasons. Least square means and standard errors for the interaction effect of ecotype and season on reproduction traits are presented in Table 4.14 below. The Venda ecotype had a significantly lower ($p<0.05$) weaning efficiency in seasons 2010 at 0.312 (0.027) and 2011 at 0.324 (0.016) than both Pedi and Shangaan ecotype, which performed similarly ($p>0.05$) for all seasons. Shangaan ecotype in season 2011 outperformed the rest of the seasons with regards to the number of days it took for the ecotype to reconceive, by having the lowest ($p<0.05$) number of days at 60.34 (19.02) days followed by the Venda ecotype in 2010 at 62.77 (11.46) days. There were no other differences ($p>0.05$) observed within and between ecotypes for all the seasons when it came to days to reconception. There were no differences ($p>0.05$) observed for cow weight at breeding within and between ecotypes for all seasons.

There were no significant differences ($p<0.05$) observed for cow weight at weaning except for Pedi ecotype in 2012 which differed significantly ($p<0.05$) from the rest of the seasons at 366.75 (8.41)kg. The differences observed for cow weight at weaning in season 2012 can be attributed to the rainfall pattern illustrated in Figure 3.1 which indicates a very low precipitation for season 2011 which made availability of nutrition very scarce in the subsequent season. Season 2010 within the Pedi ecotype exhibited the lowest period taken between two consecutive calving events at 369.09 (74.65) days and differed significantly ($p<0.05$) with the rest of the seasons. The Venda ecotype in season 2011 was the worst performing ecotype, with the highest ($p<0.05$) number of days taken between two consecutive calving events at 586.31 (38.56) days. The low precipitation in 2011 affected available nutrition, coupled with suckling which are the two main factors that affect inter calving period according to Short & Adams (1988); Randel (1990); and Montiel & Ahuja (2005).

Table 4.14 Least square means and (standard errors) for the interaction effects of ecotype and season on reproduction traits

Ecotype	Season	Weaning Efficiency	Days to Reconception	Cow weight @ breeding	Cow weight @ weaning	Inter calving period
Pedi	2009	0.421 (0.014)^{a}		343.67(11.71)^{a}	408.86 (8.30)^{a}	
	2010	0.428 (0.062)^{a}	96.78 (10.63)^{a}	332.87(13.32)^{a}	382.50 (38.35)^{a}	369.09 (74.65)^{a}
	2011	0.309 (0.015)^{a}	86.75 (6.63)^{a}	376.46 (8.54)^{b}	411.66 (8.69)^{a}	518.93 (32.98)^{b}
	2012	0.486 (0.014)^{a}	88.46 (5.02)^{a}	348.60 (8.30)^{a}	366.75 (8.41)^{b}	449.35 (31.95)^{b}
	2013	0.393 (0.015)^{a}	85.29 (4.48)^{a}	360.02 (7.97)^{a}	388.81 (8.82)^{a}	481.55 (27.87)^{b}
						-
Shangaan	2009	0.435 (0.040)^{a}		296.81 (21.34)^{a}	325.32 (22.69)^{a}	
	2010	0.484 (0.051)^{a}	112.50 (18.09)^{a}	311.78 (31.66)^{a}	300.58 (31.41)^{a}	397.50 (127.73)^{a}
	2011	0.363 (0.019)^{a}	60.34 (19.02)^{b}	297.49 (12.06)^{a}	334.11 (11.97)^{a}	562.56 (91.70)^{a}
	2012	0.498 (0.025)^{a}	91.98 (8.55)^{a}	301.67 (16.49)^{a}	309.46 (15.71)^{a}	380.18 (60.33)^{a}
	2013	0.414 (0.022)^{a}	84.75 (9.05)^{a}	333.33 (13.70)^{a}	359.78 (13.59)^{a}	520.54 (47.13)^{a}
						-
Venda	2009	0.435 (0.019)^{a}		360.82 (12.90)^{a}	374.88 (12.13)^{a}	
	2010	0.312 (0.027)^{b}	62.77 (11.46)^{b}	355.60 (17.28)^{a}	402.50 (17.15)^{a}	405.53 (74.08)^{a}
	2011	0.324 (0.016)^{b}	82.21 (9.09)^{a}	379.67 (9.88)^{a}	409.89 (9.78)^{a}	586.31 (38.56)^{b}
	2012	0.433 (0.016)^{a}	86.65 (6.04)^{a}	357.90 (10.53)^{a}	362.14 (9.74)^{a}	375.23 (42.64)^{a}
	2013	0.400 (0.017)^{a}	83.03 (5.14)^{a}	370.10 (10.93)^{a}	389.72 (10.67)^{a}	438.85 (33.61)^{a}

