Declaration

I, Felicity Nomfuzo Mkhize, declare that this dissertation is my own work conducted under the supervision of Prof E.C. Webb and Prof M.M. Scholtz. Approval to conduct this study was granted by the University of Pretoria in October 2013. This work has never been submitted to any other University for degree purposes.

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Table of Contents

Acknowledgements i

Abstract iv

Opsomming vi

List of Abbreviations viii

List of Figures ix

List of Tables xi

Chapter 1: General Introduction **1**

1.1 Background 1

1.2 Objectives of the research 2

1.3 Hypothesis 2

Chapter 2: Literature Review **3**

2.1 Review into the Nguni breed 3

2.2 Adaptability 4

2.3 Breeding season 6

2.4 Factors that affect production and reproduction efficiency of Nguni cows 6

2.4.1 Introduction 6

2.4.2 Inter-calving period (ICP) 6

2.4.3 Age at puberty 7

2.4.4 Calving percentage 8

2.4.5 Cow efficiency 8

2.5 Geographical regions for beef cattle farming in South Africa 9

2.5.1 Introduction 9

2.5.2 Veld types 9

2.5.3 Biomes and bioregions 10

Chapter 3: Materials and Methods **12**

3.1 Collection of data 12

3.2 Statistical Analysis 15

Chapter 4: Cow Efficiency Based on Calf Weaning Weight and Cow Weight at Weaning **17**

4.1 Introduction 17
4.2 Materials and Methods for cow weight at weaning 17
4.3 Results and Discussions 17
4.4 Materials and methods for cow efficiency 21
4.5 Results and Discussions 22
4.6 Conclusions 30

Chapter 5: The Effect of Non-genetic Factors on the Inter-calving Period of Nguni Cows in South Africa **32**

5.1 Introduction 32
5.2 Materials and Methods 34
5.3 Results and Discussion 35
5.4 Conclusions 42

Chapter 6: The Effect of Environmental Factors on Pre- and Post-Weaning Growth of Nguni Calves **43**

6.1 Introduction 43
6.2 Materials and Methods 43
6.3 Results and Discussions 43
6.4 Conclusions 57

Chapter 7: Breeder Effects on the Production and Reproduction Efficiency of Nguni Cattle **59**

7.1 Introduction 59
7.2 Materials and Methods 59
7.3 Results and Discussions 60
7.4 Conclusions 77

Chapter 8: General Discussion and Conclusions **80**

References **86**

ABSTRACT

Nguni cattle are known for their qualities of adaptability to harsh environmental conditions. Research has shown that this breed of *Bos taurus africanus* has evolved over the years and in the process developed resistance to difficult conditions such as tick burden and tick borne diseases, scarcity of food, high temperatures and humidity (Mukasa-Mugerwa, 1989, Schoeman, 1989, Maree & Casey, 1993, Kars *et al*., 1994, Collins-Lusweti, 2000a, Scholtz, 2005). The hardiness of the Nguni breed makes it an appropriate breed for farmers at any level i.e. communal, emerging and commercial farmer, as they vary in the purpose of keeping the breed. Nguni cattle are therefore a good breed for any environment, hence their being scattered all over Africa. Despite their adaptability qualities, the environment in which they are does affect efficiency of production of the Nguni cattle.

The adaptability of the Nguni breed has been thoroughly researched and is well documented in many publications and books. Research is lacking on the effect of different geographical regions as determined by climate on the production and reproduction of Nguni cattle. This study addressed this hypothesis, hence non-genetic factors such as dam age, biome, bioregion, season and birth year were analyzed to test their effects on the production and reproduction of this breed. The effect of environmental conditions such as climate, expressed in seasons, and vegetation, expressed as biomes and bioregions, was tested by using GLM of SAS (2017), version 9.3. A total of 7 biomes were identified from the location of farmers, however breeders with the most animals were located only in the Savannah and Grassland Biomes. Within each of the two biomes, four bioregions were identified. The main factors assessed were age of dam in months, bioregion, season, calf sex and year grouping. Interactions between the main factors were also explored through analytical methods. Statistical analysis showed significant differences ($P<0.0001$) between the different geographical regions in terms of the productivity of the Nguni cattle. The age of dams significantly affected ($P<0.0001$) the performance of the Nguni cattle although this varied according to the different parameters. The effects were most significant in the birth, weaning, 12-month and 18-month weights of the calves in each bioregion as well as in calf and cow weights at weaning.

The calf sex was found to be significant ($P<0.0001$) to the weights of the calves at all stages of growth, where male calves were heavier than the females in all main factors analysed, such as bioregions, seasons, year groupings and between breeders. Differences were also observed between the different bioregions within each of the two biomes. Cow efficiency was evaluated using 3 different equations, namely; calf weaning weight as a proportion of cow

weight at weaning, percentage Inter-calving Period (ICP) as a proportion of ICP as per Nguni breed standards and calf weaning weight corrected to 205 days as a proportion of livestock unit (LSU). . The equations utilized the cow and calf weights at weaning as well as the ICP of cows in the study. Irrespective of the evaluation method used, the best cow efficiency was observed in the Eastern Kalahari Bushveld bioregion of the Savannah biome. In the Grassland Biome, the best cow efficiency was observed in the Drakensberg bioregion. The data was collected over 20 years, which were grouped into 5-year periods. Significant differences were observed between year groupings in performance of calves, with best performance observed in year grouping 1 (1990-1995) and year grouping 4 (2005-2010). According to the available weather data, in year groupings 1 and 4 there were good rains received both in the Savannah and in the Grassland Biomes. This partly explained the good performance observed in this study. Seasonal effects influenced the performance of calves and cow weights at weaning. Of further interest was the difference in performance of the Nguni breed, not only as affected by the environment but also due to the breeder or management factors. The breeder effects were evident through different calf weights at various growth stages, different cow weights at weaning and varying ICP of cows of the breeders though farming at the same bioregion although this was not easy to quantify, as it would mean having a broader knowledge and understanding of each breeder's management style.

In this study, cow performance based on cow weights at weaning and ICP was significantly affected by the environment and by the management of breeders. Similarly, calf growth expressed as calf weights at different stages of growth namely birth, weaning, 12- and 18-months differed significantly within and between bioregions as well as between the different breeders. This study established that the production and reproduction efficiency of the Nguni cows which are renowned for their hardiness and adaptability to harsh environments (e.g. semi-arid and arid regions in southern Africa), are affected by the environmental factors.

OPSOMMING

Nguni beeste (*Bos taurus africanus*) is bekend vir hul aanpasbaarheid. Navorsing het bevesitig dat die ras ontwikkel het deur jare van blootstelling aan moeilike omstandigehede soos bosluise en bosluis-oordraagbare siektes, min en swak kwaliteit voeding, hoë omgewings temperatuur en humiditeit (Collins-Lusweti 2000a; Maree and Casey, 1993; Mukasa-Mugerwa, 1989; Schoeman 1989 and Scholtz, 2005). Die gehardheid van die Nguni beesras maak dit geskik vir vleisbeesproduksie in kommunale, opkomende en kommersiele boerderystelsels. Nguni beeste pas geredelik aan in die meeste van dié stelsels en daarom kom die beesras wyd verspreid voor in Afrika. Ten spyte van Nguni's se aanpasbaarheid, blyk dit dat die fisiese omgewing hul produksie doeltreffendheid wel noemenswaardig beïnvloed.

Alhoewel die aanbasbaarheid van die Nguni ras nagevors is, is daar ontbrekende inligting oor die invloed van klimaat op die produksie en reproduksie doeltreffendheid van Nguni beeste in die verskillende geografiese streke in Suid Afrika. In die huidige studie is die hipotese ondersoek dat nie-genetiese faktore soos koei ouderdom, bioom, biostreek, seisoen en geboorte jaar 'n invloed het op die produksie en reproduksie eienskappe van Nguni's. Die invloed van klimatologiese faktore soos klimaat in terme van die verskillende seisoene, vegetasie (veldtipe en kwalitiet) soos bepaal deur die bioom en biostreke in Suid Afrika op die produskie en reproduksie eienskappe van Nguni koeie is geevalueer deur middel van regressive modelle in SAS (2017). Nguni beeste van Nguni telers in 7 verskillende biome is bestudeer, maar die meeste beeste was afkomstig uit die Savanna en Grasveld biome. Vier verskillende biostreke is in elkeen van die biome geïdentifiseer. Die belangrikste faktore wat bestudeer is, was koei ouderdom, biostreek, seisoen, geslag van kalf en jaar ouderdomsgroep. Verskille is statisties getoets vir betekenisvolle verskille op 'n peil van $P<0.0001$.

Die ouderdom van koeie het hul produksieprestasie betekenisvol beïnvloed ($P<0.0001$), maar die omvang van die effekte het verskil afhangende van die eienskappe wat bestudeer is. Byvoorbeeld, biostreke het geboorte, speen, 12- en 18-maaande massas van kalwers die meeste beïnvloed, terwyl koei massas tydens speen ook beïnvloed is. Die geslag van kalwers het 'n betekenisvolle invloed gehad op die daaropvolgende kalfmassas tydens speen, jaaroud en self later stadia van groei ($P<0.0001$). Bulletjies was deurgaans swaarded as verse in al die biome, streke en jare van die studie wat bestudeer is. Verskille in groei eienskappe is ook waargeneem tussen biostreke in die verskillende biome. Koei doeltreffendheid is bestudeer deur middel van 3 wiskundige funksies wat gebaseer was op koei en kalfmassas tydens speen en interkalfperiodes. Afgesien van die wiskundige model gebruik, is die beste koeidoeltreffenheid van koeie verkry in die Oosterlike Kalahari Bosveld biostreek in die Savanna bioom. In die Grasveld Bioom is die beste koei doeltreffendheid bereken in die

Drakensberg biorstreek. Die data is verkry oor ‘n periode van 20 jaar en is onderverdeel in 5 jaar periodes om ontleding daarvan te vergemaklik. Betekenisvolle verskille is waargeneem tussen jaar kategorieë, ten opsigte van die prestasie van kalwers, met die beste prestasie in die jare 1990-1995, gevolg deur jare 2005-2010. Volgens die beskikbare weerkundige data vir die jare 1990-1995, en 2005-2010, was dit ook die periodes wanneer die hoogste reënval waargeneem is in beide die Savanna en Grasveld Biome. Die data kan moontlik die goeie prestasie van beeste in die beste jare verklaar. Seisoene het ook ‘n invloed gehad op die massas van kalwers en koeie tydens speen. Dit is verder belangrik om daarop te let dat die prestasie van Nguni beeste nie net deur die omgewing nie, maar ook deur die telers en hul bestuursvernuf beïnvloed is. Alhoewel die invloed van telers waarneembaar was, was dit nie moontlik om die statistiese effek te kwantifiseer nie aangesien bestuursfaktore nie genoegsaam bestudeer is nie.

LIST OF ABBREVIATIONS

ARC	-	Agricultural Research Council
AVE	-	Average
EFF	-	Efficiency
INTERGIS	-	Integrated Registration and Genetic Information Systems
FCR	-	Feed conversion ratio
ICP	-	Inter-calving period
GLM	-	General Linear Methods
Kg	-	Kilogram
LSU	-	Large stock unit
No	-	Number
SAS	-	Statistical Analysis System
Wnd	-	Weaned
Wng	-	Weaning
Wt	-	Weight
Wwt	-	Weaning weight
Yr	-	Year

LIST OF FIGURES

Figure 2.1: Biomes of South Africa (Low & Rebelo, 1996), Desert (Rutherford, 1997)
Figure 3.1: Towns with Nguni breeders per vegetation biome in South Africa
Figure 3.2: Towns with Nguni breeders per Savannah and Grassland Biomes in South Africa
Figure 4.1: Effect of dam age on cow weight at weaning
Figure 4.2: Effect of dam age on calf weaning weight as a percentage of cow weight at weaning (calf Wwt/cow wt at weaning *100)
Figure 4.3: Effect of dam age on ICP as a percentage of breed standard
Figure 4.4: Effect of dam age on kg calf weaned/cow LSU (kg calf/cow LSU)
Figure 5.1: Effect of dam age on ICP
Figure 5.2: Seasonal rainfall in the Savannah Biome 1990-2010 (ARC Weather data)
Figure 5.3: Seasonal rainfall in the Grassland Biome 1990-2010 (ARC Weather data)
Figure 6.1: Effect of dam age on calf birth weight
Figure 6.2: Effect of dam age on calf weaning weight
Figure 6.3: Effect of dam age on 12-month calf weight
Figure 6.4: Effect of dam age on 18-month calf weight
Figure 7.1: Effect of breeder on calf weights in the Central Bushveld (bioregion 1)
Figure 7.2: Effect of breeder on mean ICP of cows in the Central Bushveld (bioregion 1)
Figure 7.3: Effect of breeder on calf weights in the Eastern Kalahari Bushveld (bioregion 2)
Figure 7.4: Effect of breeder on mean ICP of cows in the Eastern Kalahari Bushveld (bioregion 2)
Figure 7.5: Effect of breeder on calf weights in the Lowveld (bioregion 3)
Figure 7.6: Effect of breeder on mean ICP of cows in the Lowveld (bioregion 3)
Figure 7.7: Effect of breeder on calf weights in the Sub-Escarpment (bioregion 4)
Figure 7.8: Effect of breeder on mean ICP of cows in the Sub-Escarpment (bioregion 4)
Figure 7.9: Effect of breeder on calf weights in the Drakensberg (bioregion 5)
Figure 7.10: Effect of breeder on mean ICP of cows in the Drakensberg (bioregion 5)
Figure 7.11: Effect of breeder on calf weights in the Dry Highveld (bioregion 6)
Figure 7.12: Effect of breeder on mean ICP of cows in the Dry Highveld (bioregion 6)
Figure 7.13: Effect of breeder on calf weights in the Mesic Highveld (bioregion 7)
Figure 7.14: Effect of breeder on mean ICP of cows in the Mesic Highveld (bioregion 7)

Figure 7.15: Effect of breeder on calf weights in the Grassland Sub-Escarpment (bioregion 8)
Figure 7.16: Effect of breeder on mean ICP of cows in the Grassland Sub-Escarpment (bioregion 8)
Figure 8.1: Savannah Biome in South Africa (Rutherford & Westfall, 1986)
Figure 8.2: Grassland Biome in South Africa (Rutherford & Westfall, 1986)
Figure 8.3: Annual rainfall average in the Savannah and Grassland Biomes 1990-2010 (ARC Weather data)
Figure 8.4: Annual rainfall average in the Savannah and Grassland Biomes in year groupings (ARC Weather data)

LIST OF TABLES

Table.3.1:	Number of observations per measured parameter
Table.4.1:	Effect of biome on cow weight at weaning
Table 4.2:	Effect of bioregion on cow weight at weaning
Table 4.3:	Effect of year grouping on cow weight at weaning
Table 4.4:	Effect of season on cow weight at weaning
Table 4.5:	Effect of biome and year grouping interaction on cow weight at weaning
Table 4.6:	Effect of biome and season interaction on cow weight at weaning
Table 4.7:	Effect of biome on three measures of cow efficiency
Table 4.8:	Effect of season on three measures of cow efficiency
Table 4.9:	Effect of bioregion on three measures of cow efficiency
Table 4.10:	Effects of year grouping on three measures of cow efficiency
Table 4.11:	Effect of biome and season interaction on two measures of cow efficiency
Table 4.12:	Effect of calf sex on three measures of cow efficiency
Table 4.13:	Effect of biome and year grouping interaction on two measures of cow efficiency
Table 5.1:	Effect of biome on ICP
Table 5.2:	Effect of season on ICP
Table 5.3:	Effect of bioregions on ICP
Table 5.4:	Effect of year grouping on ICP
Table 5.5:	Effect of biome and season interaction on ICP
Table 5.6:	Effect of biome and year grouping interaction on ICP
Table 6.1:	Effect of biome on pre- and post-weaning growth of calves
Table 6.2:	Effect of calf sex on pre- and post-weaning growth of calves
Table 6.3:	Effect of bioregion on pre- and post-weaning growth of calves
Table 6.4:	Effect of season on pre- and post-weaning growth of calves
Table 6.5:	Effect of year grouping on pre- and post-weaning growth of calves
Table 6.6:	Effect of biome and calf sex interaction on calf birth weight
Table 6.7:	Effect of biome and season interaction on calf birth weight
Table 6.8:	Effect of biome and year grouping interaction on calf birth weight
Table 6.9:	Effect of biome and calf sex interaction on calf weaning weight
Table 6.10:	Effect of biome and season interaction on calf weaning weight
Table 6.11:	Effect of biome and year grouping interaction on calf weaning weight
Table 6.12:	Effect of biome and calf sex interaction on 12-month calf weights
Table 6.13:	Effect of biome and season interaction on 12-month calf weights

Table 6.14: Effect of biome and year grouping interaction on 12-month calf weights
Table 6.15: Effect of biome and calf sex interaction on 18-month calf weights
Table 6.16: Effect of biome and season interaction on 18-month calf weights
Table 6.17: Effect of biome and year grouping interaction on 18-month calf weights
Table 7.1: Cow and calf performance for Nguni breeders in the Central Bushveld bioregion and also including the ICP of cows
Table 7.2: Cow and calf performance for Nguni breeders in the Eastern Kalahari Bushveld bioregion and also including the ICP of cows
Table 7.3: Cow and calf performance for Nguni breeders in the Lowveld bioregion and also including the ICP of cows
Table 7.4: Cow and calf performance for Nguni breeders in the Savannah Sub-Escarpment bioregion and also including the ICP of cows
Table 7.5: Cow and calf performance for Nguni breeders in the Drakensberg bioregion and also including the ICP of cows
Table 7.6: Cow and calf performance for Nguni breeders in the Dry Highveld bioregion and also including the ICP of cows
Table 7.7: Cow and calf performance for Nguni breeders in the Mesic Highveld bioregion and also including the ICP of cows
Table 7.8: Cow and calf performance for Nguni breeders in the Grassland Sub-Escarpment bioregion and also including the ICP of cows
Table 8.1: Comparison between calf weights for both biomes
Table 8.2: Comparison between calf weights for both sexes
Table 8.3: Comparison between calf weights as affected by calf sex and biome

<u>Chapter 1</u>

GENERAL INTRODUCTION

1.1 Background

For a long period it was accepted that indigenous cattle in South Africa have low reproductive rates (Schoeman, 1989). This perception did not take into account the environment in which they performed, the management systems and pasture quality. Research has shown the beneficial effects of supplementation compared to natural pasture in the rearing of Nguni cattle, especially on reproductive ability of Nguni females. Age at first calving, weaning weight of calves and re-conception was shown to be improved by supplementation of heifers (Lepen *et al.,* 1993). Indigenous African cattle breeds are characterized by qualities such as tolerance to difficult climatic conditions, especially high temperatures, poor feed quality, ticks and tick-borne diseases (Schoeman, 1989, Kars *et al.*, 1994, Collins-Lusweti, 2000a, Muchenje *et al.,* 2007). Nguni cattle have developed tolerance and become renowned as a tick resistant breed in South Africa compared to other local cattle following years of exposure to infectious diseases such as heart-water (Schoeman, 1989, Collins-Lusweti, 2000a, Scholtz, 2005, Muchenje *et al.,* 2007). These authors have also specifically noted the value of the Nguni breed for its hardiness, adaptation to poor quality grazing, its tick resistance qualities and hence resistance to tick-borne diseases. In any animal production system, the breed chosen is critically important in terms of efficiency and sustainability of farming systems.

Performance of cattle is affected by environmental factors such as air temperature, air movement and humidity. These environmental factors may be stressors, and with other stress factors related to management, can have a considerable impact on the productivity of the animal. It is therefore critical that the genetic capability of an animal should be in harmony with the environment in which it is expected to perform, so that feeding and animal health issues become manageable. Therefore, animals adapted to a specific environment through natural selection are the best breed to farm with in that particular environment (Maree & Casey, 1993).

In beef cattle production, the best breeding season is the one in which the highest possible pregnancy rate can be achieved, which is a balance between conception rate and weaning weight (Meaker *et al.,* 1980). The optimal breeding season is one in which there will be sufficient nutritious feed for cows and calves at calving and early lactation.

Therefore, it has been suggested that late spring or summer calving can be an effective way of reducing feed costs because the available forage has a good nutrient status (Kruse *et al.*, 2008).

In fact, according to Maree & Casey (1993), calves that are born just before the start of the rainy season stand a chance of growing well as the cows are able to meet their nutritional demand and produce enough milk. The amount and quality of the forage will also make it possible to extend the grazing period for the calves. Due to the nutritional impact, calves that are born at this time are heavier at weaning (Maree & Casey, 1993).

1.2 Objectives of the research:

1. To study the effect of the different geographical regions of South Africa on reproduction of Nguni cows, as affected by age at first calving and inter-calving period including re-conception and breeding season.
2. To establish the effect of the different geographical regions of South Africa on cow efficiency as affected by calf weaning weight and cow weight at weaning. Cow efficiency can be determined by measuring calf weight as a percentage of cow weight at weaning, inter-calving period (ICP) and as kilogram calf weaned per large stock unit (kg/LSU).
3. To determine the effect of non-genetic factors on calf growth performance and mothering ability of Nguni cows in different geographical regions of South Africa, in relation to region of origin of the cow, birth weight, weaning weight, 12-month and 18-month weights.
4. To investigate the influence of the breeder on the production and reproduction efficiency of Nguni cattle in different geographical regions of South Africa.

1.3 Hypothesis

The climatic effects of different geographical regions result in different productive and reproductive performances of Nguni cattle in South Africa. This is aggravated by different herd management systems, environmental constraints and feed availability.

Chapter 2

LITERATURE REVIEW

2.1 Review into the Nguni breed

The Nguni breed, which is an ecotype of the Sanga cattle (*Bos taurus africanus*), is said to be a product from crosses of Zebu (a Tibetan word for Zen or Zeba which means the hump of the camel) and humpless Hamitic Longhorn and Shorthorn cattle that occurred in East and Central Africa many years ago (Mukasa-Mugerwa, 1989). The Nguni breed, which was originally found along the East Coast of Southern Africa, is said to be a breed associated with the descendants of the Nguni tribes (in Swaziland, Kwazulu, Mozambique and Zimbabwe). As a result of the association of the cattle with these tribes, the Nguni breed has different names used by each of these tribes, such as Nguni in Kwazulu, Nkone in Zimbabwe, Tswana or Tuli in Botswana; while in Namibia the Nguni breed is called Sanga, an Ethiopian word for ox (Schoeman, 1989).

In the past, these southern African indigenous breeds, the Nguni, Afrikaner and Drakensberger were perceived as inferior, less productive than other breeds (Brahman and Hereford) especially for commercial purposes. As a result, these breeds were often crossed, if not replaced with exotic breeds or other breeds perceived to be highly productive (Köhler-Rollefson, 2001; Schoeman, 1989). However, studies to compare the indigenous breeds against exotic breeds have continued to prove that under similar circumstances the two types of breeds may compete reasonably well in terms of productivity. Indigenous breeds further proved their superiority in their ability to adapt to harsh environmental conditions.

Nguni cattle are preferred for their adaptive qualities that include high fertility, short inter-calving period, ease of calving, low calf mortality, cow efficiency and tick resistance (Strydom, *et al.,* 2001; Lepen *et al.,* 1993).

In a study carried out by Collins-Lusweti (2000b), Nguni cattle were compared with Afrikaner and Bonsmara cattle for performance under prolonged drought conditions. Weights (birth and 200 day weights) and cow productivity parameters (calving intervals and percentage) were compared. The findings of the study showed that birth weights did not vary widely between the three breeds. Although Bonsmara and Afrikaner breeds were better for most parameters, the Nguni breed had the highest calving percentage. In a separate study, Schoeman (1989) reviewed the production of Sanga cattle breeds of South Africa and Namibia. In this review, the Nguni breed was compared to four other breeds, which included Drakensberger and Bonsmara.

According to Schoeman (1989), the Nguni cattle had a high calving rate (89.6%) compared to the other breeds, which averaged 77.4%. Furthermore, Nguni cattle reached puberty much earlier (349.9 days of age) than Bonsmara, which reached puberty at 419 days of age, and the Drakensberger, which reached puberty at 407.2 days of age. The Ngunis also proved their worth in that they had low calving losses. Nguni heifers could be mated as early as 12-months (Schoeman, 1989). This however should be done with caution as it can affect the length of the reproductive life of the cow.

2.2 Adaptability

The importance of breed adaptability to the environment cannot be emphasized enough. Experience in practical situations as well as research have proved that the production efficiency of an animal depends on its ability to maintain physiological activities at levels that allow it to grow and reproduce in the particular environment (Van der Westhuizen, 1973). This is described as adaptability, and it may be defined basically as a result of natural selection. Different cattle breeds differ in the way in which they are able to withstand climatic stress, disease and low food levels.

According to Van der Westhuizen (1973), under temperate conditions *Bos taurus* cattle have higher productivity than *Bos indicus*. As already stated, research has shown that the Nguni breed is adapted to harsh environments, low forage availability, ticks and tick borne diseases (Kars *et al.,* 1994, Collins-Lusweti, 2000a).The Nguni breed has relatively short strong legs which enables it to walk long distances in search for food and water, without suffering stress (Scholtz *et al.*, 2010). Adaptability can be improved through genetic selection for breeds that are capable of adapting to the environment. Where there is genetic selection for adaptability to a certain environment, the intention is usually to increase production rate within that particular environment.

According to Gregory (1972), if the environment changes at a slow rate, selection among the animals for the particular environment can be a beneficial exercise. However, if an environment changes at a faster rate, selection among the biological types by focusing on breeds that have higher performance can result in faster progress.

A study was conducted by Fredeen *et al.* (1987) to look into the performance of beef cattle in relation to the environment. In the study, two breeding herds were compared under two contrasting environments. The breeding herds were comprised of Hereford and Angus, then Charolais, Simmental and Limousin bulls were crossed to Hereford, Angus and Shorthorn cows. Crossbreeding took place over 3 years. The F1 female calves produced from the crossbreeding were reared under feedlot conditions up to the age of 12 months after which they were transferred to the two contrasting environments. One environment was a semi-intensive management system, while the second environment was an extensive range management system.

The breeding herd that was in the semi-intensive management system showed higher conception rates, lower calf mortality rates as well as pre-weaning calf gains that were higher than in the herd in the extensive management system. This also resulted in calves that had heavier weaning weights at each mating exposure (Fredeen *et al.,* 1987). At the same time cows at the extensive management system were lighter (15%) and had less fat (60%) when compared to their contemporaries in the semi-intensive system. An increase in feed inputs at the extensive system resulted in improved condition of the cows in terms of weights and fat.

Further work on adaptability was done by Strydom *et al*. (2001), who conducted a study to compare relationships between production and production traits between five Bonsmara strains and two Nguni sub-populations. The Bonsmara is a composite breed that was developed by the National Department of Agriculture of South Africa by crossing the Afrikaner (*Bos taurus africanus*) and Shorthorn/ Hereford (*Bos taurus taurus*) at the ratio of 5/8 to 3/8 respectively. In the study by Strydom *et al.* (2001), the cattle were fattened intensively and slaughtered serially at different slaughter weights. Growth performance, carcass characteristics and meat quality characteristics were compared between the five strains of the Bonsmara breed and the two sub-populations of the Nguni Cattle.

The results of genetic comparison showed that the five strains differed from each other, as determined through variation in genetic distances. The variation in genetic distances was confirmed by differences in the rate of weight gain, carcass quality as well as muscle weight gain. However, genetic distance between the Nguni sub-populations was very small, implying similarity of genetic make-up between the two sub-populations.

2.3 Breeding season

Research has shown that a successful breeding season is the one in which the cows calve when the least expensive but adequate source of good quality feed is available. This can be achieved by proper planning for the breeding season, so that calving occurs at least a few weeks before the grass starts growing (Maree & Casey, 1993, Bergh, 2004). This ensures that there is sufficient quality feed for the calves at weaning and therefore reduces costs of supplementary feed.

The effect of breeding season has been researched. According to Deutscher *et al.* (1991), calves that are born early in the calving season end up with higher weaning weights and are chronologically older at weaning and physiologically more developed than their counterparts that are born later in the calving season. This was thought to be purely the effect of availability of sufficient quantities of quality forage. It is therefore necessary to find a working solution for efficient beef cattle production with feed costs taken into consideration. As research has shown the timing of the breeding season to be one way of doing this, proper management and knowledge of how to do it is critical for successful practices.

2.4 Factors that affect production and reproduction efficiency of Nguni cows

2.4.1 *Introduction*

In any beef herd, reproductive efficiency is the most important factor that ensures the increase in herd size (Ladermann & Schoeman, 1994). Early mating of heifers can increase the reproductive life of a cow; however, this has always been approached cautiously because of fear of dystocia. Lepen *et al.* (1993) have stated that early mating can also affect re-conception rate and result in poor mothering ability of the cow, which can be observed in low weaning weights of calves. Lepen *et al.* (1993) therefore emphasized the importance of heavier weights of heifers at first mating, especially if good conception rates are to be achieved. Reproductive efficiency is also affected by inter-calving period (Burns *et al.*, 2010).

2.4.2 *Inter-calving period (ICP)*

Inter-calving period (ICP) is the time from one calving to the next. It has been described as a process that involves three phases, namely the gestation period, postpartum anoestrus and the service period. Of the three phases, it is only the postpartum period (from the last calving to the next oestrus) that can be improved through management. According to Mukasa-Mugerwa (1989), the postpartum period, which is instrumental in the re-establishment of the ovarian activity and preparing the cow for re-conception, can be shortened by good nutrition.

The postpartum period is the most critical of the three phases to ensure that ICP stays within the target of approximately 365 days on average for the herd. It is therefore recommended that the postpartum period should not exceed 80-85 days. As observed by Meaker *et al.* (1980), the target weight also influences re-conception in cows. An increase in body weight of cows above the target weight results in infertility due to excessive fat deposition. Meaker *et. al.* (1980) explains that if the body weight of cows decreases to below the target weight, the outcome could be reduced reproductive ability. Furthermore, the cow weight at the beginning and end of the mating season was noted to also have an influence on the conception rate (Meaker *et. al.,* 1980).The effects of environmental factors such as vegetation type and availability as a feed source, and how these are influenced by biome and bioregion, season and year were evaluated in relation to ICP in this study.

2.4.3 Age at puberty

Age at puberty has been noted as one of the most critical factors that determine reproductive efficiency of a cow. Together with age at first calving and calving interval, age at puberty influences the lifetime productivity of a cow (Mukasa-Mugerwa, 1989).

That means, depending on the breed, adequate nutrition is very important in its effect on the time taken for the heifer to reach puberty. Some researchers (Van Niekerk *et al.,* 1986; McDonald *et al.,* 1988, Mukasa-*Mugerwa*, 1989) believe that puberty will not be reached if the critical weight is not reached, irrespective of the age of the heifer. While poor nutrition delays puberty, very high levels of feeding will not necessarily improve age at puberty. Other than the environmental factors such as temperature, season of birth and disease, age at puberty is also influenced by the genetic make-up of the animal.

The importance of age and weight at puberty has been discussed by many researchers (Lepen *et al.,* 1993, Schoeman, 1996, Scholtz, 1985). Age at puberty between different breeds and within the same breed has been researched and reviewed with the intention of extending the productive life of a cow without compromising its reproductive performance. Lepen (1988), conducted research at Bartlow Combine Breeding Station to compare the age at puberty between three breeds namely Drakensberger, Nguni and Bonsmara. In the trial, measurements of age and weight at puberty, ADG, total feed intake and FCR for all three breeds were recorded under both feedlot and veld conditions.

The findings of the study showed that of the three breeds, Nguni heifers not only reached puberty much earlier than the other two breeds, they also consumed less feed and were much lighter than the Drakensberger and Bonsmara heifers. It was further noted that Bonsmara and Drakensberger heifers had a better growth rate; however, there were no significant differences in the feed conversion ratio between feedlot and veld groups of the three breeds. Lepen *et al.* (1993) also observed significant differences in age at puberty in the Nguni cattle which was earlier in those raised in a feedlot compared to the group on natural pasture.

2.4.4 Calving percentage

The calving percentage in any production environment is of utmost importance as it determines the increase in herd size and the number of animals that can be sold. Studies have been conducted to look into the effect of age at first calving within and across breeds. One of the studies to test early mating was conducted by Lepen *et al.* (1993) at Bartlow Research Station where the norm was to mate heifers at 24 months of age, resulting in a calving percentage of 83%. This study was conducted on two groups of Nguni heifers (45) to establish if age at first calving would affect their reproduction in terms of calving percentage, weaning weights, re-conception rates and birth problems. The first group of 15 heifers were stall-fed immediately after weaning; this group was mated at 13 months of age. The second group of 30 heifers were reared on sweetveld and mated at 15 months. Results of the study showed higher calving and weaning percentages for the first group. Furthermore, in both groups of the early-mated Nguni heifers no birth problems were experienced. To investigate the performance at second mating on re-conception rates, both groups of heifers were then grazed on veld. Re-conception rates of 83.3 and 78.3 % were reported for the group mated at 13 months and the one mated at 15 months respectively. These results showed that Nguni heifers could be mated at an early age for the first time without a compromising effect on their subsequent reproduction. Lepen *et al.* (1993) emphasized the importance of heifer weight at mating to improve conception rate, this agrees with the recommendations of Meaker *et al.* (1980) that the condition of the cow at calving significantly influences re-conception rates.

2.4.5 Cow efficiency

Cow efficiency is key to any beef enterprise, and is best described by the production and reproduction efficiency of the cow. Adaptation of an animal to its environment remains a factor if production and reproduction are critical goals (Scholtz *et al.,* 2010). The calving rate is one of the measures of cow efficiency, because it is linked to body condition of the cow which is achieved mainly through good feeding (Foster *et al.,* 2014). An individual cow is maintained in the breeding herd if the reproductive rate is acceptable through the calving percentage and weaning weight of calves. Meaker *et al.* (1980) emphasized the importance of the cow weight at mating as a factor that plays an important role in the re-conception of cows. Pre- weaning growth of calves is an indication of the genotype of the cow, therefore birth and weaning weights of calves are a product of the parent's genetic make-up and the available nutrition. Many researchers have used calf weaning weight as one of the measures to evaluate the cow efficiency. However researchers such as Dinkel & Brown (1978) believe that this method could favour small framed breeds and therefore are not in full support for its use. This has resulted in the development of other methods to evaluate cow efficiency such as using the cow's ICP. Cow efficiency can also be determined through the kilograms of calf weaned per large stock unit, which method is frame size specific (Mokolobate *et al.,* 2015).

2.5. Geographical regions for beef cattle farming in South Africa

2.5.1 *Introduction*

Geographical regions in South Africa are affected by differences in climate. Factors such as rainfall, temperature and soil type influence the type of vegetation for each region. Many different veld types have been identified according to the vegetation that grows in these different areas. An early detailed classification was carried out by Acocks (1988), and resulted in the identification of 70 veld types in South Africa, Lesotho and Swaziland. More work has since been done which suggests that veld types have been altered by factors such as the environment, climate change, living organisms and farming practices.

2.5.2 *Veld types*

For an area to be defined as a veld type, the vegetation in the area must be similar enough to allow the whole area to have the same farming potential (Acocks, 1988, Maree & Casey, 1993). Veld types are therefore classified according to the farming potential as determined by grasses in the veld type, hence the names sweetveld, sourveld and mixed veld. Sweetveld is characterized by 'sweet' grasses which have a relatively low fibre content and high palatability even at maturity. These grasses maintain their quality for about 10 to 12-months of the year (Hardy & Hurt, 1999). Rainfall in these areas usually ranges between 500 – 700mm per year, mainly in the summer rainfall areas, allowing plant material to remain palatable through a great part of the year (Maree & Casey, 1993).

On the other hand, sourveld occurs in areas with high rainfall (750-1000mm per year), and often on coarse and sandy soils. High rainfall results in highly leached soils with fast growth and early maturity of plant material, which as a result loses quality and becomes more fibrous, thereby losing palatability as it matures. The poor pasture quality at this time results in loss of weight in livestock. Mixed veld is a mixture of the two veld types; it is described as sweet mixed veld type with more sweet grasses or sour mixed veld type where there are more sourveld grasses (Acocks, 1988).

2.5.3 *Biomes and bioregions*

A biome is defined as a large-scale community of plants or animals, which exist in one area on a permanent basis; this usually results in a noticeable pattern of the plant cover. The occurrence of a biome is a result of the climatic conditions of the region as well as the environment. Mucina & Rutherford (2006) mapped 9 biomes in South Africa. The biomes include Fynbos, Succulent Karoo, Desert, Nama-Karoo, Grassland, Savannah, Albany Thicket, Indian Ocean Coastal Belt and Forests (Low & Rebelo, 1996).

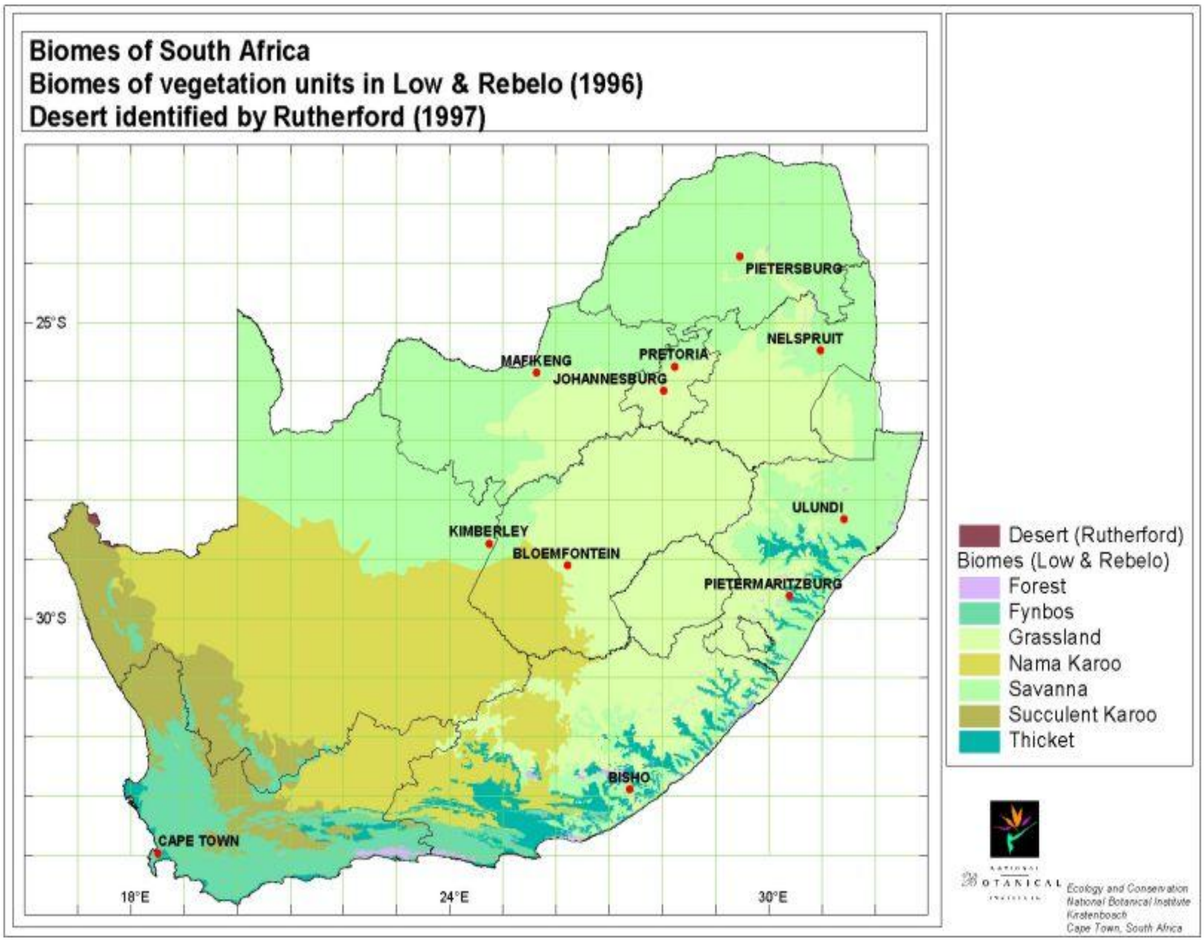

Figure 2.1: Biomes of South Africa (Low & Rebelo, 1996); Desert (Rutherford, 1997)

Of these biomes, Savannah is the largest biome in southern Africa. It easily occupies 46% of its area and more than one third of the area of South Africa. Savannah is mostly used for grazing livestock or game, because of its good grass cover with shrubs and trees (Low & Rebelo, 1996). Grassland Biome is the second largest biome in South Africa. Grassland

Biome also called Grassveld is dominated by a layer of grasses with few trees. This make it suitable for livestock farming. Grassland Biome is also suitable for maize crop production. Grassland Biome has sweet and sour grasses which respond to seasons differently. It is important to note that with high rainfall on acidic soils, it is possible to get sour grasses which will affect palatability of the vegetation (Low and Rebelo, 1996)

Chapter 3

MATERIALS AND METHODS

3.1 Collection of data

Permission was requested and obtained from the Nguni Cattle Breeders Society of South Africa to utilize performance data of Nguni cattle from all Provinces. Data were therefore obtained from the Integrated Registration and Genetic Information Systems (INTERGIS), database, managed by Agricultural Research Council (ARC), for all registered Nguni breeders throughout South Africa. The data, which were collected from farms located throughout South Africa, contained 427 entries of breeders, 26681 cows and 85606 entries of calves that were identified with computer numbers. Data that were identified as outliers and could not be used for analysis were removed before performing analysis. These included breeders with less than 50 cows and breeders which could not be allocated into specific biomes. Breeders with less than 50 cows were removed because it is believed that managing a small herd size would be easier and not give a true reflection of the management skills required for a big herd. Age at first calving was based on the Nguni standards, and cows that were older than 39 months at first calving were excluded from the analysis. Inter-calving period (ICP) was also based on the Nguni standards, and the maximum ICP was set at 730 days. All cows records with ICP less than 315 days as well as more than 730 days were removed from the data before analysis. Out of 85606 records, 1596 records had ICP less than 315 days and 1746 records had ICP above 730 days. This was done so that outliers could not affect the results of the analysis; this could also impede the objective of the study, which was to test the effect of the environment on the performance of the breed under normal circumstances.

As the aim of the study was to look into the effect of the different regions on the production and reproduction of Nguni cattle, the different regions in which Nguni cattle are farmed were categorized into biomes and bioregions.

Of the nine biomes mapped by Mucina and Rutherford (2006), the data could be allocated to only six biomes according to the location of the breeder. The six biomes were identified as Albany Thicket Biome, Fynbos, Nama-Karoo, Succulent Karoo, Savannah and Grassland Biomes. Of the six biomes, four did not have sufficient data to perform analysis and get sensible results. The breeder allocation in the biomes is shown in Figure 3.1. To address the shortcoming, performance records from the four biomes (Albany Thicket Biome, Fynbos, Nama-Karoo and Succulent Karoo Biomes) were removed from the data set. Analysis was done for only two biomes, Savannah and Grassland Biomes, as they had enough data for all the years of production.

The distribution of the breeders in the Savannah and the Grassland Biomes is shown in Figure 3.2.

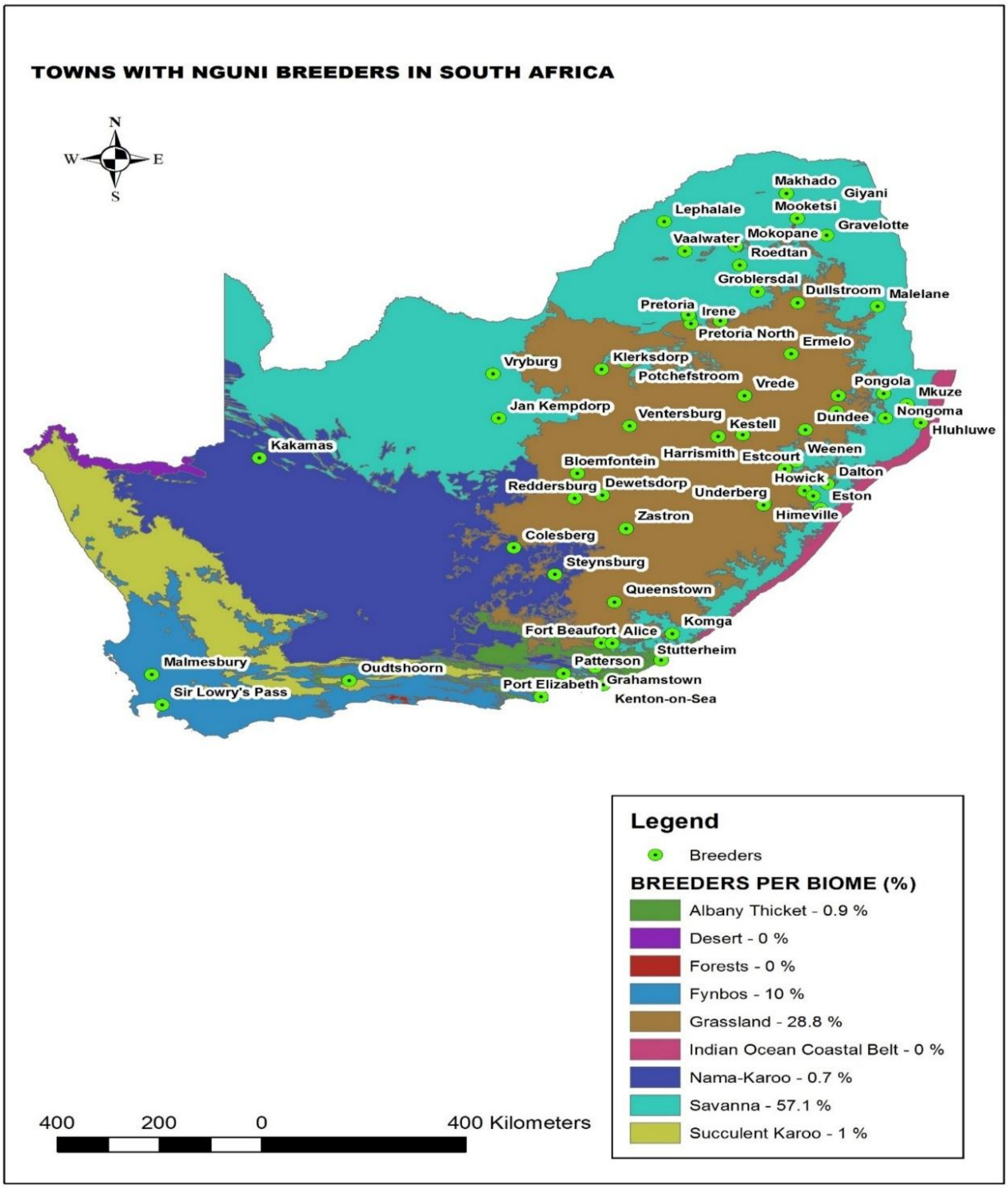

Figure 3.1: Towns with Nguni breeders per vegetation biome in South Africa (427 Nguni breeders)

The Savannah Biome had 57% of the total breeders, while the Grassland Biome had 28.8% of the total breeders. Within the two biomes, eight bioregions were identified, with four bioregions in each biome. The bioregions under the Savannah Biome were identified as Central Bushveld, Eastern Kalahari Bushveld, Lowveld and Sub-Escarpment Savannah.