Means in columns with different superscripts within the same Nguni ecotype differed ($p<0.05$)
Open cells for days to reconception and inter calving period for the year 2009 reflect missing values

Chapter 5

Conclusions and recommendations

The aim of this study was to investigate the effects of ecotype and season on the production and reproductive performance of three ecotypes of Nguni cattle. The first objective was to investigate the effects of ecotype on cow size for Nguni cattle present at Mara Research Station. Although differences can be observed through visual appraisal, there were too many inconsistencies with regards to size variation among these three ecotypes; no significant statistical differences were observed. A conclusion can be made that they are not different; therefore we fail to reject the null hypothesis.

The second objective was to determine the effect of ecotype and season on the production of Nguni cows. It was found that ecotype had a significant effect on birth weight and weaning weight. The Pedi ecotype had a higher birth weight and a higher weaning weight, and can be recommended above the Venda and Shangaan ecotypes in terms of producing heavier weaners. The Venda ecotype had a lower birth weight and a high weaning weight; this is desirable in a breeding herd as it shows the ecotype's ability to balance birth weight with growth rate. The Shangaan ecotype had a higher birth weight and a lower weaning weight which is an undesirable trait in a breeding herd. Even though the Shangaan is similar in birth weight to the Pedi ecotype, it cannot be recommended as the best ecotype due to its observed inconsistencies; as can be observed with its lower weaning weight that is similar to the Venda ecotype and higher birth weight similar to the Pedi ecotype. It was expected for the Pedi ecotype to have a higher weaning weight than the two ecotypes since it has a larger frame than the Venda and Shangaan ecotypes. Season also had an effect on birth weight and weaning weight. In seasons where the precipitation was high, the production was high as well. The precipitation in the season 2011 was lowest and the Shangaan ecotype which is the smallest of all frames performed much better than the Pedi and the Venda ecotype. This was expected since there is evidence that a smaller animal allows for efficient utilization of energy during periods of scarce feed; which results in a better performance. Ecotype and season had a significant effect on the production characteristics of Nguni cattle at Mara Research Station, therefore we reject the null hypothesis.

The third objective was to determine the effect of ecotype and season on the reproduction of Nguni cows. The observed effect of ecotype on reproduction characteristics was weight related, no effect was observed for inter calving period and days to reconception. Pedi and Shangaan ecotypes performed better than the Venda ecotype for weaning efficiency, and Pedi and Venda ecotypes performed better than Shangaan ecotype for both cow weight at breeding and cow weight at weaning. Season had a tremendous effect on reproduction where significant differences were observed between 2011 and 2012 and the subsequent years. Precipitation was poor in 2011 and higher in 2012, therefore a lower weaning efficiency and a longer inter calving period were observed for season 2011. Season 2012 also had a subsequent reduction in cow weight at weaning. A higher weaning efficiency was observed in season 2012. Ecotype and season had a significant effect on the reproduction characteristics of Nguni cattle at Mara Research Station, therefore we reject the null hypothesis.

There seems to not be any consistent differences observed with regards to production and reproduction for the three Nguni ecotypes in a similar environment. The observed lack of differences between the Shangaan, Venda and Pedi ecotypes is important for

Nguni farmers, because either of the ecotypes would fare well in beef production systems in sub-tropical regions. The implication is that no differences are required in the management of these ecotypes for optimal production, thus farmers can choose either of the ecotype, and if well managed they should be able to produce a calf each year. Due to lack of differences, as was observed in the study, there is no need to manage the Nguni ecotypes differently at Mara Research Station of the Limpopo province.

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