In the Grassland Biome, the four bioregions were Drakensberg, Dry Highveld bioregion, Mesic Highveld and Sub-Escarpment Grassland.

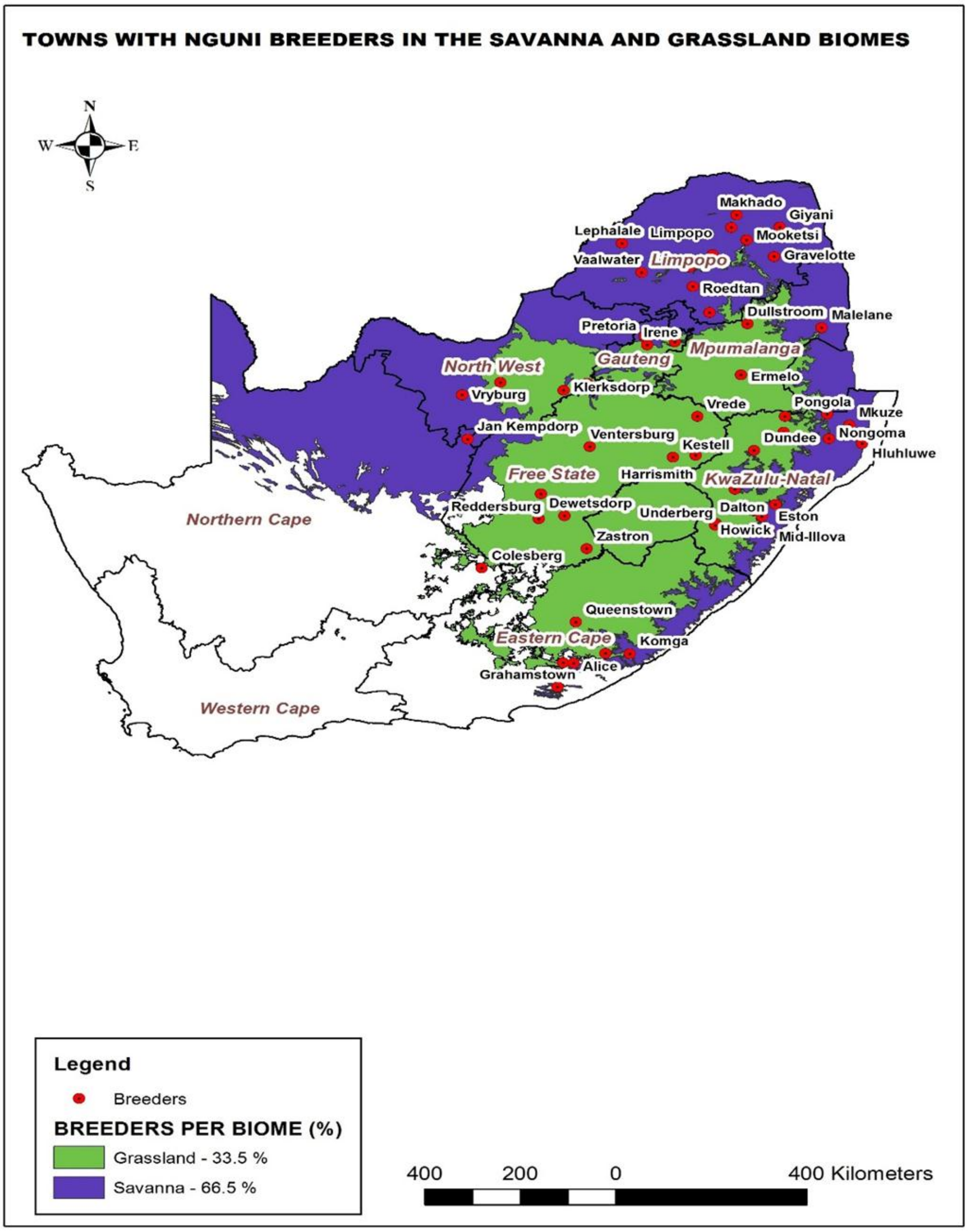

Figure 3.2: Towns with Nguni breeders per Savannah (244 breeders) and Grassland (123 breeders) Biomes in South Africa

To determine the seasonal effects on the performance of the Nguni cows, the year was divided into seasons as follows: Summer (November, December and January), Autumn (February, March and April), Winter (May, June and July) and Spring (August, September and October). Performance data were collected over a 20-year period from 1990 to 2010. This constituted a voluminous amount of data. Firstly, all the data were analyzed together and results were critically assessed for each year. The data collected over 20 years was divided into four year groupings as follows: year grouping 1 (1990 to 1995), year grouping 2 (1996 to 2000), year grouping 3 (2001 to 2005), and year grouping 4 (2006 to 2010).

Since the aim of the study was to look into the effects of the different geographical regions of South Africa on production and reproduction of Nguni cattle, the following parameters were focused on and analyzed:

- Cow efficiency as affected by calf weaning weight (corrected for 205 days to standardize weights and simplify statistical analysis) and cow weight at weaning
- Inter-Calving Period (ICP) for the whole cow herd
- Weights of calves: birth weight, weaning weight (corrected to 205 days), 12- and 18-month weights
- Breeder effects on production and reproduction of the different Nguni herds

3.2 Statistical Analysis

Data comprised of 427 breeders, 26681 cows and 85606 calves collected between 1990-2010 in farms located in the Savannah and Grassland Biomes throughout South Africa and recorded on the Integrated Registration and Genetic Information Systems were grouped according to the different objectives and analyzed to address the different areas.

Calf weaning weight as a percentage of cow weight at weaning is sometimes used to measure cow efficiency in cow-calf production; it is mostly used to determine biological rather than economic efficiency. In this study, cow efficiency was estimated in three ways, namely:

1. The traditional way which is calf/ cow ratio. The following equation was used to estimate this:
   - Cow efficiency = (calf weaning weight (205 d wt)/cow weight at weaning) *100
2. The ICP of each cow relative to the average of the Nguni breed was used to evaluate the cow efficiency. According to the Nguni Cattle Breeders Society standards the average ICP is 409 days. The following equation was used:
   - Cow efficiency (% ICP) = (Cow ICP/ICP Nguni standard) *100
3. Kilogram calf weaned per large stock unit (kg calf/LSU) mated was used to get an indication of efficiency (also expressed as cow productivity in Nguni cows. The following equation was used:

- Cow productivity= (Calf Wwt (corrected 205 day)/LSU)*Estimated calving %).

To calculate the large stock units (LSU), a frame size specific equation (Mokolobate *et al.,* 2015) was used. The formula for small framed animals was used, as shown below:

- Y =0.2871428571+ 0.0025542857*x-0.0000005714*$x^{2,}$ where y= Large Stock Units (LSU) and x= cow weight. The results of the calculation were analyzed to determine effect of non-genetic factors on the cow efficiency.
- Calving % = 100-((average ICP/year-365)/365)*100,

Calf growth measurements expressed as birth, weaning, 12 - and 18 - month weights were an important part of the data. The number of observations for calf growth measurements and ICP are shown in Table 3.1 below.

Table 3.1: Number of observations per measured parameter

	Birth Weight	Weaning Weight	12 month Weight	18 month Weight	Inter-Calving Period
*n	33816	29883	14739	9810	26681

The ages of dams at all calf growth stages were critical to the analysis, these were analyzed to see the effect on all performance measures. Data were analyzed using the general linear method (GLM) of SAS (2017), version 9.3. For each performance parameter, the main factors which were analyzed for included, biome, bioregion, season, year grouping and interactions between the main factors. Dam age in months was analyzed for as a covariant.

The interaction model used was as follows:

$Y_{iklmnop}= \mu+BC_i+BCBR_j+YG_k+S_l+BCYG_m+BCS_n+DC_o+BCDC_p+e_{ijklmnop}$

Where, Y= the dependant variable (e.g. ICP, cow weight at weaning, calf weights)

BC = effect of the i^{th} Biome code

BR = effect of j^{th} Bioregion within Biome code

YG = effect of the k^{th} Year grouping

S = effect of the l^{th} Season

BCYG = effect of the m^{th} interaction between the Biome code and Year grouping

BCS = effect of the n^{th} interaction between the Biome code and Season

DC = effect of the o^{th} Dam age code

BCDC = effect of the p^{th} interaction between Biome code and Dam age code

e = error

Chapter 4

COW EFFICIENCY BASED ON CALF WEANING WEIGHT AND COW WEIGHT AT WEANING

4.1 Introduction

Cow efficiency is an important selection criterion in a beef herd, once an acceptable level of this parameter has been attended to, herd production efficiency can then be achieved through correct management practices (du Plessis *et al.*, 2006). When cow productivity is defined as kilogram calf weaned per large stock unit (Mokolobate *et al.,* 2015), it becomes important to take frame size into consideration. Depending on the formula used to calculate cow productivity accurately some parameters are critical. These include the number of cows exposed to bulls, the number of calves weaned, birth weight, date and sex of the calf, weaning weight and date, as well as the body weight and condition score of the cow (Lancaster & Arthington, 2014).

4.2 Materials and Methods for cow weight at weaning

Performance data of Nguni cows from all the provinces were obtained from the Nguni Cattle Breeders Society of South Africa, as described in Chapter 3. The objective was to establish the productivity and reproduction efficiency of the cows by analyzing cow and calf weights at weaning. To get the answers, data were analyzed and studied using two different procedures. Firstly, the effects of non-genetic factors such as biome and bioregion, season, year grouping, and interactions between the main factors on cow weight were assessed. Dam age in months was measured as a covariant. The interaction model used is described in materials and methods, with the dependent variable being cow weight at weaning. Analysis results for each factor are discussed below.

4.3 Results and Discussions:

4.3.1 *Effect of dam age on cow weight at weaning*

Statistical analysis of the effect of dam age as a covariant on cow weight revealed significant effects ($P<0.0001$). An increase in cow weight was observed as age of dam increased up to the age of 120 months. Assessing the numbers of cows at the time of weaning of calves showed a continuous decline until 120 months of age. Figure 4.1 shows how the cow weight at weaning was affected by dam age. The numbers of productive cows also decreased with increase in dam age. It is apparent that after 120 months (10 years), productivity of a cow declined, thereby reducing the number of older cows in production and at weaning, because they would have been culled.

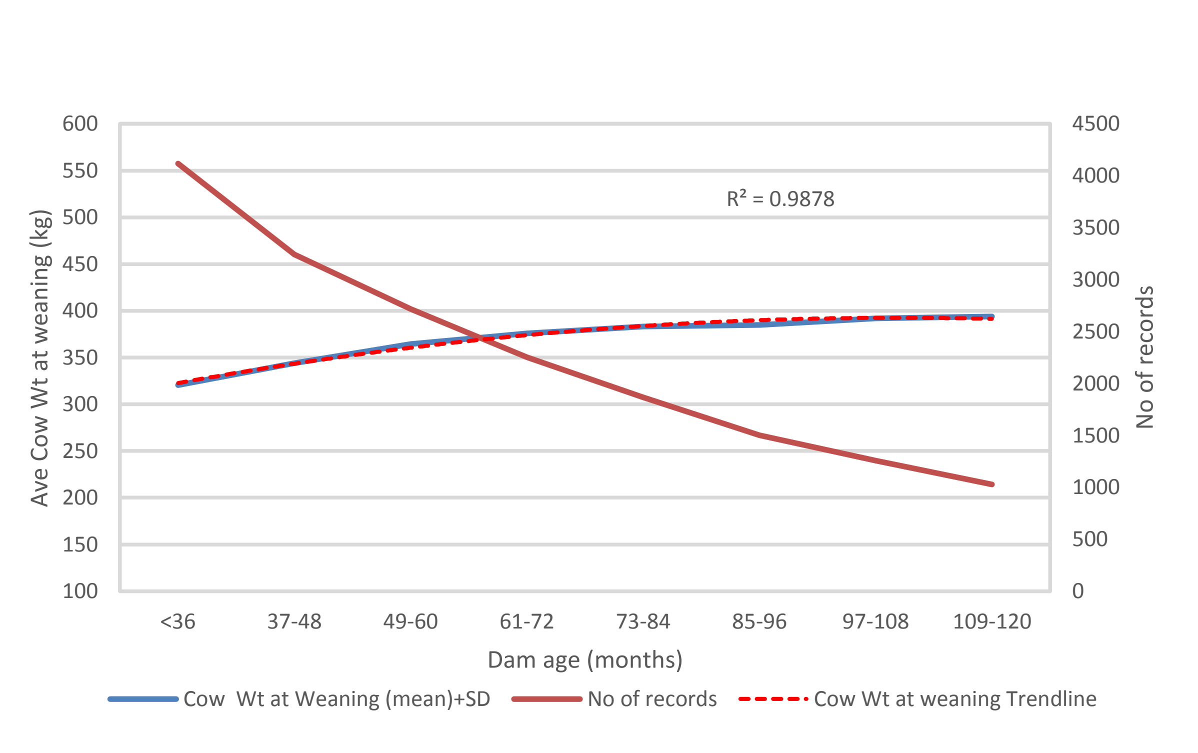

Figure 4.1: Effect of dam age in months on cow weight at weaning

4.3.2 *Effect of biome on cow weight at weaning*

Statistical analysis showed that a biome in which the cows produced had significant effects (P<0.0001) on cow weights at weaning. Cow weights were significantly higher in the Savannah Biome than in the Grassland Biome. Table 4.1 shows that cows in the Savannah Biome were 14.3 kg heavier than those in the Grassland Biome. There was also a difference in the number of observations.

Table 4.1: Effect of biome on cow weight at weaning (mean ± SD)

Biome	**Cow weight at weaning**	**n**
Savannah	371.4kg ±57.11[a]	12592
Grassland	357.1kg ±52.68[b]	7918

Column means with different superscripts differ at (P<0.0001)

4.3.3 *Effects of bioregion on cow weight at weaning*

The different bioregions had significant effects (P<0.0001) on cow weights. In the Savannah Biome, cow weights were significantly higher in the Sub-Escarpment bioregion compared to all other bioregions as shown in Table 4.2. Table 4.2 also shows that there were higher cow weights at weaning in the Drakensberg and Dry Highveld bioregions of the Grassland Biome.

Table 4.2: Effect of bioregion on cow weight at weaning (mean ± SD)

Savannah Biome		
Bioregion	**Cow weight at weaning**	**n**
Central Bushveld	372.8kg ±57.47[b]	5988
Eastern Kalahari Bushveld	360.0kg ±52.77[c]	3392
Lowveld	363.0kg ±59.55[c]	1982
Sub-Escarpment	389.9kg ±59.35[a]	1230
Grassland Biome		
Bioregion	**Cow weight at weaning**	**n**
Drakensberg	366.4kg ±50.28[a]	1416
Dry Highveld	365.7kg ±54.07[a]	1390
Mesic Highveld	349.4kg ±55.06[b]	2380
Sub-Escarpment	346.8kg ±50.66[b]	2732

Column means with different superscripts differ at P<0.0001

4.3.4 *Effect of year grouping on cow weight at weaning*

The twenty (20) year set of data was divided into four-year groupings. Statistical analysis showed that the year grouping had a significant effect (P<0.0001) on cow weight at weaning. As shown in Table 4.3 below, higher cow weights at weaning were observed in year groupings 1 and 2 than in the later groupings.

Table 4.3: Effect of year grouping on cow weight at weaning (mean ± SD)

Year category at weaning	**Cow weight at weaning**	**n**
Year grouping 1 (1990-1995)	373.1kg ±55.41[a]	5242
Year grouping 2 (1996-2000)	369.8kg ±53.82[a]	4047
Year grouping 3 (2001-2005)	358.9kg ±56.25[b]	3878
Year grouping 4 (2006-2010)	355.1kg ±56.85[b]	7343

Column means with different superscripts differ (P<0.0001)

According to the weather data, higher rainfall was experienced in year grouping 1 (1990-1995), and this is thought to have resulted in better cow weights at weaning through increased quantity and quality of forage.

4.3.5 *Effect of season on cow weight at weaning*

Season was found to have significant effects (P<0.0001) on cow weight at weaning. Cow weights differed between seasons, with significantly higher cow weights observed in spring, which was 19.2 kg higher than the lowest cow weights (Autumn), as shown in the Table 4.4.

Table 4.4: Effect of season on cow weight at weaning (mean ± SD)

Seasons at weaning	Cow Weight at Weaning	n
Summer	367.7kg ±56.46[b]	8401
Autumn	353.8kg ±57.38[c]	874
Winter	362.4kg ±52.38[b]	1605
Spring	373.0kg ±55.51[a]	9630

Column means with different superscripts differ (P<0.0001)

4.3.6 *Effect of biome and year grouping interaction on cow weight at weaning*

Having analyzed and determined separately the effects of biome and year grouping on cow weights, it was necessary to see the interaction of the two factors on the cow weights at weaning. Results of the analysis showed significant effects (P<0.0001) of the biome and year grouping interaction on cow weights at weaning. Even though cow weights at weaning were slightly higher in year grouping 1 (1990-1995) of the Savannah Biome, differences were not statistically significant between the year groupings, as shown in Table 4.5.

Table 4.5: Effect of biome and year grouping on cow weight at weaning (mean ± SD)

	Savannah Biome		Grassland Biome	
Year Groupings	**Cow weight at weaning**	**n**	**Cow weight at weaning**	**n**
Year grouping 1	374.4 kg ±55.64[a]	3915	371.9 kg ±54.23[a]	1327
Year grouping 2	371.4 kg ±53.86[a]	2539	368.1 kg±53.57[a]	1508
Year grouping 3	370.1 kg ±57.01[a]	2018	347.6 kg ±53.69[b]	1860
Year grouping 4	369.6 kg ±60.20[a]	4120	340.7 kg ±49.70[b]	3223

Column means with different superscripts differ (P<0.0001)

A similar trend was observed in the Grassland Biome, where significantly higher cow weights at weaning were observed in year grouping 1.

4.3.7 *Effects of biome and season interaction on cow weights at weaning*

As was done with the biome and year grouping, the interaction between biome and season as it affected the cow weights at weaning was analyzed. The results showed that the biome and season interaction had significant effects (P<0.0001) on cow weights at weaning. Differences were observed in interactions of the different seasons with biomes.

As demonstrated in Table 4.6, cow weights at weaning were significantly (P<0.0001) higher in spring compared to all other weights in the Savannah Biome. Similarly in the Grassland Biome, cow weights at weaning were significantly higher in spring compared to other seasons in the same biome.

Table 4.6: Effect of biome and season interaction on cow weight at weaning (mean ± SD)

	Savannah Biome		**Grassland Biome**	
Season	**Cow weight at weaning**	**n**	**Cow weight at weaning**	**n**
Summer	374.2kg ±56.79[b]	5896	361.3kg ±53.38[b]	2505
Autumn	364.9kg ±59.23[c]	501	342.7kg ±51.01[c]	373
Winter	367.8kg ±52.40[c]	970	357.1kg ±49.81[b]	635
Spring	378.7kg ±57.68[a]	5225	367.3kg ±51.74[a]	4405

Column means with different superscripts differ (P<0.0001)

4.4 Materials and Methods for cow efficiency

In this section, cow efficiency was evaluated using three different equations as described in Chapter 3. Production records for the cows in the study were analyzed to establish the effect of non-genetic factors on cow efficiency. The main factors that were analyzed to determine their effect on cow efficiency were biomes, bioregions, year grouping, calf sex, season of birth and interactions between some of the main factors. Dam age in months was included as a covariant.

4.5 **Results and Discussions**

4.5.1 *Effect of dam age on calf weaning weight as a percentage of cow weaning weight (calf Wwt /cow wt at weaning*100)*

As a covariant, dam age had a significant effect (P<0.001) on calf weaning weight as a percentage of cow weight at weaning. The results of the analysis showed that as the dam became older, the cow efficiency declined. Maciel *et al.* (2016), also noted the age at which dam age declined as 10 years, and this was observed with the reduction in the number of cows in production, as a result of culling.

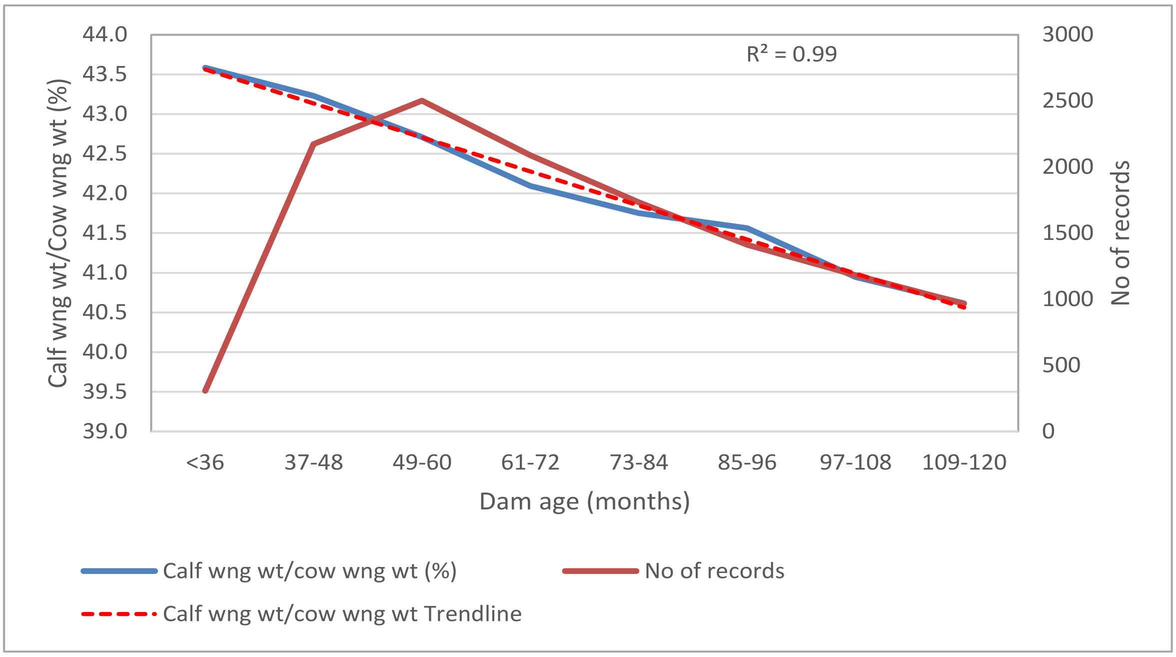

Figure 4.2: Effect of dam age on calf weaning weight as a percentage of cow weight at weaning (calf Wwt /cow wt at weaning*100)

In this study, a steady decline in the number of cows in production was observed with increase in dam age, as shown in Figure 4.2. The trend of decline in cow productivity with increase in dam age was consistent in all three equations used to determine cow efficiency. This was in line with the age of productive dams in a herd, as the cow efficiency percentage clearly showed that as dams became older cow efficiency dropped. This resulted in fewer older dams in a herd as less productive dams were culled.

4.5.2 *Effect of dam age on ICP as percentage of breed average*

Statistical analysis of dam age as a covariant revealed significant effects (P<0.0001), as indicated in Figure 4.3. When ICP was expressed as a percentage of the breed average, cow efficiency increased slightly with the age of the dam. The analysis of results for the cow efficiency as determined with ICP agreed with the results of cow efficiency determined in calf weaning weight percentage. Also shown in Figure 4.3, the number of available records started at low levels for young dams, increasing as the dam age reached 36 to 48 months. Beyond the ages of 60 months there was a clear decline of records, this coincided with the decline in the efficiency of the dams as determined though the ICP. The decline in cow efficiency as determined through the ICP could be due to the decline in the condition of cows, most probably the cow weight. As observed by Meaker *et al.* (1980), while the target weight of cows is key for re-conception, the weight of cows at the beginning and end of the mating season plays an important role on the conception rate.

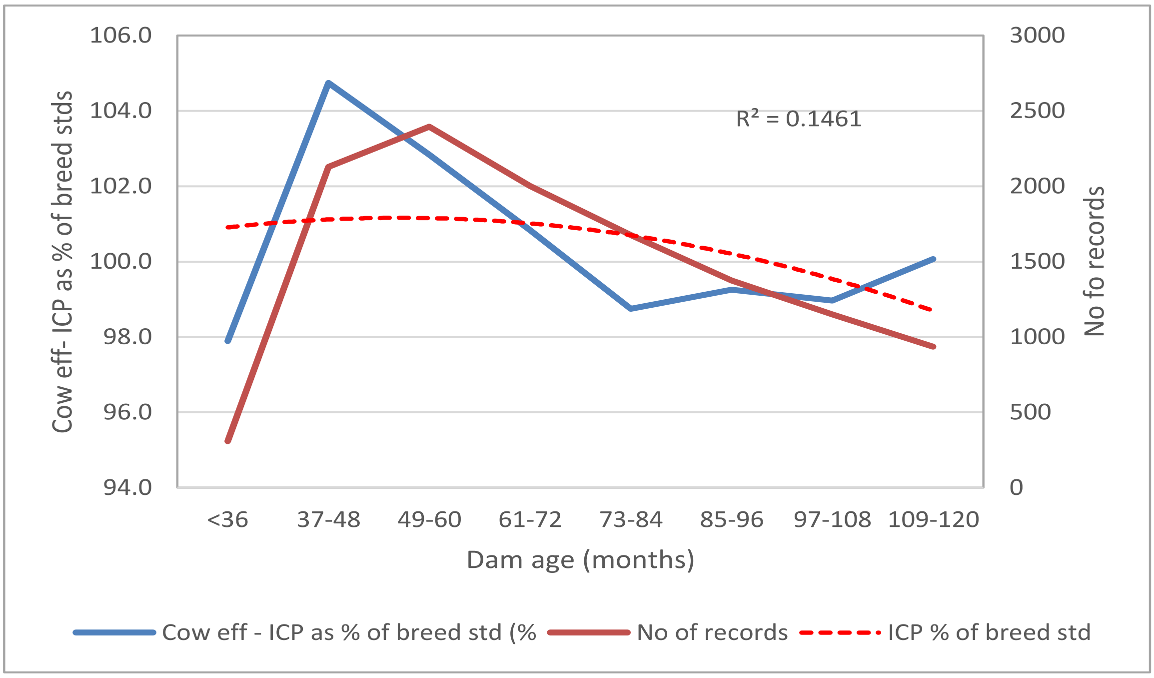

Figure 4.3: Effect of dam age on ICP as percentage of breed standard

4.5.3 *Effect of dam age on kg calf/cow LSU*

The effect of dam age on cow productivity as determined through weight (kg) of calf weaned per large stock unit was found to be significant ($P<0.0001$). In Figure 4.4 a decline of cow efficiency that coincided with an increase in dam age is demonstrated. This is in agreement with the trend shown in the cow efficiency as calculated above using different equations. The total number of available records for cow efficiency as determined using kilogram calf weaned per large stock unit (kg calf/LSU) was assessed. The results showed higher numbers of young dams producing higher kilograms calf per large stock unit at weaning. However a decline in numbers was observed when dams grew older. This was also accompanied by a decline in weight of calf produced per large stock unit at weaning, as shown in Figure 4.4.

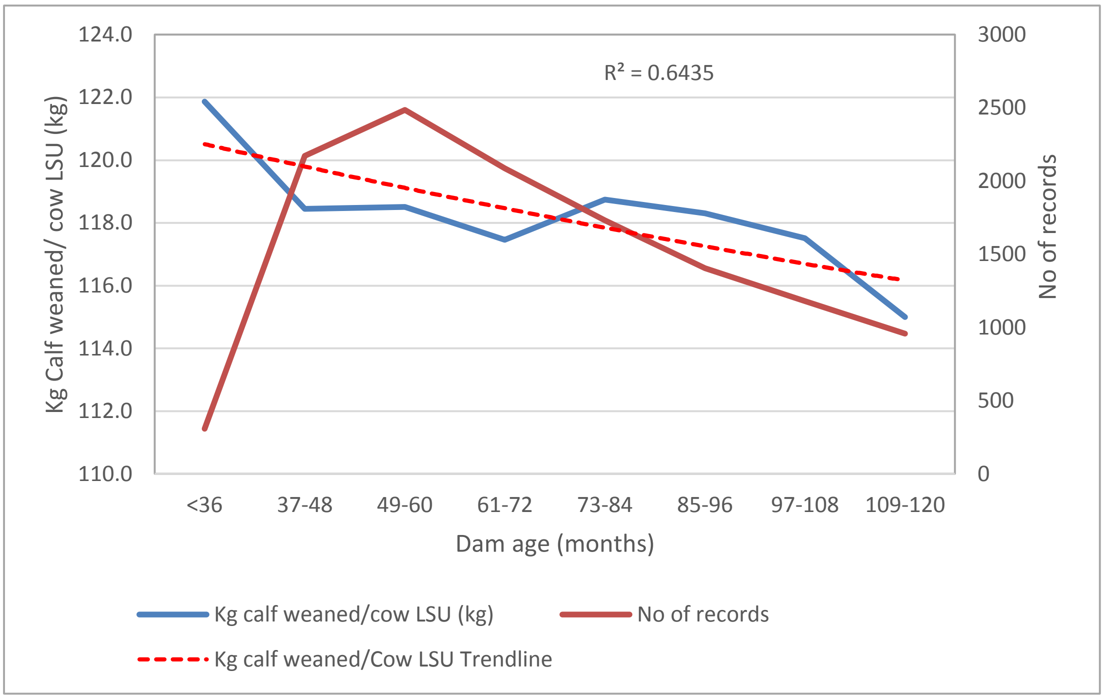

Figure 4.4: Effect of dam age on kg calf weaned/cow LSU (kg calf/cow LSU)

The decline in the number of cows in production coinciding with increase in dam age has been observed throughout in the analysis above, however it does not imply a decrease in cow efficiency. The observation is that with the increase in dam age there tends to be a decline in the productivity of the cow. It is thought that this is due mostly to biological reasons, but management can also play a role in extending the age at which the dam becomes less productive.

4.5.4 *Effect of biome on three measures of cow efficiency*

Savannah and Grassland Biomes were found to have a significant but small effect ($P<0.0075$, Table 4.7) on cow efficiency. The calf weaning weight percentage was at an acceptable level exceeding 40%. At the same time, the two biomes were found to also influence ($P<0.0136$) cow ICP relative to the Nguni average. Cows in the Savannah Biome had a marginally higher efficiency than those in the Grassland Biome. Both biomes produced cows which had good ICP and were close to the average ICP (409 days) according to the Nguni standards. Furthermore, the two biomes differed slightly in kg calf /LSU, but the effects were not statistically significant. The results of the three different formulae showed that cows in the Savannah Biome had slightly better cow efficiency than the Grassland Biome, as shown in Table 4.7 below. An ICP of 409 days is an indication of high conception and calving rate. As noted by Meaker *et al*. (1980), the body condition of the cow at calving is very important to ensure re-conception. It can be concluded that both biomes are conducive for cow efficiency depending on management practices.

Table 4.7: Effect of biome on three measures of cow efficiency (mean ± SD)

Biome	Calf Wwt/Cow Wng Wt (%) (n)	Cow ICP/ICP Nguni std (%) (n)	Kg calf Wnd/Cow LSU (kg) (n)
Savannah Biome	41.4±6.95[b] (9118)	100.7 ±12.98[b] (8856)	117.4 ±23.34[a] (9140)
Grassland Biome	42.0±7.02[a] (5620)	101.8 ±15.01[a] (5387)	116.8 ±23.29[b] (5548)

[a,b] Column means with different superscripts differ (P<0.075)

4.5.5 *Effect of season on three measures of cow efficiency*

Seasonal effects have implications on vegetation and the quality of the grazing, and it is therefore logical that seasons will have an effect on cow efficiency. Analysis showed that seasons had significant effects (P<0.0001) on cow efficiency. In summer and spring, cow efficiency was similarly at the best level for all the three equations used (Table 4.8); while the lowest cow efficiency was observed in autumn in all three equations.

Table 4.8: Effects of season on three measures of cow efficiency (mean ± SD)

Seasons	Calf Wwt/ Cow Wng Wt (%) (n)	Cow ICP/ ICP Nguni std (%) (n)	Kg calf Wnd/ Cow LSU (kg) (n)
Summer	42.5 ±7.18[a] (6206)	95.0 ±10.67[a] (6061)	123.2 ±23.14[a] (6206)
Autumn	40.2 ±7.89[b] (540)	108.9 ±19.36[b] (543)	109.2 ±25.06[b] (549)
Winter	41.5 ±7.02[c] (1135)	107.4 ±21.24[b] (1121)	112.4 ±22.62[b] (1138)
Spring	42.5 ±6.66[a] (6857)	93.5 ±13.23[a] (6518)	123.5 ±22.90[a] (6795)

Column means with different superscripts differ (P<0.0001)

4.5.6 *Effect of bioregion on cow efficiency*

Cow efficiency was significantly (P<0.0001) affected by the bioregions in all three different equations used to calculate cow efficiency. Irrespective of the measure or method of evaluation, cow efficiency was found to be best in the Eastern Kalahari Bushveld bioregion of the Savannah Biome. At the same time, cow efficiency in the Grassland Biome was best in the Drakensberg bioregion irrespective of the evaluation method (Table 4.9).

Table 4.9: Effect of bioregion on three measures of cow efficiency (mean ± SD)

Savannah Biome			
Bioregion	**Calf Wwt/ Cow Wng Wt (%) (n)**	**Cow ICP/ ICP Nguni std (%) (n)**	**Kg calf Wnd/ Cow LSU (kg) (n)**
Central Bushveld	39.7 ±6.73[c] (43210	99.9 ±11.89[b] (4197)	117.7 ±22.14[b] (4337)
Eastern Kalahari Bushveld	43.8 ±6.49[a] (2594)	96.1 ±12.08[c] (2588)	129.7 ±20.06[a] (2604)
Lowveld	40.3 ±6.93[c] (1426)	103.5 ±14.62[a] (1322)	104.2 ±22.23[c] (1424)
Sub-Escarpment	41.7 ±6.83[b] (777)	103.2 ±16.72[a] (749)	117.8 ±23.57[b] (775)

Grassland Biome			
Bioregion	**Calf Wwt/ Cow Wng Wt (%) (n)**	**Cow ICP/ ICP Nguni std (%) (n)**	**Kg calf Wnd/ Cow LSU (kg) (n)**
Drakensberg	44.5±6.19[a] (1018)	99.1±12.20[a] (996)	120.2±21.70[a] (1020)
Dry Highveld	42.0±6.98[b] (1103)	103.9±15.14[c] 1063)	118.1±21.50[b] (1103)
Mesic Highveld	41.9±7.36[b] (1650)	103.6 ±16.85[c] (1583)	111.3±24.40[c] 1651)
Sub-Escarpment	39.5±7.08[c] (1849)	100.6±14.34[b] (1745)	117.4±23.13[b] (1774)

Column means with different superscripts differ (P<0.0001)

4.5.7 *Effect of year grouping on cow efficiency*

The analysis revealed that year grouping had significant effects (P<0.0001) on cow efficiency. All year groupings had a calf weaning percentage of more than 40%, and year groupings 4 and 1 had cows with better efficiencies. The best ICP was observed in the same year groupings as the best calf weaning weight percentage, and similarly the best weight of calf produced per LSU was observed in year groupings 4 and 1. The three equations gave consistent results in terms of cow efficiency, where year grouping 4 (2006-2010) had better cow efficiencies as shown in Table 4.10 below.

Table 4.10: Effects of year grouping on three measures of cow efficiency (mean ± SD)

Year Groupings	Calf Wwt/ Cow Wng Wt (%) (n)	Cow ICP/ ICP Nguni std (%) (n)	Kg calf/ Cow LSU (kg) (n)
Year grouping 1	42.6 ±7.16[a] (3626)	102.7 ±12.57[a] (3396)	116.6 ±24.08[a] (3618)
Year grouping 2	41.5 ±6.72[a] (2927)	103.3 ±13.33[a] (2850)	116.4 ±24.08[a] (2928)
Year grouping 3	40.4 ±6.99[b] (2846)	101.1 ±14.5[b] (2800)	113.0 ±23.36[b] (2859)
Year grouping 4	42.1 ±6.88[a] (5339)	97.8 ±14.48[c] (5197)	122.2 ±22.05[c] (5283)

Column means with different superscripts differ (P<0.0001)

4.5.8 *Effect of biome and seasons interaction on two measures of cow efficiency*

The analysis revealed that biome and season interactions had significant effects (P<0.0001) on cow efficiency. Biome and season interactions were not significant for cow efficiency as measured by ICP for both biomes. In the Savannah Biome, cow efficiency levels were good in three seasons, and only autumn had a low cow efficiency. As shown in Table 4.11, in the Grassland Biome, summer and spring had higher cow efficiency as observed in the measurements.

Table 4.11: Effect of biome and seasons interaction on two measures of cow efficiency (mean ± SD)

Savannah Biome		
Season	Calf Wwt (%) (**n**)	Kg calf/LSU (kg) (**n**)
Summer	41.8 ±7.06[b] (4359)	123.1 ±23.24[a] (4345)
Autumn	39.2 ±8.17[c] (285)	107.6 ±27.13[c] (278)
Winter	41.7 ±6.09[b] (708)	114.4 ±21.54[b] (707)
Spring	42.7 ±6.78[a] (3788)	124.3 ±22.61[a] (3788)
Grassland Biome		
Season	Calf Wwt (%) (**n**)	Kg calf/LSU (kg) (**n**)
Summer	43.2 ±7.28[a] (1847)	123.2 ±22.90[a] (1861)
Autumn	41.1 ±7.57[b] (264)	110.8 ±22.55[b] (262)
Winter	41.3 ±8.23[b] (430)	110.3 ±23.21[b] (428)
Spring	42.2 ±6.50[a] (3007)	122.7 ±22.80[a] (3788)

Column means with different superscripts differ (P<0.0001)

4.5.9 *Effect of calf sex on cow efficiency*

Both sexes had a significant effect on cow efficiency, which was in both cases at acceptable levels. Cow productivity was higher for dams that gave birth to male calves, in that more kilograms per calf were weaned in male calves than in female calves. There was also a noticeable difference of 4.3 kg in weaning weight as a percentage of cow weight between male and female calves, as shown in the Table 4.12. There was no difference in the ICP of cows that gave birth to male or female calves.

Table 4.12: Effect of calf sex on three measures of cow efficiency (mean ± SD)

Calf Sex	Calf Wwt (%) (n)	ICP/ICP Nguni std (%) (n)	Kg calf/LSU (kg) (n)
Female	39.1±6.54[b] (7385)	101.1±13.87[a] (7125)	111.8±21.84[b] (7353)
Male	43.4±6.98[a] (7353)	101.1±13.87[a] (7118)	122.3±23.73[a] (7335)

Columns means with different superscripts differ significantly at P<0.0001

4.5.10 *Effect of biome and year grouping interaction on two measures of cow efficiency*

Analysis showed that this interaction had a significant effect (P<0.0001) on cow efficiency. Both the Savannah and Grassland Biomes had acceptable cow efficiency levels as calculated using the different formulas. In the Savannah Biome, the different year groupings did not differ significantly from each other, but year grouping 4 did however show a better calf weaning weight percentage. Similarly, year grouping 4 had the highest kilogram calf weaned per LSU. In the Grassland Biome as shown in Table 4.13, cow efficiency differed significantly for all year groupings. The best calf weaning weight percentage was observed in year groupings 1 and 4. Similarly, in year groupings 1 and 4 more kilograms calf weaned per LSU were produced.

Table 4.13: Effect of biome and year grouping interaction on two measures of cow efficiency (mean ± SD)

Savannah Biome		
Year Groupings	**Calf Wwt % (n)**	**Kg calf/LSU (n)**
Year grouping 1	41.2 ±7.22[b] (2794)	114.7 ±23.84[c] (2796)
Year grouping 2	41.9 ±6.89[a] (1884)	117.7 ±23.37[b] (1884)
Year grouping 3	40.3 ±6.45[c] (1517)	114.1 ±23.34[c] (1521)
Year grouping 4	42.0 ±6.78[a] (2923)	123.0 ±21.72[a] (2939)
Grassland Biome	**Calf Wwt % (n)**	**Kg calf/LSU (n)**
Year grouping 1	44.0 ±6.47[a] (832)	118.5 ±24.72[b] (822)
Year grouping 2	41.1 ±6.36[c] (1043)	115.2 ±24.89[b] (1044)
Year grouping 3	40.6 ±7.53[c] (1329)	112.0 ±22.54[c] (1338)
Year grouping 4	42.2 ±7.00[b] (2416)	121.3 ±22.07[a] (2344)

Column means with different superscripts differ (P<0.0001)

4.6 **Conclusions**

Cow productivity and reproduction are the key aspects of any beef enterprise (Schoeman, 1996). The ratio of calf weaning weight to cow weight at weaning has been used widely by researchers to measure cow efficiency. Using the calf weaning weight to evaluate the efficiency or cow productivity is one of the methods to determine cow efficiency. According to Dinkel & Brown (1978), this method might not the best one to determine cow efficiency as it tends to favour the small framed breeds or cows, and this is why three different equations were used to compare the results in the current study. In two of the three equations, calf-weaning weight adjusted for 205 days was used as explained in chapter 3, while one equation used cow ICP. There was a clear trend in the results. In using all three equations, results showed that cow efficiency was greater in the Savannah Biome compared to the Grassland Biome. It was further apparent that cow efficiency was best in the Eastern Kalahari Bushveld bioregion of the Savannah Biome, while in the Grassland Biome the best cow efficiency was observed in the Drakensberg bioregion.

Between the seasons, cow efficiency was significantly better in summer and spring in both biomes. Year grouping 1 (1990-1996) and year grouping 4 (2006-2010) had the best cow efficiency, and this can be explained by the rainfall patterns experienced in both biomes during the period of study. Cows that gave birth to male calves were more efficient and produced more kilogram calf per large stock unit. This shows that all three evaluation methods arrived at the same answer. The improved cow weights could be attributed to sufficient feed in the particular season. In terms of records of cows at weaning, cow numbers dropped drastically after the age of 120 months. This made it difficult to observe and draw conclusions about cow efficiency even though there were clear trends for each parameter. When cows exceed 120 months of age or 10 years, numbers in production are reduced and any conclusion would be difficult to make. This was also observed by Maciel, *et al*. (2016), in a study conducted to observe performance of different Nguni ecotypes. In this chapter, the main factors analysed, showed that spring and summer are good seasons in which the farmer can achieve higher and more efficient cow production. This also emphasizes the importance of seasonal breeding for efficient cow production and reproduction. The results imply that practicing seasonal breeding should produce good economic returns, especially considering the savings on feed.

Chapter 5

EFFECTS OF NON-GENETIC FACTORS ON THE INTER-CALVING PERIOD OF NGUNI COWS IN SOUTH AFRICA

5.1 Introduction

Reproductive efficiency of cows is a key factor to improve profits in a beef herd (Ladermann & Schoeman, 1994). One of the factors that is related to cow productivity is inter- calving period (ICP), which is defined as the time period from one calving to the next. It has been described as a measure that involves three phases, namely the gestation period, postpartum anoestrus and the subsequent breeding period. Of the three phases, it is only the postpartum period (from the last calving to the next oestrus) that can be improved through management. According to Mukasa-Mugerwa (1989), the postpartum period, which is instrumental in the re-establishment of the ovarian activity and preparation of the cow for re-conception, can be shortened by good nutrition. The postpartum period is the most critical of the three phases to ensure that ICP is within the target of less than 400 days on average for the herd if a cow is to calve every year. It is therefore recommended that the postpartum period should not exceed 80-85 days. ICP is a major factor in the determination of the reproductive efficiency of a cow and it is affected among others by the level of available nutrition and management (Mukasa-Mugerwa, 1989). Meaker *et al*. (1980) observed that the target weight also influences re-conception in cows. An increase in body weight of cows above the target weight results in infertility due to excessive fat deposition. Meaker *et. al*. (1980) further explains that if the body weight of cows decreases to below the target weight, the outcome could be reduced reproductive ability. Furthermore, the cow weight at the beginning and end of the mating season was noted to also have an influence on the conception rate (Meaker *et. al.*, 1980).

Experience in practical situations as well as research have confirmed that the productivity of an animal depends on its ability to maintain physiological activities at levels that allow it to grow and reproduce in a particular environment (Webb *et al*., 2017; Maree & Casey, 1993; Gregory, 1972; Van der Westhuizen, 1973). This is described as adaptability, and may develop as a result of selection. Different cattle breeds differ in the way in which they are able to withstand and react to climatic stress, diseases and low feed levels.

Factors such as rainfall, temperature and soil type influence the type of vegetation in each region, and these determine the resultant vegetation of an area (Acocks, 1988, Low & Rebelo, 1996). It is expected that an animal will perform well in an environment to which it is adapted (Bonsma, 1983). The Nguni breed is one of the breeds which are perceived to be adapted to harsh climatic conditions, such as high temperatures, resulting in poor feed quality, and the occurrence of ticks and tick-borne diseases (Schoeman, 1989, Collins-Lusweti, 2000a, Muchenje *et al*., 2007). Although Nguni cattle are adaptable to harsh environments, their production and reproduction will not be efficient where there is scarcity of food. This was shown by the study of Collins-Luswetti (2000b), in which performance of Nguni, Afrikaner and Bonsmara cattle was tested under drought conditions in the North West Province of Southern Africa. The three breeds performed well under the conditions, with the Afrikaner performing better than the Nguni and Bonsmara in body weights and calving intervals. According to Collins-Luswetti (2000b), improving the genetic make-up can improve the performance of these breeds.

It can be assumed that the Nguni breed will perform better than other breeds in most geographic areas as defined by these climatic conditions. This was demonstrated in studies by many researchers. Among these are the study conducted by Schoeman (1989), where he investigated the production performance of the different indigenous breeds. Breeds compared include Nguni (Sanga ecotype), Afrikaner, Hereford, Santa Gertrudis and Simmentaler. The outcomes of the study showed high calving and re-calving percentages of first calf heifers and heifers respectively of the Nguni breed compared to the four breeds. Schoeman (1989) further reported low ICP in Nguni cattle breed when compared to Afrikaner, Hereford, Bonsmara, Santa Gertrudis and Simmentaler

The Savannah Biome is mostly used for grazing of livestock and/or wildlife, because of its good grass cover together with shrubs and trees (Low & Rebelo, 1996).

The Grassland Biome is generally characterized by large areas dominated by grasses and less trees which makes it particularly suitable for cattle farming. The difference between the two biomes is largely the result of climatic differences defined by the rainfall and temperatures. These influence the types of grasses that grow in the different areas, and the quality of grazing at different times of the year. Although calf sex and culling rate were recorded in this study, these parameters were not discussed in detail due to insignificant effects. The purpose of this study was to address the question of whether non-genetic factors such as vegetation type and availability of feed sources have any effect on the reproduction of Nguni cattle, in particular on ICP.

5.2 Materials and Methods

Data were obtained from the Integrated Registration and Genetic Information Systems (INTERGIS) of the Agricultural Research Council (ARC) of Republic of South Africa and involved 26681 Nguni cows. These data were earlier collected from 427 Nguni breeders in the Savannah and the Grassland Biomes of South Africa. Nguni breeders from the Savannah Biome constituted 57% of the data, while 28.8% of the Nguni breeders were located in the Grassland Biome. Both biomes are in the summer rainfall areas of South Africa.

Within the two biomes, eight bioregions were identified, four in each biome. Bioregions in the Savannah Biome were identified as Central Bushveld, Eastern Kalahari Bushveld, Lowveld and Sub-Escarpment Savannah. In the Grassland Biome, the four bioregions were, Drakensberg, Dry Highveld bioregion, Mesic Highveld and the Sub-Escarpment grassland. Data collected over a period of 20 years (1990-2010), were categorized into 5- year groupings (1990-1995, 1996-2000, 2001-2005 and 2006-2010). The years were divided into calving seasons, namely Summer (November, December, January); Autumn (February, March, April), Winter (May, June, July) and Spring (August, September, October).

Data that were identified as outliers and could not be used for analysis were removed before performing analysis. This included breeders with less than 50 cows and breeders which could not be allocated into specific biomes. Cows that were older than 39 months at first calving were excluded in the analysis. Cows with an ICP less than 315 and above 730 days were also removed from the dataset before analysis, while the breed average ICP of 409 days was used to compare the efficiency of Nguni cows in the study. These limits are in line with the Nguni breed standards and will ensure the study can be translated into practical and realistic production practices for the Nguni breeders country-wide. A small proportion (1.86%) of records had ICP values less than 315 days, while 2.04% had ICP values greater than 730 days, all these records were removed before analysis because they did not comply with the Nguni breed standards. Data were analyzed statistically using the General Linear Method (GLM) of SAS (2017), version 9.3 to establish the impact of non-genetic effects on ICP as a measure of reproduction efficiency for all cows in the herd. The main factors considered in the analysis were biomes, bioregions, seasons and year groupings. Dam age in months was included as a covariant.

5.3 Results and Discussions

All the main factors considered in the analysis showed interesting trends, the details of which will be discussed below. As in the other analysis, years were categorized into 4 year groupings. Data were analyzed to see the effect of non-genetic factors on ICP for the total cow herd. The main factors included were biomes and the applicable bioregions, seasons and year groupings. Initially calf sex was included in the analysis; however, this proved to be inapplicable and it was removed from the equation.

5.3.1 *Dam age*

Dam age was analyzed as a covariant, and it showed significant ($P<0.0001$) effects. The inter-calving period (ICP) increased slightly up to 48 months of age, probably because first cows tend to have a longer ICP, after which a decline was noticed up to 108 months of age. Mukasa-Mugerwa (1989) noted that if the cow is not in the correct body condition, it will not conceive. As can be seen in Figure 5.1, the decrease in number of productive cows after the age of 108 months made conclusions unreliable. The observation is that a longer ICP plays a role in reducing the number of cows in production, since such cows will eventually be culled from the herd.

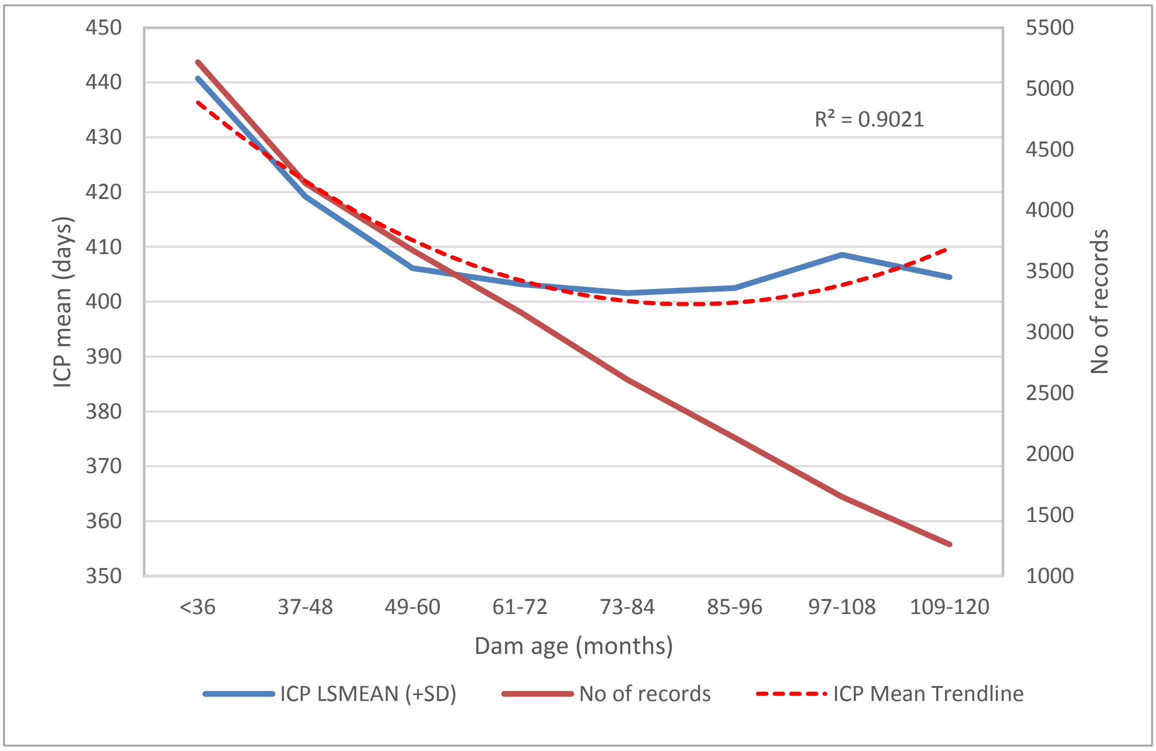

Figure 5.1: Effect of dam age on ICP

5.3.2 *Effect of biome on ICP*

The different biomes had a significant effect (P<0.0001) on the mean ICP of the total cowherd. Cows in the Savannah Biome had significantly shorter mean ICP compared to those in the Grassland Biome (Table 5.1). The Savannah Biome has more grasses and shrubs (Low & Rebelo, 1996) compared to the Grassland biome. The types of grasses that occur in any biome are dictated by the climate, types of soil and grazing of the biome, however the management of the grasses can alter the type of grasses in a biome.

According to Tainton (1999), palatability and quality of grasses are good with the spring re-growth, after which the grass matures resulting in reduced quality and palatability which affects cattle performance. Tainton, (1999) further explains that frequency of fire and overgrazing of grasses may change the grass communities. Overgrazing generally result in the emergence of unpalatable and grazing tolerant species which in sour grassveld areas is an irreversible action. In this study, it is believed that the quality of grasses in the Savannah Biome resulted in better performance by the cowherd compared to the Grassland Biome. Reducing the post-partum period has been noted as a critical measure (Mukasa-Mugerwa, 1989, Messine *et al*., 2004, Burns, *et al*., 2010) to improve reproduction of a cow as well as its productive life.

According to Messine *et al*. (2004), suckling was noted to have the biggest contribution towards longer ICP's in beef cattle especially in zebu cattle. This is aggravated by the time of day for suckling as it has a huge effect on the resumption of ovarian activity in beef cattle (Escrivao *et al*., 2012). It must be noted that the forage quality and quantity contribute to the necessary nutrition required to ensure that the cows are in good condition at breeding so that conception will be successful earlier post-partum and thus shorten the post-partum period.

Table 5.1: Effect of biome on ICP (mean ± SD)

Biomes	**ICP (days) ±SD**	**n**
Savannah	410.6 ±85.68^{a}	16260
Grassland	417.5 ±92.60^{b}	10421

Columns with different superscripts differ (P<0.0001)

5.3.3 *Effect of season on the ICP*

Calving seasons showed a statistically significant effect on the ICP of Nguni cows. Cows calving in spring and summer had shorter ICP's compared to those calving in autumn and winter, as shown in Table 5.2. Some of the researchers (Bergh, 2004, Grobler *et al*., 2014) who explored seasonal breeding agree that choosing the breeding season carefully, results in improved weaning weights, reduced calf mortalities and also ensures good body condition even at lactation. In fact seasonal breeding is one of the production methods used whereby the ICP can be reduced by ensuring good body condition of the cow after giving birth. Meaker *et al.* (1980) emphasized that nutrition of the cow is key for successful reproduction. According to Meaker *et al.* (1980), nutrition of the cow both pre and post- partum ensures good reproductive performance of beef cows. This, as explained by Meaker *et al.* (1980) is not an increase in the weight of a cow during breeding but it is ensuring that the target body weight is achieved. The correct target body weight which differs according to breed also ensures re-conception pf cows at mating thereby keeping the ICP at an acceptable breed average of 404 days (Scholtz, 2010). The effects of seasons on ICP were demonstrated in the current study with long ICP experienced in cows that calved in autumn and winter.

Table 5.2: Effect of season on ICP (mean ± SD)

Seasons	**ICP (days) ±SD**	**n**
Summer	402.8 ±101.76^{a}	10606
Autumn	430.8 ±98.89^{b}	1782
Winter	423.0 ±79.72^{c}	2519
Spring	399.8a ±73.30^{a}	11774

Column means with different superscripts differ (P<0.0001)

5.3.4 *Effect of bioregion on ICP*

Bioregions had different effects (P<0.0001) on the ICP of Nguni cows within biomes. In the Savannah Biome, the mean ICP was significantly shorter for cows bred in the Eastern Kalahari Bushveld bioregion than for cows bred in the other bioregions in the same biome. In the Grassland Biome, cows bred in the Drakensberg bioregion had significantly shorter mean ICP (Table 5.3) than cows bred in the other bioregions of the Grassland Biome. This shows the effect of these bioregions on productivity of Nguni cattle, despite the renowned adaptability of the breed to harsh conditions. Cows bred in different parts of the Savannah Biome can therefore be expected to differ in their reproductive efficiency as measured by ICP. Similarly, the ICP's of Nguni cows in the different bioregions in the Grassland Biome differed (P<0.0001).

The variation in ICP within bioregions as shown in Table 5.3 has been observed with other breeds. In a study done in Bonsmara breeds, Webb *et al*. (2017), reported ICP median of 407.7 days compared to a breed average of 422.8 days.

Table 5.3: Effect of bioregions on ICP (mean ± SD)

Savannah Biome		
Bioregions	**ICP (days) ±SD**	**n**
Central Bushveld	408.7±85.28[a]	8066
Eastern Kalahari Bushveld	392.5 ±65.77[b]	3181
Lowveld	424.7±100.47[c]	2570
Sub-Escarpment	416.7 ±87.98[d]	2443
Grassland Biome		
Bioregions	**ICP (days) ±SD**	**n**
Drakensberg	403.1 ±63.62[a]	1374
Dry Highveld	410.0 ±83.64[b]	2470
Mesic Highveld	422.8 ±88.75[c]	2714
Sub-Escarpment	434.3 ±106.50[d]	3963

Column means with different superscripts differ (P<0.0001)

5.3.5 *Effect of year grouping on the ICP*

Year groupings of cows also influenced (P<0.0001) the ICP. Cows that calved in year group 2 (1996-2000) and year group 4 (2005 - 2010) had significantly shorter mean ICP (Table 5.4) than cows categorized in the other groups of years. The differences can probably be attributed to different weather conditions experienced in the year groupings as well as the management of the breeders. Year groupings that received more rains would most likely have improved grazing quantity and quality of forage, this together with good management practices will shorten the ICP of cows.

These are explained further in Chapter 7.

Table 5.4: Effect of year grouping on ICP (mean ± SD)

Year Grouping	**ICP (days) ±SD**	**n**
Year grouping 1	420.7 ±98.77[a]	6988
Year grouping 2	410.8 ±86.05[c]	6347
Year grouping 3	415.3 ±85.02[b]	5794
Year grouping 4	409.7 ±82.40[c]	7552

Column means with different superscripts differ (P<0.0001)

5.3.6 *Effect of biome and season interaction on ICP*

The interaction between biome and season of calving influenced (P<0.0001) the ICP of cows. In the Savannah Biome, the mean ICP was significantly shorter for cows calving in summer and spring compared to those calving in autumn and winter. In the Grassland Biome, ICP of cows calving in spring was significantly shorter compared to that of cows calving in the other three seasons. In both biomes, autumn and winter seasons had the longest mean ICP (Table 5.5). Previous research has shown that seasonal effects on productivity of cows can be reduced by applying management practices such as correct stocking rates and providing feed supplementation. According to (Webb *et al*., 2017), the use of summer calving season and early winter weaning results in good weaning weight of calves as well as good body condition of cows after weaning.

Table 5.5: Effect of biome and season interaction on ICP (mean ± SD)

	Savannah Biome		**Grassland Biome**	
Season	**ICP (days) ±SD**	**n**	**ICP (days) ±SD**	**n**
Summer	396.8 ±96.66[b]	7124	408.8 ±110.95[c]	3482
Autumn	421.9±97.68[a]	1094	439.6 ±99.67[a]	688
Winter	424.3 ±81.16[a]	1643	421.7±77.00[b]	876
Spring	399.6 ±68.34[b]	6399	400.0 ±78.63[d]	5375

Column means with different superscripts differ (P<0.0001)

5.3.7 *Effect of biome and year grouping interaction on the ICP*

The interaction between biome and year groupings had an influence (P<0.0001) on the ICP of cows. Cows categorized in year grouping 4 (2006-2010) of the Savannah Biome had a significantly shorter mean ICP than cows categorized in the other three-year groupings (Table 5.6). In the Grassland Biome, cows in year grouping 2 had a shorter mean ICP than those in the other year groupings in the same biome, but the differences were not significant. The effect of year groupings on the ICP of cows can only be explained by differences in prevailing climatic conditions in the particular years, which includes rainfall and temperatures. However, information about temperature patterns for the 20 year period could not be verified in this study.

Table 5.6: Effect of biome and year grouping interaction on ICP (mean ± SD)

	Savannah Biome		Grassland Biome	
Year Grouping	ICP (days) ±SD	n	ICP (days) ±SD	n
Year grouping 1	415.4 ±96.81[a]	4945	426.0 ±102.32[a]	2043
Year grouping 2	412.0 ±82.60[a]	4147	409.5 ±92.14[c]	2200
Year grouping 3	412.6 ±78.55[a]	3011	417.9 ±91.27[b]	2783
Year grouping 4	402.6 ±78.56[b]	4157	416.8 ±86.53[b]	3395

Column means with different superscripts differ (P<0.0001)

Analysis to determine the effect of season of calving on ICP, indicates that cows bred in summer and spring had significantly shorter ICP expressed as a mean for all the cows. These two seasons both fall into the rainfall season where there is re-growth of grass. Due to improved quality and quantity of grass, improved performance of cattle is obtained. According to Bergh (2004), breeding in autumn and winter results in expensive production since the breeder has to use supplements to ensure growth of the calf and maintain good body condition of the cow. Breeding outside summer and spring can easily result in long ICP due to the nutritional impact on the cow.

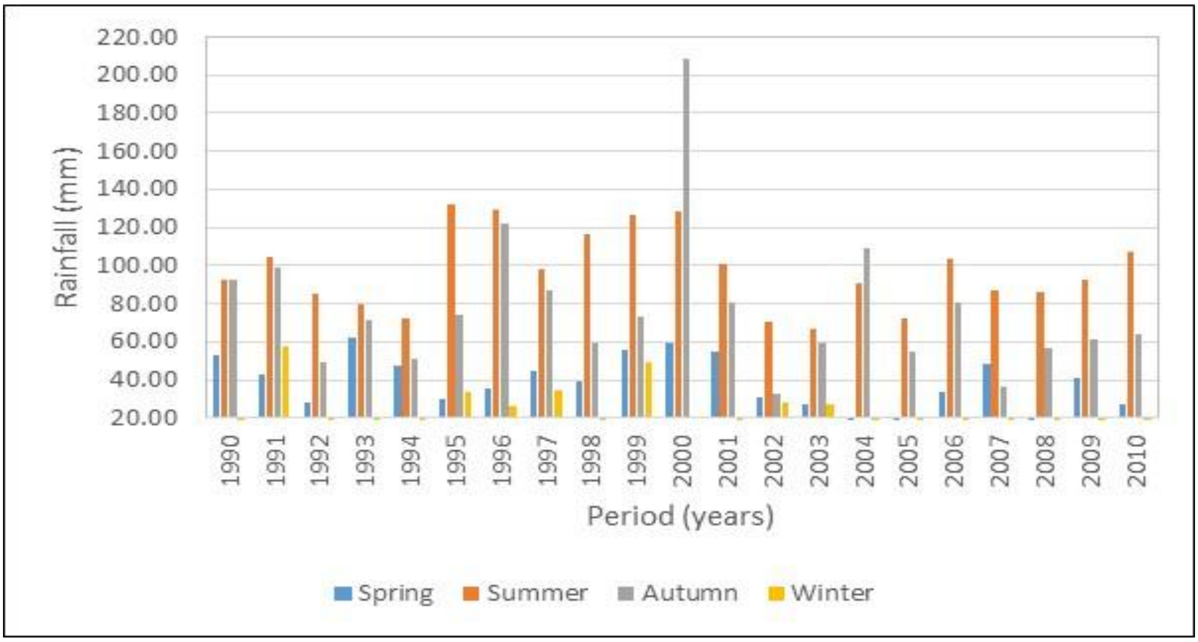

Figure 5.2 Seasonal rainfall in the Savannah Biome 1990-2010 (ARC Weather Data)

Figure 5.2 shows the rainfall received in the Savannah Biome, while Figure 3 below shows the rainfall pattern in the Grassland Biome for the period 1990-210.

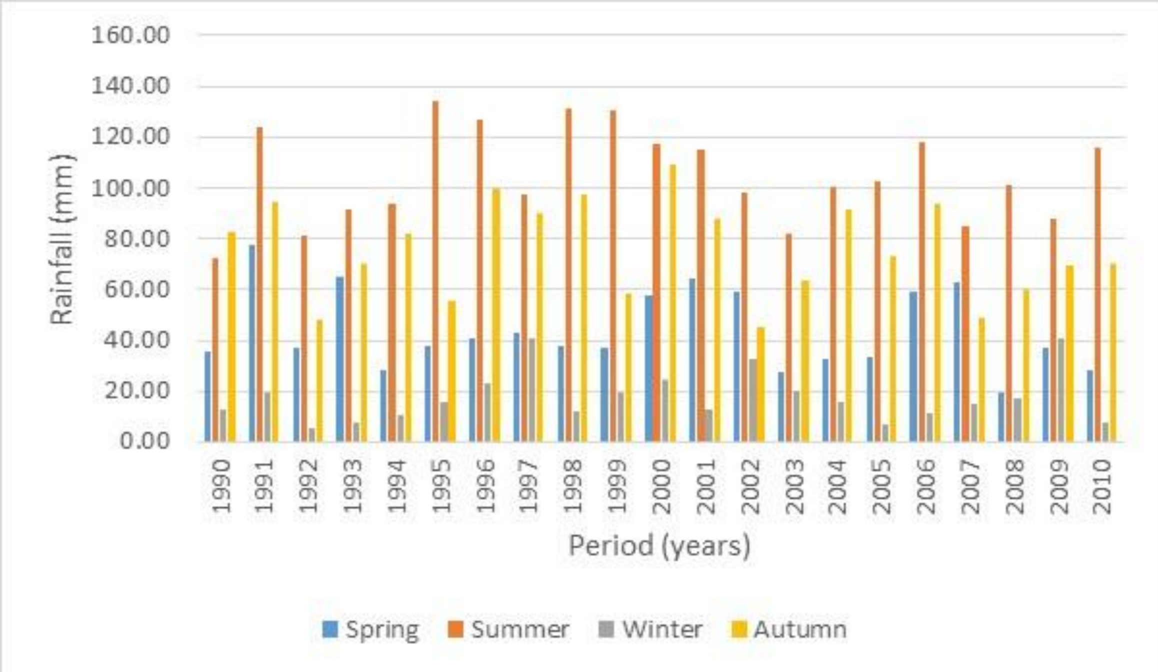

Figure 5.3 Seasonal rainfall in the Grassland Biome 1990-2010 (ARC Weather data)

From Figures 5.2 and 5.3 it is clear that both Savannah and Grassland Biomes had more rains in spring and summer yielding more forage. This may explain the improved cow performance in the two seasons compared to that of cows bred in autumn and winter. In the Grassland Biome, more rains were experienced in autumn compared to the Savannah Biome. Such rains will not contribute much to the quality and quantity of forage as the temperatures are too low to promote any quality re-growth. Where there is high rainfall on acidic soils, the outcome is sour grasses which are not palatable (Low & Rebelo, 1996). Unless there is supplementation, this can affect the reproduction ability of cows as they will not be able to achieve the target weight, especially during the breeding season. It is evident from the performance of the cows kept in the two biomes that the Nguni breed does not need much interference nutritionally from the environment due to their adaptation. It appears that improving the nutrition of the cows through management (e.g. better pasture management or feed supplementation) may reduce the effects of winter, and can give good results in terms of production and reproduction of the cows. The present study suggests that feed supplementation is not vital for Nguni cattle if enough forage is available, but it may improve cow production marginally.

It should be noted that in the present study, ICP data that fell outside the limits of the Nguni Cattle Breeders Society standards were discarded, which implies that cows with a long ICP should be culled. However, the decision to retain or cull cows differs between breeders and may explain some of the differences in cow performance observed. One of the practical implications of this is that breeders who cull less productive cows will be left with a smaller number of cows at each given breeding season, which may limit the availability of replacement cows. This supports the recommendation by (Donkin, 1973) that ICP alone cannot be used as measure of reproduction efficiency in beef cattle simply because it is easy to measure. It is believed that if breeders can manage the condition of cows to ensure good body condition especially at mating, less cows would be unproductive and therefore less cows would be culled.

5.4 Conclusions

The results of this study indicate that dam age significantly influenced the ICP of Nguni cows. Inter-calving period increased slightly up to 48 months of age, then declined up to the age of 108 months. The decline of ICP is good for production and reproduction of the cow, it is probably due to environmental factors such as the availability and quality of feed and to some extent the management of breeders.

The bioregions significantly affected the ICP of cows, due to the differences in nutritional value of vegetation in different biomes. Seasonal differences in ICP were also observed, due to the availability of nutritious herbage and the weather conditions such as humidity, wind speed and cold weather. The average ICP of Nguni cattle is 404 days (Scholtz, 2010), while the average ICP of cows in this study was 405 days. It follows that in both the Savannah and the Grassland Biomes, the Nguni cows are able to perform as well as is expected of an adapted animal. Cows kept in the Eastern Kalahari Bushveld of the Savannah Biome performed better than cows in the other bioregions of the same biome.

Chapter 6

THE EFFECT OF ENVIRONMENTAL FACTORS ON PRE- AND POST WEANING GROWTH OF NGUNI CALVES

6.1 Introduction

Growth and performance of an animal are influenced by the genetic make-up of the animal and the environment in which it performs (Nowers, *et al.,* 2013, Meulenbeld, 2013). Birth and weaning weight are often an indication of an animal's potential to perform in any environment; this is because these two traits are directly related to the animal's genetic make-up (Van Niekerk *et al.,* 2004a). Hence, the two traits are often used to select for growth potential of an animal. Once these two traits are known, performance and breeding capabilities of an animal are influenced by adaptability to the environment.

The Nguni breed is known for being productive despite difficult environmental conditions because of its hardiness and adaptability to harsh conditions. However, as with other breeds, its performance is still likely to be affected by the environment in which it produces. The extent of the effect needs to be established and taken into account when business plans are drawn up. In this case, environmental factors, better described as non-genetic factors, including vegetation, season and year are the critical factors to be considered.

6.2 Materials and Methods

Data for 85606 calves were analyzed statistically to determine the effects of non-genetic factors on growth of calves. Attention was given to growth parameters such as birth, weaning, 12- and 18-month weights of calves. For all growth measurements of calves, effects of non-genetic factors, which were included in the analysis were biome, bioregion, season, year grouping and calf sex. Dam age was analyzed for as a covariant. The analysis results are reported below.

6.3 Results and Discussions

6.3.1 *Dam age*

6.3.1.1 *Effect of dam age on calf birth weight*

It was found that as a covariant, dam age had a significant ($P<0.0001$) effect on the birth weight of the calf. Figure 6.1 shows that birth weight of calves increased slowly until the dam reached the age of 70 months, after which birth weights showed a plateau. The implication is that as dams became older they were more likely to have higher birth weights in their calves; however as the condition of the cow deteriorated due to age, management and environmental issues, calf weights remained at the same level..

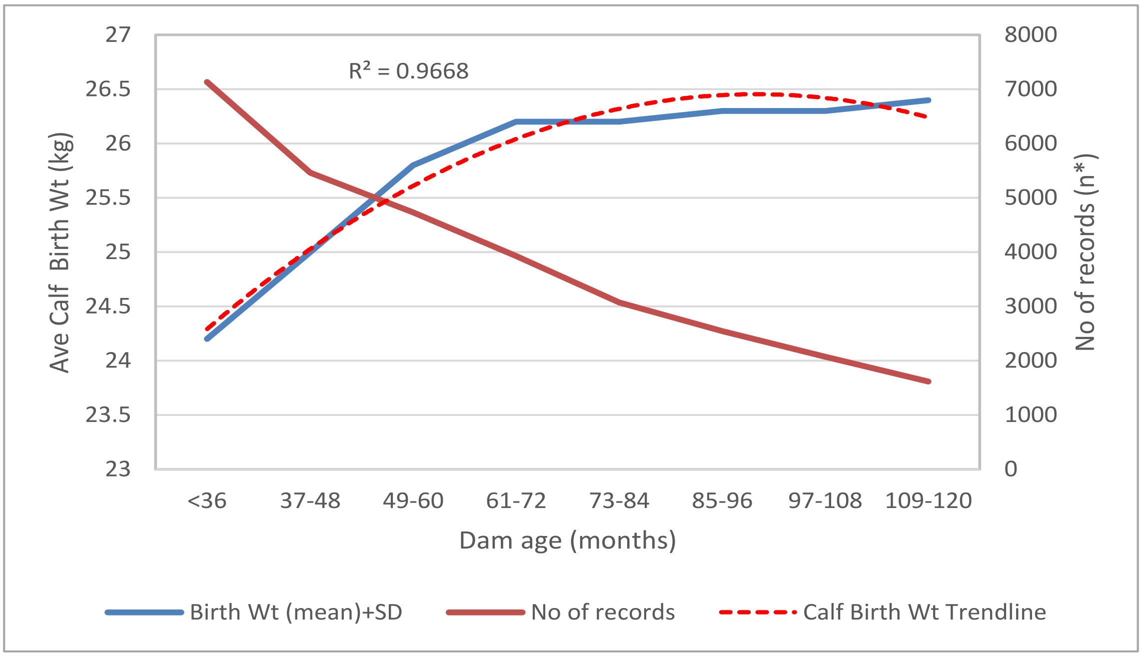

Figure 6.1: Effect of dam age on calf birth weight

When the number of available records was added as a factor to observe the effect of the dam's age, it was clear that with increase in dam age there was a decrease in the number of productive dams. Records as well as calf birth weight declined making it less easy to discern the trends. Nevertheless, with the fewer numbers of cows, birth weights fluctuated but seemed to be lower. This could be explained by the condition of the dam at the productive stage, as with loss of teeth, dams are likely to have reduced intake and this would affect the body condition. In the last trimester, foetal growth of about 70% needs to be achieved, hence there is a great increase at that time in the nutritional requirements of a pregnant cow (Mukasa-Mugerwa, 1989). Proper feeding of a pregnant cow at this time does not only increase the likelihood of timely re-conception of the cow, but also ensures a healthy calf and a good weaning weight through good milk production.

6.3.1.2 *Effect of dam age on calf weaning weight*

Many researchers have shown that weaning weight of a calf (Dinkel *et al.*, 1990) can be used to determine the productivity of a cow. Weaning weight is influenced by the genotype of the parents and the environment in which the dam produces. (Johnson *et al.,* 2007). In the current study, statistical analysis revealed that as a covariant, dam age had significant effects

(P<0.0001) on calf weaning weight. The analysis showed that the weaning weight increased with increase in dam age until 96 months, where-after it started to decline. Similar results were obtained by Paterson *et al.* (1980), where five dam breed types were managed under an intensive production system. As observed with birth weight, the number of available records became less with increase in dam age. However, the trend showing the effect of dam age on weaning weight was quite consistent. As observed with calf birth weight, a sharp decline in the number of available records was apparent after 120 months.

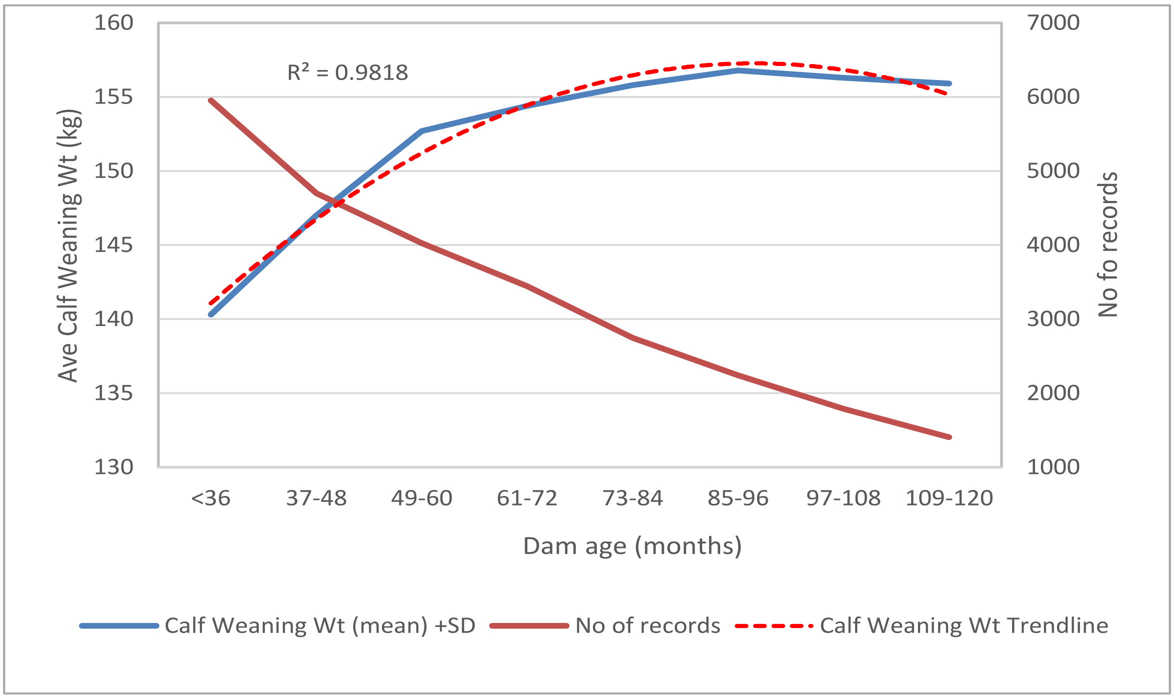

Figure 6.2: Effect of dam age on calf weaning weight

6.3.1.3 *Effect of dam age on 12-month calf weight*

Analysis for effect of dam age as a covariant revealed significant effects (P<0.0001) on 12-month weight. Weights at 12-months fluctuated between the dam ages, but the trend showed an increase in the 12-month weight with increase in dam age. The weight at 12 months is greatly dependent on the available forage and supplementation, if there is. The influence of the dam is only of genetic nature to the calf (and the milk supply before weaning). Figure 6.3 demonstrates the relationship between the age of dam and 12-month weight.

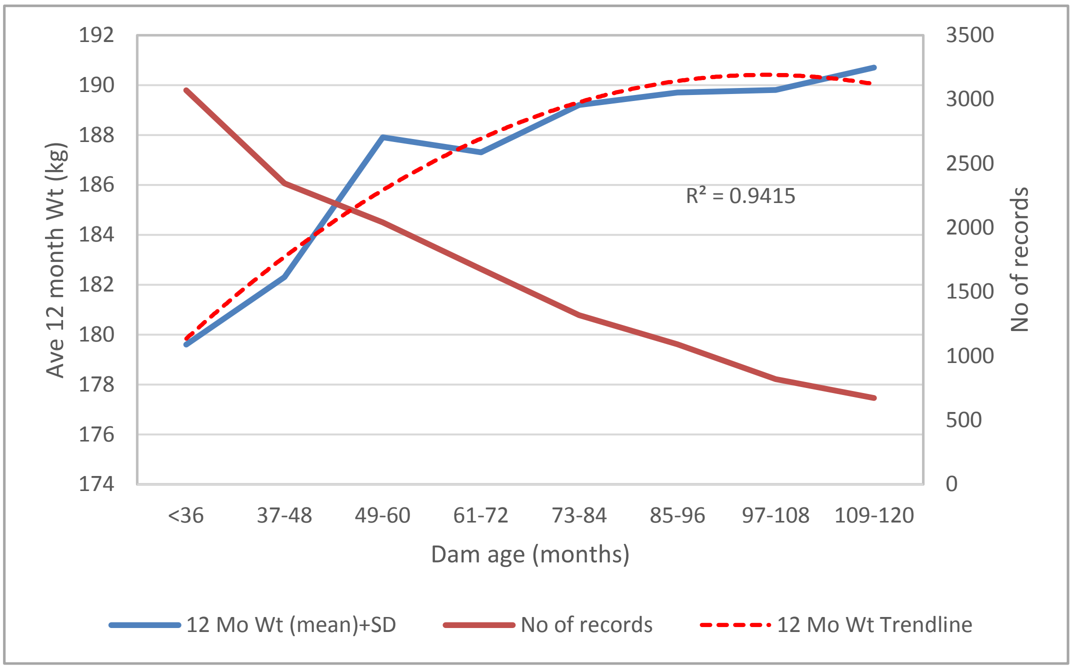

Figure 6.3: Effect of dam age on 12-month calf weight

6.3.1.4 *Effect of dam age on 18-month calf weight*

To complete the analysis on growth measurements of the calves, statistical analysis was carried out to evaluate the 18-month performance of the calves. Analysis of dam age as a covariant revealed significant effects (P<0.0001) on the 18-month weight of the calves. The calf 18-month weight also increased with the increase in dam age up to about 60 months, after-which it fluctuated with no particular trend .(Figure 6.4). As with the 12-month weight, 18-month weight is mainly a product of the genetic make-up of the animal and the environment. Weight gain is dependent on the nutritional status and management system of the farmer. Calf weight at 18-months is a product of selection for mature weight of the dam.

When available records were included in the analysis, a steep decline was observed as seen with the calf weights described above.

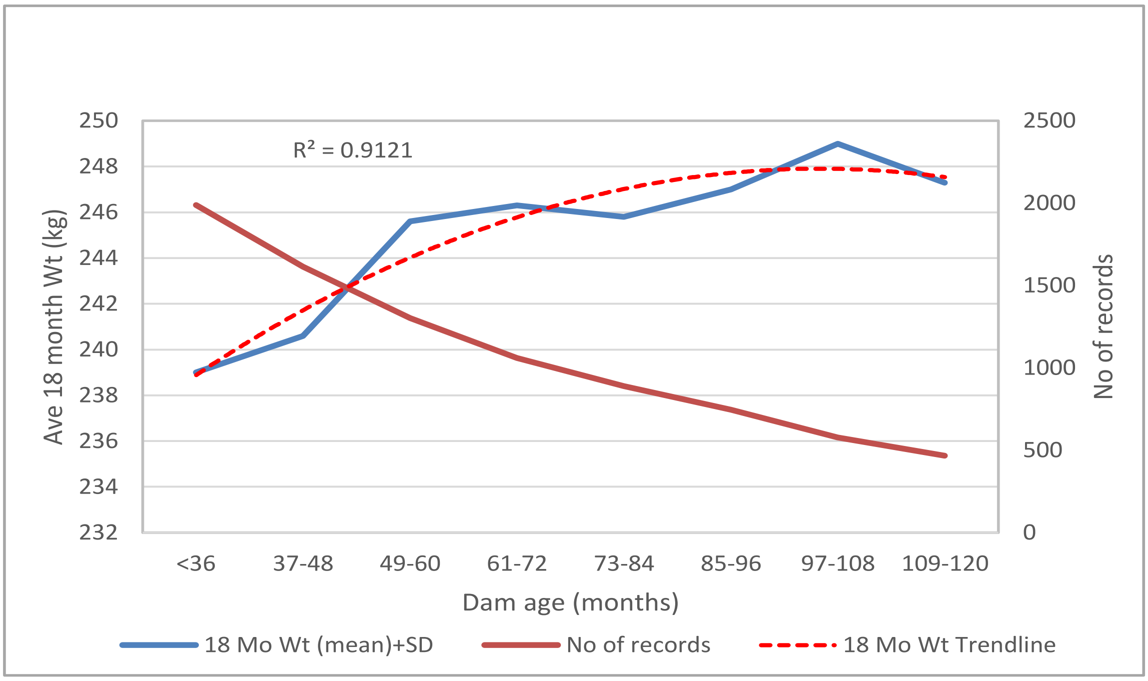

Figure 6.4: Effect of dam age on 18-month calf weight

6.3.1.5 *Effect of biomes on pre- and post-weaning growth of calves*

On analysis, the results indicated a significant effect (P<0.0001) of the two biomes on calf growth before and after weaning. In the Savannah Biome, growth measurements at all stages were significantly higher than in the Grassland Biome (Table 6.1). In the Savanna Biome, calves gained 126.6 kg from birth to weaning, while in the Grassland Biome the weight gain for this period was only 123. 6 kg. There was a similar trend in the Savannah Biome for calf weight gain from weaning to 12-months which was 38.1 kg compared to 31.9 kg in the Grassland Biome for the same period. From 12-months to 18-months calves in the Savannah Biome achieved a higher weight gain of 2.8 kg compared to that of calves in the Grassland Biome. This can be attributed to the natural factors making up a biome, as described in the literature. Calves in both biomes started with very similar birth weights and weaning weights. These were a reflection of the dam's genetic make-up and her milk production. However, as the growth of calves became more and more dependent upon the quantity and quality of nutrition, as well as the management of the farmer, the weights of calves in the two biomes started to differ significantly, as shown in Table 6.1.

Table 6.1: Effect of biome on pre- and post-weaning growth of calves (mean ± SD)

Biome	**Birth Wt (n)**	**Weaning Wt (n)**	**12-month Wt (n)**	**18-month Wt (n)**
Savannah Biome	25.7kg ±3.97[a] (20339)	152.3kg ±26.62[a] (17746)	190.4kg ±33.97[a] (8247)	249.8kg ±40.31[a] (5089)
Grassland Biome	25.1kg ±3.84[a] (13477)	148.7kg ±26.64[b] (12137)	180.6kg ±32.15[b] (6492)	237.2kg ±42.09[b] (4721)

Column means with different superscripts differ (P<0.0001)

6.3.1.6 *Effect of calf sex on pre- and post-weaning growth of calves*

Results of the analysis showed that calf sex had a significant effect (P<0.0001) on the pre- and post-weaning growth of calves. Male calves were significantly heavier than female calves at all growth stages measured. Table 6.2 shows that as the calves grew, the weight difference between the two sexes became wider. At birth, male calves were 1.1 kg heavier than female calves. As the calves grew, the gap between the two sexes widened with males being 10.2 kg heavier than female calves at weaning. At 12- and 18-months of age, male calves were heavier than female calves by 18.8 kg and 30.2 kg respectively. Male calves gained more than female calves at all stages, from birth to weaning, to 12-months and to 18-months by 9.1 kg, 8.6 kg and 11.9 kg respectively.

Table 6.2: Effect of calf sex calf on pre- and post-weaning growth of calves (mean ± SD)

Calf Sex	**Birth Wt (n)**	**Weaning Wt (n)**	**12-months Wt (n)**	**18-month Wt (n)**
Female	24.9kg ±3.81[b] (17181)	145.4kg ±24.72[b] (15182)	176.1kg ±30.42[b] (9391)	228.2kg ±36.40[b] (6780)
Male	26.0kg ±3.94[a] (16635)	155.6kg ±27.29[a] (14701)	194.9kg ±35.72[a] (5348)	258.9kg ±45.94[a] (3030)

Column means with different superscripts differ (P<0.0001)

6.3.1.7 *Effect of biomes on pre- and post-weaning growth of calves*

As each biome had four bioregions, it was necessary to establish the effect of the bioregions within each biome on the birth weight of the calf.

Statistical analysis revealed that the bioregions had significant (P<0.0001) effects on the pre- and post-weaning growth of calves. Within the Savannah Biome, birth weights did not differ much between the four bioregions even though the number of observations varied widely

(Table 6.3). Effects of the environment became more significant as calf growth progressed. This is explained by the fact that the birth weight is largely a function of the genetic make-up of the dam; the phenotypic influence is much less. Post weaning, calf growth is indicative of the quality and quantity of the available nutrition. Hence, calves that had high birth weights were not necessarily the heaviest at 18-months.

Table 6.3: Effect of bioregion on pre- and post-weaning growth of calves (mean ± SD)

Savannah Biome				
Bioregion	**Birth Wt (n)**	**Weaning Wt (n)**	**12-month Wt (n)**	**18-month Wt (n)**
Central Bushveld	25.1kg ±3.96[b] (10665)	148.8kg ±25.85[b] (9158)	186.6kg ±32.21[b] (4692)	242.9kg ±39.25[c] (2813)
Eastern Kalahari Bushveld	25.8kg ±3.91[b] (1949)	159.4kg ±24.78[a] (3643)	189.1kg ±30.91[b] (579)	255.8kg ±39.88[b] (335)
Lowveld	26.2kg ±3.95[a] (4008)	147.3kg ±25.16[b] (2783)	182.0kg ±33.33[b] (1991)	236.5kg ±39.58[c] (1231)
Sub-Escarpment	25.9kg ±3.87[b] (3717)	153.7kg ±30.98[a] (2162)	203.9kg ±36.45[a] (985)	264.0kg ±39.16[a] (710)
Grassland Biome				
Bioregion	**Birth Wt (n)**	**Weaning Wt (n)**	**12-month Wt (n)**	**18-month Wt (n)**
Drakensberg	25.0kg ±3.87[b] (1187)	159.8kg ±23.05[a] (1884)	193.4kg ±29.07[a] (1020)	261.4kg ±35.17a (941)
Dry Highveld	26.0kg ±3.40[a] (3028)	149.3kg ±25.96[b] (2672)	181.7kg ±30.79[b] (1075)	237.2kg ±39.28[b] (622)
Mesic Highveld	25.1kg ±3.60[b] (3665)	146.5kg ±27.10[b] (3586)	175.5kg ±36.34[c] (1699)	223.7kg ±53.28[c] (1139)
Sub-Escarpment	24.3kg ±4.12[c] (5636)	139.1kg ±27.83[c] (3995)	171.4kg ±30.46[c] (2698)	226.6kg ±36.21[c] (2019)

Column means with different superscripts differ (P<0.0001)

6.3.1.8 *Effect of season on pre- and post-weaning growth of calves*

Analysis of results show that a significant effect (P<0.0001) existed between season and pre- and post-weaning growth of calves. There were no significant differences in birth weights of calves between seasons. Weaning weights differed significantly between the seasons (Table 6.4), with higher weights observed in calves born in spring and summer, while those born in autumn had significantly lower weaning weights compared to all seasons. The weaning weights are a true reflection of the milk production of the cow, which is a product of the quantity and quality of available forage. Weights continued to fluctuate throughout the growth period, with no definite pattern. It was observed that from 12- to 18-months, calves grew differently from the pre-weaning patterns. This might well be expected, as growth at this stage is influenced by the genetic make-up, the nutrition availability and management system of the breeder. The effect of season of the year was demonstrated with calves born in summer and spring. As shown in Table 6.4, these calves had much lower 12-months weights than the calves born in autumn and winter. This is because calves which are born in summer grow up when the quality and quantity of vegetation deteriorates. At 12-months of age, if no supplementation is provided, body weights of calves are indicative of the nutritional status of the veld. However at 18-months of age, calves born in summer and spring had improved substantially in relation to those born in autumn and winter.

Table 6.4: Effect of season on pre- and post-weaning growth of calves (mean ± SD)

Seasons	**Birth Wt (n)**	**Weaning Wt (n)**	**12-month Wt (n)**	**18-month Wt (n)**
Summer	25.7kg ±3.97^{a} (13741)	153.1kg ±26.18^{a} (12238)	177.5kg ±31.49^{b} (6067)	251.1kg ±40.57^{a} (3983)
Autumn	25.7kg ±3.90^{a} (2408)	143.4kg ±27.25^{b} (1550)	195.1kg ±38.26^{a} (810)	230.6kg ±45.11^{b} (529)
Winter	24.9kg ±3.98^{a} (3130)	148.1kg ±26.66^{b} (2752)	189.2kg ±35.13^{a} (1599)	237.2kg ±43.72^{b} (1002)
Spring	25.4kg ±3.86^{a} (14537)	157.3kg ±26.50^{a} (13343)	180.1kg ±33.34^{b} (6263)	255.1kg ±41.10^{a} (4296)

Column means with different superscripts differ ($P<0.0001$)

6.3.1.9 *Effect of year grouping on pre- and post-weaning growth of calves*

The analysis showed that year groupings had significant effects on the growth of calves as observed with growth measurements. Higher growth measurements were observed in year grouping 1 (1990- 1995), from birth to 18-month weights. Calves born in year grouping 1 continued to have higher weights throughout the growth period. Those born in year grouping 3 started with low birth weights; though not significantly lower than the other seasons.

The trend in year grouping 3 continued throughout the growth period. The weather pattern and climatic conditions are thought to be the main reason for the differences in growth trends when year groupings were considered.

Table 6.5: Effect of year grouping on pre- and post-weaning growth of calves (mean ± SD)

Years (groupings)	**Birth Wt (n)**	**Weaning Wt (n)**	**12-month Wt (n)**	**18-month Wt (n)**
Yr grouping 1	26.3kg ±3.89[a] (9197)	155.9kg ±26.89[a] (8791)	196.8kg ±34.10[a] (6241)	255.4kg ±41.96[a] (4009)
Yr grouping 2	25.2kg ±3.88[b] (8437)	151.1kg ±26.34[a] (5921)	184.5kg ±31.95[b] (2789)	241.7kg ±37.78[b] (1923)
Yr grouping 3	25.0kg ±3.97[b] (6464)	144.3kg ±26.50[b] (5574)	172.5kg ±30.88[c] (2510)	233.2kg ±40.61[c] (1826)
Yr grouping 4	25.2kg ±3.91[b] (9718)	150.5kg ±26.64[a] (9597)	186.2kg±33.29[b] (3199)	243.7kg ±43.13[b] (2052)

Column means with different superscripts differ (P<0.0001)

6.3.2 *Effect of non- genetic interactions on calf birth weight*

6.3.2.1 *Effect of biome and calf sex interaction on calf birth weight*

Analysis showed that the biome and calf sex interaction had significant effects (P<0.0001) on pre- and post-weaning growth of calves. The interaction between biome and calf sex did not deviate from the results of these parameters when analyzed individually. Heavier birth weights were observed among calves in the Savannah Biome than in the Grassland Biome, with male calves being heavier than the female calves. In this case, significant differences were influenced by the effect of the individual factors, the biomes and calf sex.

In Table 6.6 analysis results are shown, but the calf weights did not differ significantly when evaluated against the interaction of the biome and calf sex.

Table 6.6: Effect of biome and calf sex interaction on calf birth weight (mean ± SD)

Biome	**Female**	**n**	**Male**	**n**
Savannah	25.1kg ±3.86[a]	10437	26.4kg ±3.94[a]	9902
Grassland	24.6kg ±3.69[b]	6744	25.6kg ±3.89[b]	6733

Column means with different superscripts differ (P<0.0001)

6.3.2.2 *Effect of biome and season interaction on calf birth weight*

Analysis of results confirmed that there were definitely significant (P<0.0001) effects between the biome and season interaction and calf birth weights. Trends between the biomes were consistent, with heavier weights observed in the Savannah Biome. As shown in Table 6.7, calf birth weights varied slightly between the seasons within the biomes. Birth weights were slightly lower in winter in both biomes. In all seasons, there were no significant differences between the birth weights.

Table 6.7: Effect of biome and season interaction on calf birth weight (mean ± SD)

	Savannah Biome		Grassland Biome	
Seasons	**Birth Weight**	**n**	**Birth Weight**	**n**
Summer	26.0kg ±4.03[a]	9446	25.4kg ±3.80[a]	4295
Autumn	25.7kg ±3.91[a]	1571	25.6kg ±3.86[a]	837
Winter	25.5kg ±3.71[b]	1955	24.4kg ±4.33[b]	1175
Spring	25.7kg ±3.95[a]	7367	25.1kg ±3.75[a]	7170

Column means with different superscripts differ (P<0.0001)

6.3.2.3 *Effect of biome and year grouping interaction on birth weight*

Analysis of results showed a significant (P<0.0001) effect of the interaction on birth weights. In the Savannah Biome, birth weights were similar in all year groupings with no significant differences (Table 6.8). However, in the Grassland Biome, calves were significantly heavier in the year grouping 1 (1990-1995). As the calf weights are reflective of the parent's genetic make-up, the heavier calves in the Grassland Biome could be due to better climatic conditions in that year grouping.

Table 6.8: Effect of biome and year grouping interaction on calf birth weight (mean ± SD)

Year Groupings	**Savannah Biome**	**n**	**Grassland Biome**	**n**
Year grouping1	25.9kg ±4.09[a]	6653	26.7kg ±3.30[a]	2544
Year grouping 2	25.5kg ±3.80[a]	5397	25.0kg ±4.00[b]	3040
Year grouping 3	25.8kg ±3.66[a]	3053	24.2kg ±4.19[c]	3411
Year grouping 4	25.9kg ±4.11[a]	5236	24.6kg ±3.67[b]	4462

Column means with different superscripts differ (P<0.0001)

6.3.3 *Effect of non- genetic interactions on calf weaning weight*

6.3.3.1 *Effect of biome and calf sex interaction on calf weaning weight*

Results indicated significant effects (P<0.0001) of the biome and calf sex interaction on the calf weaning weights. Weight differences were noticed within sexes between the two biomes. Female calves were 3.1 kg heavier in the Savannah Biome than in the Grassland Biome, while male calves were 4 kg heavier in Savannah Biome than in the Grassland Biome, as shown in Table 6.9.

Table 6.9: Effect of biome and calf sex interaction on calf weaning weight (mean ± SD)

Biomes	Female	n	Male	n
Savannah	146.9kg ±24.63[a]	9063	157.6kg ±27.16[a]	8683
Grassland	143.8kg ±24.72[b]	6119	153.6kg ±27.29[b]	6018

Column means with different superscripts differ (P<0.0001)

6.3.3.2 *The effect of biome and season interaction on calf weaning weight*

On analysis, the biome and season interaction revealed significant effects (P<0.0001) on calf weaning weight. Overall, calves in the Savannah Biome had significantly higher weaning weights compared to the Grassland Biome. In the Savannah Biome, calf weaning weights were significantly higher in spring and in summer, as shown in Table 6.10. In the Grassland Biome, differences were significant between all the seasons, with higher weaning weights observed in spring and in summer

Table 6.10: Effect of biome and season interaction on calf weaning weight (mean ± SD)

	Savannah Biome		**Grassland Biome**	
Seasons	**Weaning Weight**	**n**	**Weaning**	**n**
Summer	153.8kg ±25.77[b]	8057	152.4kg ±26.89[b]	4181
Autumn	147.0kg ±28.74[c]	904	139.7kg ±24.46[d]	646
Winter	149.1kg ±25.08[c]	1769	147.1kg ±28.72[c]	983
Spring	159.2kg ±26.95[a]	7016	155.5kg ±25.69[a]	6327

Column means with different superscripts differ at P<0.0001

6.3.3.3 *The effect of biome and year grouping interaction on calf weaning weight*

Analysis of results showed significant effects (P<0.0001) of the interaction on calf weaning weight. In the Savannah Biome, weaning weights were significantly higher in year grouping 4 (2006 - 2010). However, in the Grassland Biome, weaning weights were significantly higher in year grouping 1 (1990-1995). As indicated in Table 6.11 significantly low weaning weights were observed in both biomes in year grouping 3 (2001-2005). There was noticeable consistency regarding the weaning weights of the calves in the two biomes, cows in the Savannah Biome consistently produced calves with better weaning weights than those in the Grassland Biome. The weaning weight is indicative of the milk production of the dam, while the quantity of milk is a reflection of the quality and quantity of forage available to the dam.

Table 6.11: Effect of biome and year grouping interaction on calf weaning weight (mean ± SD)

Year Groupings	**Savannah Biome** Calf Wng Wt	**n**	**Grassland Biome** Calf Wng Wt	**n**
Year grouping 1	153.2kg ±26.70[a]	5951	158.6kg ±27.14[a]	2840
Year grouping 2	152.5kg ±26.29[a]	3702	149.7kg ±26.11[b]	2219
Year grouping 3	147.6kg ±25.66[b]	2863	141.0kg ±27.14[c]	2711
Year grouping 4	155.7kg ±26.93[a]	5230	145.3kg ±25.64[b]	4367

Column means with different superscripts differ (P<0.0001)

6.3.4 Effect of non- genetic interactions on 12-month calf weights

6.3.4.1 *Effect of biome and calf sex interaction on 12-month calf weights*

The effect of biome and calf sex interactions on 12-month weights was found to be significant (P<0.0001). In the Savannah Biome, the male calves were 19.8 kg heavier than the female calves, as shown in Table 6.12. Similarly, in the Grassland Biome, male calves were 17.8 kg heavier at 12-months than their female counterparts were. Between biomes, female calves in the Savannah Biome were 8.8 kg heavier than those in the Grassland Biome, while male calves were 10.8 kg heavier than those in the Grassland Biome.

Table 6.12: Effect of biome and calf sex interaction on 12-month calf weights (mean ± SD)

Biomes	**Female** **12-month wts**	**n**	**Male** **12 month wts**	**n**
Savannah	180.5kg ±31.46[a]	5139	200.3kg ±35.15[a]	3108
Grassland	171.7kg ±28.06[b]	4252	189.5kg ±35.78[b]	2240

Column means with different superscripts differ (P<0.0001)

6.3.4.2 *Effect of biome and season interaction on 12-month calf weights*

The analysis showed that biome and season interaction had a significant (P<0.0001) effect on 12-month weights. The difference in the number of observations resulted in reduced significance between autumn and winter. However as shown in Table 6.13, autumn remained the season with the highest 12-month weights in both biomes. Table 6.13, demonstrates the effects of season in the growth of calves between the Savannah and Grassland Biomes, where 12-month weights for calves born in summer and spring are much lower than for those born in autumn and winter.

Table 6.13: Effect of biome and season interaction on 12-month calf weights (mean ± SD)

	Savannah Biome		Grassland Biome	
Seasons	12-month wts	**n**	12-month wts	**n**
Summer	179.9kg ±31.76[c]	4013	175.1kg ±30.54[b]	2054
Autumn	200.8kg ±36.93[a]	433	189.4kg ±38.72[a]	377
Winter	195.9kg ±32.71[b]	1023	182.5kg ±34.17[a]	576
Spring	185.0kg ±34.37[c]	2778	175.3kg ±31.58[b]	3485

Column means with same superscript do not differ (P<0.0001)

6.3.4.3 *Effect of biome and year grouping interaction on 12-month calf weights*

Statistical analysis for the effects of biome and year interactions revealed significant (P<0.0001) effects on the 12-month calf weights. In the Savannah Biome, 12-month weights were significantly higher in year groupings 1 and 4 only (Table 6.14). However, in the Grassland Biome, 12-month weights were significantly higher in year grouping 1. Superior performance has been observed in year groupings 1 and 4, in this area of analysis the trend was consistent. This is thought to be due to favourable weather conditions in the year groupings 1 and 4.

Table 6.14: Effect of biome and year grouping interaction on 12-month calf weights (mean ± SD)

Year grouping	**Savannah Biome**	**n**	**Grassland Biome**	**n**
Year grouping 1	196.8kg ±34.54[a]	4314	196.7kg ±32.94[a]	1927
Year grouping 2	184.8kg ±31.28[b]	1501	188.2kg ±32.74[b]	1288
Year grouping 3	182.6kg ±32.61[b]	1004	162.3kg ±28.50[d]	1506
Year grouping 4	197.4kg ±32.95[a]	1428	174.9kg ±30.58[c]	1771

Column means with different superscripts differ (P<0.0001)

6.3.5 Effect of non- genetic interactions on 18-month calf weights

6.3.5.1 *Effect of biome and calf sex interaction on 18-month calf weights*

Analysis of results revealed significant effects (P<0.0001) on the factors assessed. Table 6.15 shows that while 18-month weights were higher in the Savannah Biome, bull calves continued to be significantly heavier than heifer calves in each biome. The effect of calf sex has been observed in all analysis, with bull calves showing superior performance compared to the heifer calves. At 18-months, bull calves in the Savannah Biome were 18.5 kg heavier than their counterparts in the Grassland Biome, while heifer calves were 6.6 kg heavier than their counterparts in the Grassland Biome.

Table 6.15: Effect of biome and calf sex interaction on 18-month calf weights (mean ± SD)

Biomes	**Female**	**n**	**Male**	**n**
Savannah	231.5kg ±35.59[a]	3407	268.1kg ±43.42[a]	1682
Grassland	224.9kg ±36.19[b]	3373	249.6kg ±48.37[b]	1348

Column means with different superscripts differ at P<0.0001

6.3.5.2 *Effect of biome and season interaction on 18-month calf weights*

Analysis of results showed significant effects (P<0.0001). Significantly higher 18-month weights were observed in spring and summer, although these seasons did not differ significantly from each other. As demonstrated in Table 6.16, autumn and winter, both had significantly low 18-month weights. Observations were similar for both biomes.

Table 6.16: Effect of biome and season interaction on 18-month calf weights (mean ± SD)

	Savannah Biome		**Grassland Biome**	
Seasons	**18 Month Wt**	**n**	**18 Month Wt**	**n**
Summer	260.4kg ±38.90[a]	2425	241.9kg ±41.39[a]	1558
Autumn	238.7kg ±46.88[b]	290	222.6kg ±41.85[b]	239
Winter	237.4kg ±41.37[b]	646	237.0kg ±46.50[c]	356
Spring	262.8kg ±39.49[a]	1728	247.4kg ±41.32[d]	2568

[a,b] Column means with same superscript do not differ (P<0.0001)

[c,d] Column means with the same superscript do not differ (P<0.005)

6.3.5.3 *Effect of biome and year grouping interaction on 18-month calf weights*

Results of the analysis showed significant effects (P<0.0001) of biome and year grouping interaction on the 18-month weights. In the Savannah Biome, significantly higher weights were observed in year grouping 4 (2006-2010). In Table 6.17, it is evident that in the Grassland Biome, year grouping 1 had significantly higher 18-month weights compared to the other year groupings. Year groupings were observed to produce higher weights at 12- and 18-months of age. This trend suggests that good rains and good forage were available in year groupings 1 and 4 resulting in better weights post weaning.

Table 6.17: Effect of biome and year grouping interaction on 18-month calf weights (mean ± SD)

Year Category	Savannah Biome	n	Grassland Biome	n
Year grouping 1	252.7kg ±38.73[a]	2579	258.2kg ±46.07[a]	1430
Year grouping 2	244.3kg ±35.43[b]	847	239.2kg ±39.13[b]	1076
Year grouping 3	244.5kg ±43.08[b]	778	222.0kg ±38.17[d]	1048
Year grouping 4	257.9kg ±43.96[a]	885	229.5kg ±41d.70[c]	1167

Column means with different superscripts differ (P<0.0001)

6.4 Conclusions

In this study, a noticeable trend was observed for superior performance of cattle kept in the Savannah Biome compared to the Grassland Biome. Calf growth at all stages was generally better in summer and spring compared to autumn and winter. Higher calf weights appeared to be achieved in summer and spring but the two seasons did not differ significantly, while calves born in autumn and winter appeared to have lower weights, but they also did not differ significantly. Rainfall in the four seasons was presumed to have played a role in the performance of the calves. The calf growth post weaning is dependent on the quantity and quality of available forage. In Figure 5.2 of chapter 5, it was observed that the Savannah Biome experienced some good rains in year grouping 4 (2006-2010) resulting in good forage. On the other hand it was also seen that the Grassland Biome experienced good rains and good forage in year grouping 1 (1990-1995). These assumptions are made based on the good performance of calves in the year groupings described above.

The effect of season on calf-growth was related to the rainfall in spring and summer, which is supported by the warm weather. According to the rainfall pattern, more rainfall was experienced in autumn of some years compared to spring and summer. However, autumn rains would not make an impact on the vegetation as this is during cold weather and often windy conditions.

The effect of sex on weaning weight was also reported in a study conducted by Dinkel, *et al.* (1990), where the aim was to evaluate the variation in weaning weight and its major components. In their study, Dinkel *et al.* (1990) further noted that not only did sex of calf cause significant differences in weaning weight, but it also affected cow weights at weaning in that cow weaning weights were lower for dams which produced bull calves due to higher energy requirements of bull calves compared to heifer calves. In this study, the growth of bull calves was consistently higher than that of the heifer calves. At the same time at all growth stages, there were fewer male calves than female calves, this trend was more prominent at 12 and 18 months of age. This is explained by the fact that most breeders sell male calves and keep female calves for replacement heifers.

Chapter 7

BREEDER EFFECTS ON THE PRODUCTION AND REPRODUCTION EFFICIENCY OF NGUNI CATTLE

7.1 Introduction

Adaptability of animals to the production environment is very important and the concept has been studied by many researchers (Collins-Lusweti, 2000a, Strydom *et al*., 2001, Webb *et al.,* 2017). The Nguni breed has been found to be one of the most resilient and adaptable breeds to harsh conditions including high temperatures and humidity, low levels of nutrition, ticks and tick-borne diseases, (Collins-Lusweti, 2000a, Muchenje *et al.*, 2007, Kars *et al., 1994*, Schoeman, 1989,). Despite such adverse conditions, Nguni cattle continue to be productive. In this study, herd production records were analyzed to evaluate the effect of environment on the performance of the Nguni cattle.

However a study done by Webb *et al.* (2017) with Bonsmara cattle showed that huge differences in the performance of the cattle are caused by breeder or management effects. This indicated that it was important to find out how the Nguni breed, which is adaptable to harsh environmental conditions and normally not supplemented to reduce the effects of seasons and nutritional availability, will be affected by the breeder or management effects.

7.2 Materials and Methods

Performance data of Nguni cattle farmed at in the Savannah and Grassland Biomes were analyzed using GLM of SAS (2017), version 9.3 to establish the herd effects on the performance of the cattle. The data belonging to the Nguni Cattle Breeders Society had been collected over 20 years and registered at the INTERGIS database. As described in Chapter 3, data were allocated to eight bioregions which had been identified, with four bioregions in each biome. The bioregions within the Savannah Biome were identified as Central Bushveld, Eastern Kalahari Bushveld, Lowveld and Sub-Escarpment Savannah. In the Grassland Biome, the four bioregions were Drakensberg, Dry Highveld bioregion, Mesic Highveld and Sub-Escarpment Grassland. For this assessment, each bioregion was handled separately to see the effects of each breeder in their herds within a bioregion. Breeders were allocated codes randomly for confidentiality. Statistical analysis was carried out using the GLM model of SAS (2017), version 9.3 to evaluate the effects of bioregions on cow weights at weaning, weights of calves at different stages of growth, and ICP of cows at each bioregion. Means and standard deviations were calculated and significance of difference ($P<0.05$) between means was determined by Bonferoni test.

7.3 Results and Discussions

Analysis was performed for data in all eight bioregions. As indicated above, the first four bioregions, the Central Bushveld, Eastern Kalahari Bushveld, Lowveld and Sub-Escarpment bioregions are in the Savannah Biome, while the Drakensberg, Dry Highveld, Mesic Highveld and Sub-Escarpment are in the Grassland Biome. The effect of the main factors on the growth of calves was evaluated, including breeder, season, year grouping and calf sex. Dam age in months was analyzed for as a covariant.

7.3.1 *Dam age*

7.3.1.1 *Effects of dam age on calf weights*

The effect of dam age as a covariant has been reported in the previous Chapters, and at all growth stages the effect was noticeably present. It has further been explained that since calf birth weight is primarily a function of the genetic make-up of the dam, birth weight is unlikely to be influenced directly by environmental factors.

7.3.1.2 (a) *Effects of breeder on calf weights in Central Bushveld*

Differences in calf weights were found to be significant. Between breeders in each bioregion, the analysis showed significance of breeder effects to all calf weights. In the Central Bushveld, birth weights did not differ much between the different breeders as shown in Figure 7.1.

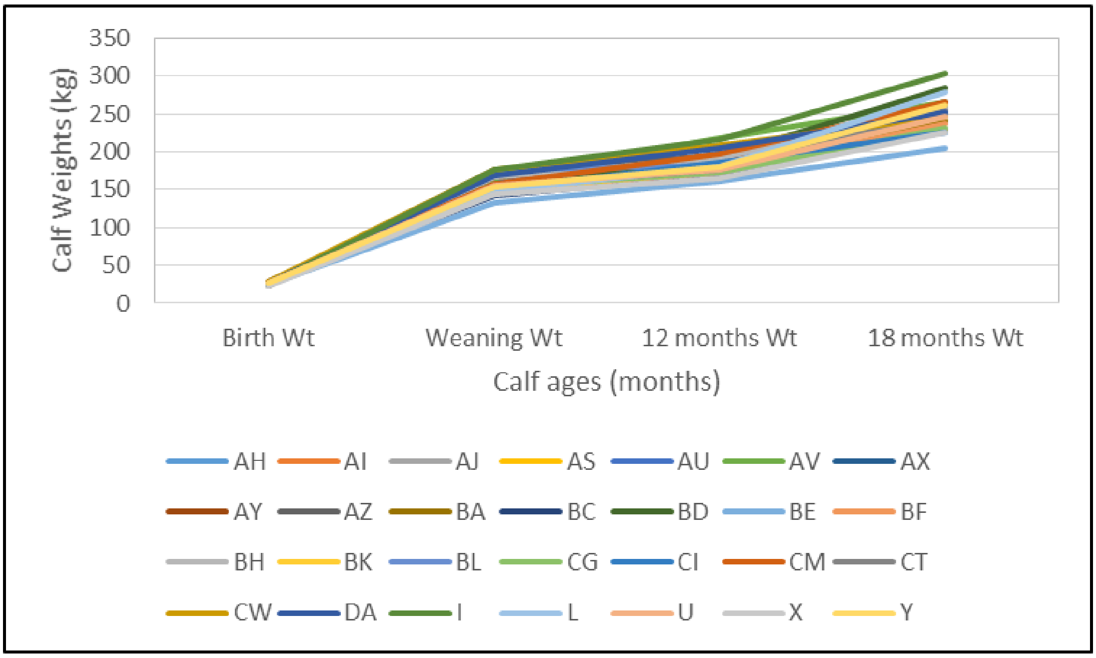

Figure 7.1: Effect of breeder on calf weights in the Central Bushveld (bioregion 1)

However as calves grew older, differences in calf weights were quite evident. Differences in growth where calves are older and depend on natural resources can be explained by the management style of the breeder. Table 7.1 shows the breeder performance of the breeders in the Central Bushveld including ICP values which are shown in Figure 7.2

Table 7.1: Cow and calf performance for Nguni breeders in the Central Bushveld bioregion and also including ICP of the cows (mean ± SD)

Breeder Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
AH	28±4.1	163±15.9	195±27.2	262±22.4	366±68.3	338±40.2
AI	26±4.0	156±24.4	186±28.9	261±30.2	418±120.0	344±47.6
AJ	26±3.0	151±28.5	175±17.1	248±39.4	416±100.1	411±50.5
AS	24±2.6	151±17.8	175±19.6	260±18.4	425±111.9	389±46.8
AU	28±3.5	159±22.9	194±25.1	261±31.6	376±79.9	378±47.6
AV	26±3.5	166±24.1	218±30.4	265±38.5	397±58.2	398±45.3
AX	27±3.6	149±23.5	197±34.9	257±43.7	405±91.9	365±51.9
AY	25±4.6	168±25.9	187±32.6	265±39.0	382±53.9	378±54.3
AZ	23±2.6	174±25.7	195±26.2	252±37.9	374±68.8	399±50.1
BA	24±3.4	152±19.5	183±18.6	240±9.89	396±99.6	350±38.2
BC	24±3.5	143±21.9	171±28.4	227±32.9	403±65.9	341±47.6
BD	25±1.6	148±24.9	193±35.4	285±45.2	423±91.6	375±49.1
BE	25±4.2	134±24.7	161±30.5	204±37.7	440±95.2	353±52.4
BF	27±5.2	151±21.9	173±20.9	237±22.6	385±72.4	328±47.3
BH	26±3.9	167±23.8	191±29.6	257±29.4	398±75.4	363±51.1
BK	28±3.6	149±18.5	174±7.78	228±40.4	434±77.4	368±48.9
BL	26±2.7	177±22.4	182±20.6	248±32.2	375±62.5	390±44.6
CG	27±4.0	153±23.6	172±8.9	230±37.2	437±80.5	390±51.1
CI	24±3.4	150±31.3	186±34.8	225±36.3	410±87.9	356±55.0
CM	28±3.6	157±29.4	197±33.8	266±34.8	380±67.1	409±57.2
CT	26±2.3	154±22.1	177±26.3	255±37.4	405±68.5	359±38.5
CW	29±3.3	176±24.2	208±16.9	247±19.8	368±43.8	415±53.4
DA	26±3.2	168±25.6	204±26.1	253±31.2	394±66.3	381±54.3
I	25±4.7	177±23.2	216±24.2	304±23.6	386±85.3	450±49.7
L	27±4.4	149±25.7	179±32.7	278±38.6	393±91.2	390±57.7
U	26±3.6	155±22.3	176±31.2	247±34.9	375±72.9	365±51.7
X	23±4.6	145±26.7	164±31.9	226±34.3	398±96.4	334±52.2
Y	27±4.2	154±21.9	181±22.3	261±37.7	381±67.2	354±42.5

Differences were noted in the growth parameters of the calves and ICP of cows between breeders in this bioregion. This demonstrates the effect of different management practices as mentioned above. Some breeders could be supplementing their cows in preparation for the breeding season to ensure the attainment of the target weight and body condition during breeding thereby increasing the conception rate of the herd. ICP varied from 366 days for breeder AH to 440 for breeder BE. At the same time, breeder I had the highest 18-month weight (304 kg) than all the breeders in the Central Bushveld bioregion. These differences in performance of cows and calves confirm breeder management practices, which this study suspected but could not confirm with the breeders.

7.3.1.2 (b) *Effects of breeder on mean ICP of Nguni cows in the Central Bushveld*

ICP appears to be affected mostly by the availability of forage, which in turn determines the body condition of the cow. ICP can be managed and improved by nutrient supplementation which can result in differences between cows in terms of ICP of cows living in the same environment but under different management systems. Figure 7.2 shows the variation in ICP averages of Nguni cows in the Central Bushveld bioregion of the Savannah Biome. The lowest ICP average observed in this bioregion was 366 days for breeder AH. The value of cow ICP is closely related to the profitability of the enterprise, where cows having high ICPs, will result in losses for the farmer, due to lost time for conception. This also contributes to an increased number of culls for unproductive cows. On the other hand, low cow ICP translates to high conception rates, achieved through correct feeding to ensure target body weight and body condition during the breeding season. In addition, nutritional supplementation of cows during pregnancy and lactation ensures high weaning rate and high weaning weights of calves.

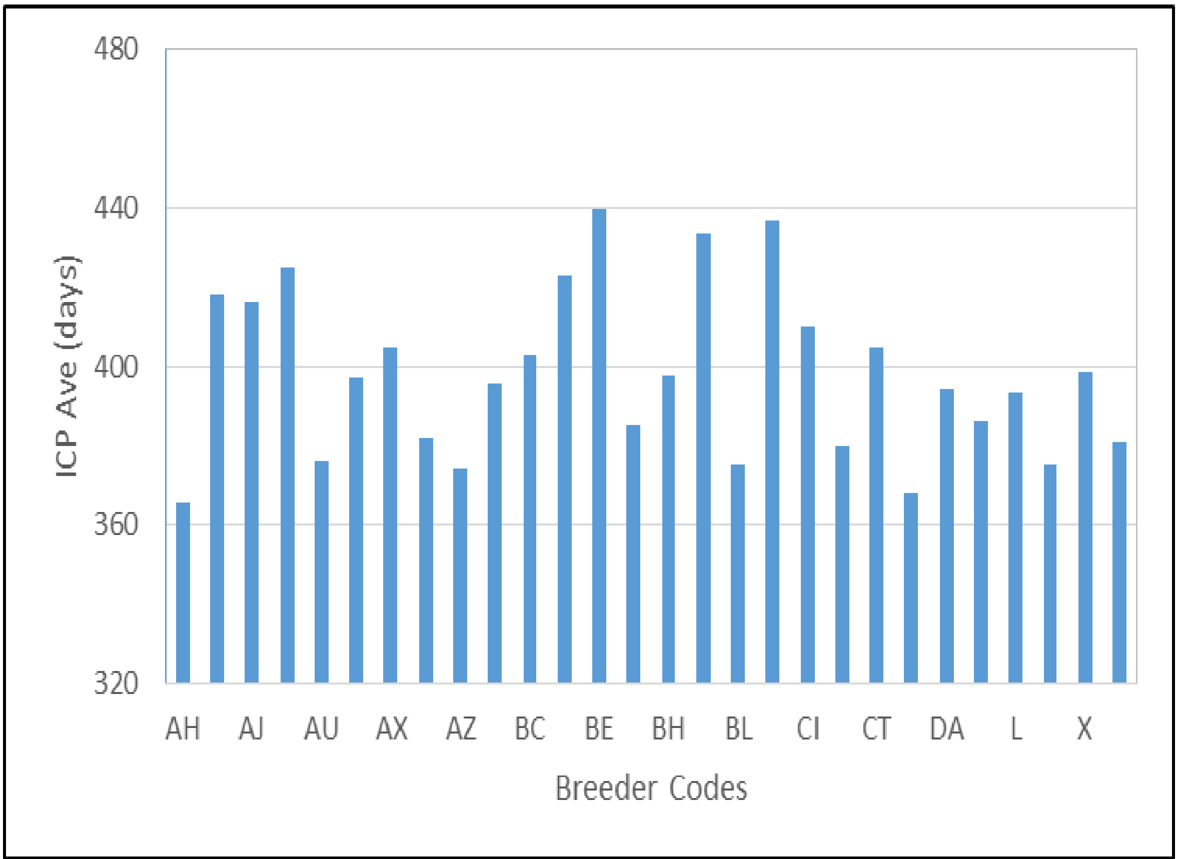

Figure 7.2: Effect of breeder on mean ICP of cows in the Central Bushveld (bioregion 1)

7.3.1.3 (a) *Effects of breeder on calf growth weights in Eastern Kalahari Bushveld*

In the Eastern Kalahari Bushveld, only six breeders were compared against each other in terms of growth weights and cow ICP's. In Figure 7.3 average calf weights for the six breeders are shown. For all breeders the calves started at almost the same birth weight, but as the calves grew older the calf weights differed. Breeder BB had better calf weights at 18 months of age compared to all the other breeders evaluated in the Eastern Kalahari Bushveld.

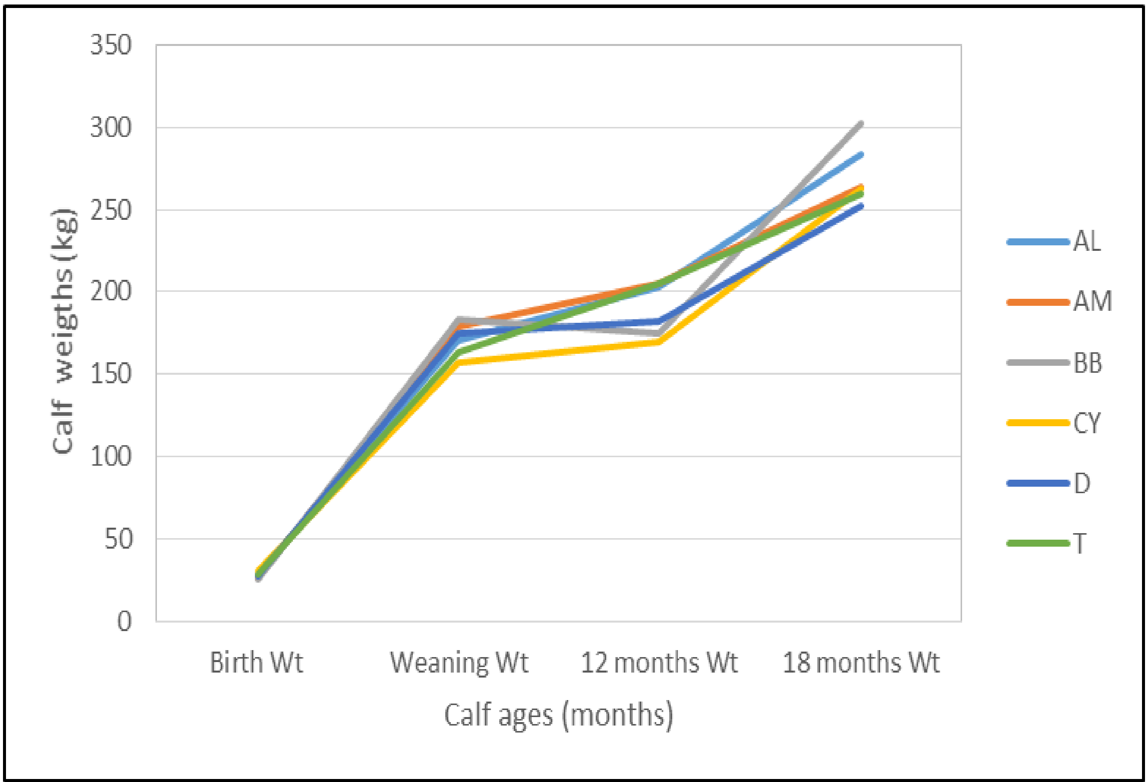

Figure 7.3: Effect of breeder on calf weights in the Eastern Kalahari Bushveld (bioregion 2)

7.3.1.3 (b) *Effects of breeder on mean ICP of Nguni cows in the Eastern Kalahari Bushveld*

The ICP of the cows managed by these six breeders is shown in Figure 7.4. The ICP of the cows varied widely within the bioregion, demonstrating breeder management differences.

Table 7.2: Cow and calf performance for Nguni breeders in the Eastern Kalahari Bushveld bioregion and also including ICP of the cows (mean ± SD)

Breeder Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
AL	28±6.2	170±22.1	203±37.4	284±33.5	388±73.6	375±48.3
AM	26±2.0	179±20.4	205±23.6	264±19.4	438±65.8	381±53.2
BB	26±3.1	183±26.0	175±20.1	303±35.0	369±58.0	363±51.4
CY	30±5.8	157±30.1	169±28.2	263±42.5	404±90.9	338±59.0
D	27±3.9	175±21.1	182±24.4	252±20.3	389±72.1	404±51.4
T	29±3.6	163±30.1	205±25.2	260±40.8	402±61.0	380±57.7

The variation in breeder performance in the Kalahari Bushveld is demonstrated in Figure 7.3 and in Table 7.2. The shortest mean ICP was 369 days for breeder BB, while the cows of breeder AM had the longest ICP average of 438 days.

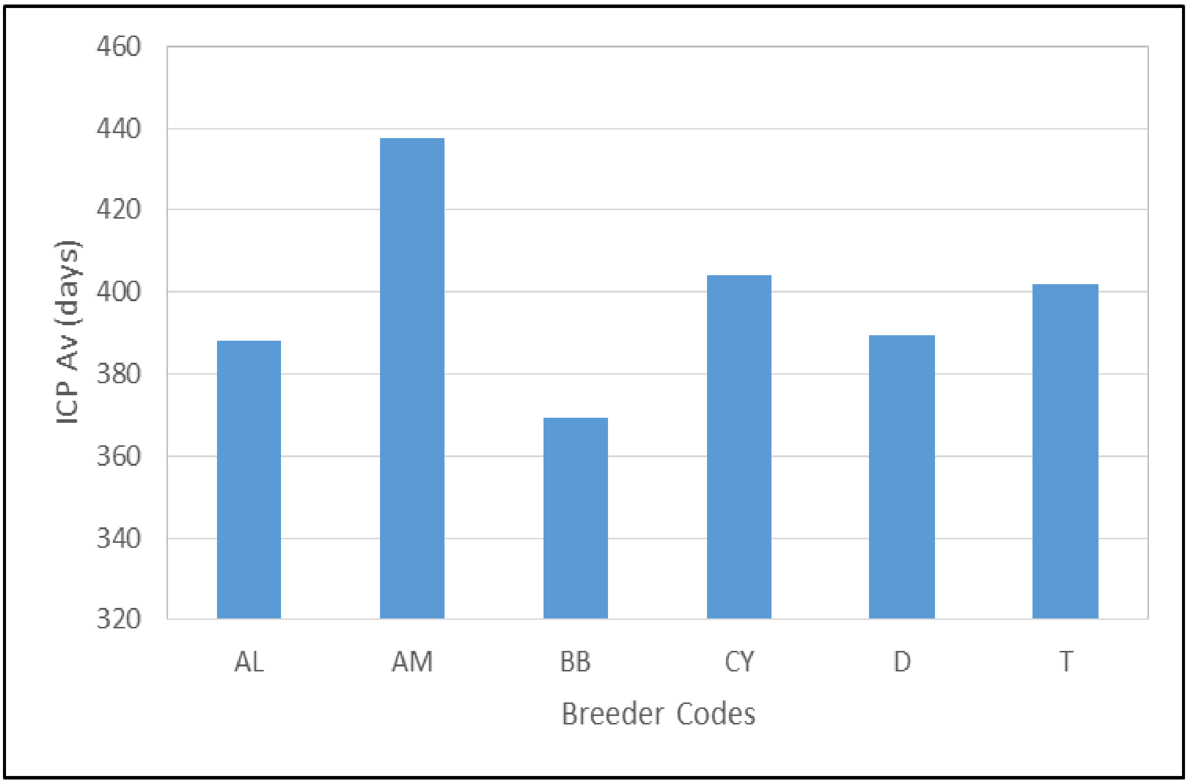

Figure 7.4: Effect of breeder on mean ICP of cows in the Eastern Kalahari Bushveld (bioregion 2)

7.3.1.4 (a) *Effects of breeder on calf growth weights in the Lowveld*

The lowveld bioregion is in the Savannah Biome. The calf weights in this bioregion were very similar initially but, as in other bioregions, subsequent growth differed as calves depended on the natural resources and the management of the each breeder, as shown in Figure 7.5 below. The variation in weight increases from birth to 18 months of age can only be due to the management of the breeder since the calves are growing in a similar environment.

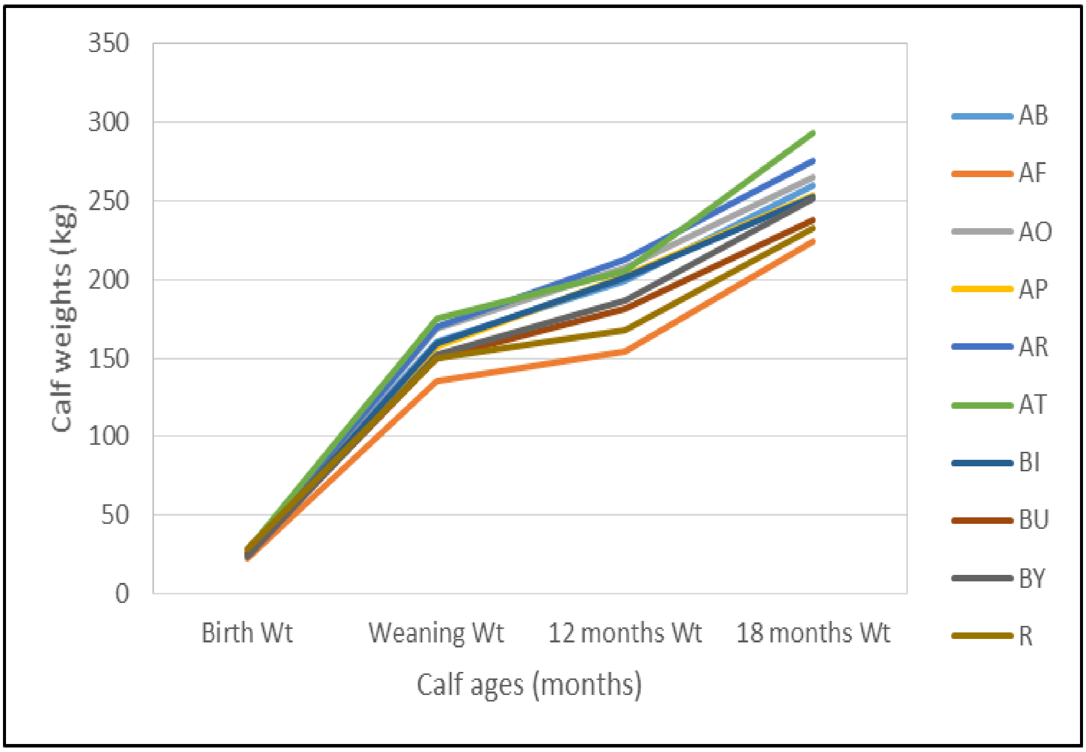

Figure 7.5: Effect of breeder on calf weights in the Lowveld (bioregion 3)

Table 7.3: Cow and calf performance for Nguni breeders in the Lowveld bioregion and also including ICP of the cows (mean ± SD)

Breeder Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
AB	27±3.1	160±21.1	200±19.3	259±33.7	399±87.1	367±61.4
AF	22±4.6	136±30.1	155±34.5	224±45.4	439±112.8	270±48.0
AO	26±2.1	168±18.7	208±32.6	265±30.9	476±119.1	324±38.7
AP	27±2.7	157±28.7	203±29.8	254±29.8	417±90.2	317±63.5
AR	26±1.8	170±28.0	212±33.7	276±44.0	416±89.9	347±50.4
AT	28±1.2	175±22.5	205±27.1	294±46.4	438±107.5	353±42.1
BI	25±2.2	160±17.9	201±20.5	252±33.6	382±79.5	400±46.3
BU	25±4.0	150±24.5	182±29.3	238±41.9	418±88.8	363±49.8
BY	24±3.2	153±23.1	186±25.1	251±31.0	416±106.9	378±49.9
R	29±5.0	150±21.0	168±26.5	233±30.9	417±118.7	357±47.7

7.3.1.4 (b) *Effects of breeder on mean ICP of Nguni cows in the Lowveld*

The mean ICP of cows in the Lowveld were compared to determine the effect of breeder on the cow performance. Mean ICP ranged from 382 days for breeder BI to the longest ICP of 476 days for breeder AO. Differences were evident as shown in Figure 7.6 below. Cows managed by Breeder AT produced calves with mean birth weights higher than those of calves of all the other breeders, and this trend continued until weaning. At 12 months, a decline was noticed in breeder AT's calf weights but again at 18 months the young cattle of AT had the highest weights. This could have been caused by supplementary feeding by breeder AT or better veld management to ensure good cow weights before the breeding season.

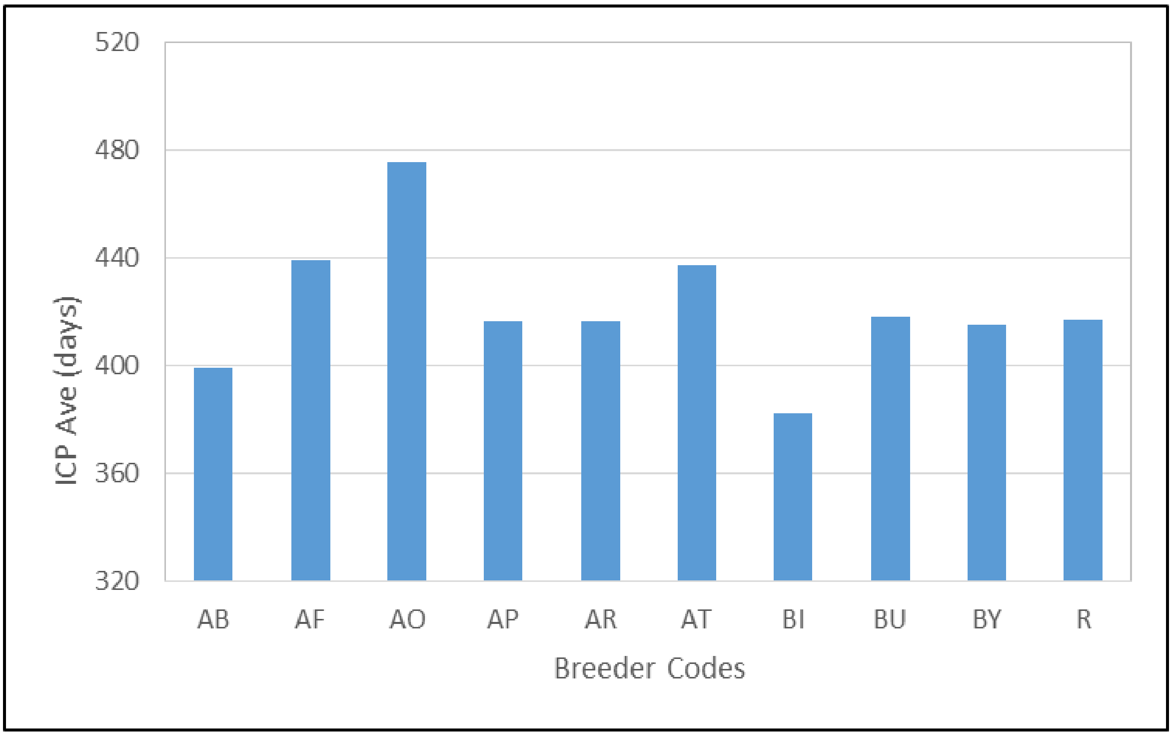

Figure 7.6: Effect of breeder on mean ICP of cows in the Lowveld (bioregion 3)

7.3.1.5 (a) *Effects of breeder on calf growth weights in the Sub-Escarpment*

In the Sub-Escarpment of the Savannah Biome, calf growth for nine breeders was compared. The birth weights of calves of all breeders in the bioregion varied from an average of 24 to 29 kg. Weaning weights ranged from an average of 124 kg (calf birth weight average of 26 kg for breeder N) to 190 kg (calf birth weight average of 29 kg for breeder CK), with no special pattern (Table 7.4). Some of the breeders had calves with higher birth weights than the rest, and they managed to keep the higher weights up until the 18 month weights (breeder CK). While some breeders had calves that started with higher birth weights but at 18 months, their calf weights were not ahead of those of other breeders at the beginning of the growth period (breeder AE). This is a clear indication of breeder effects, as after 12 months weights are an outcome of nutrition quality and quantity as well as management style, including genetic potential.

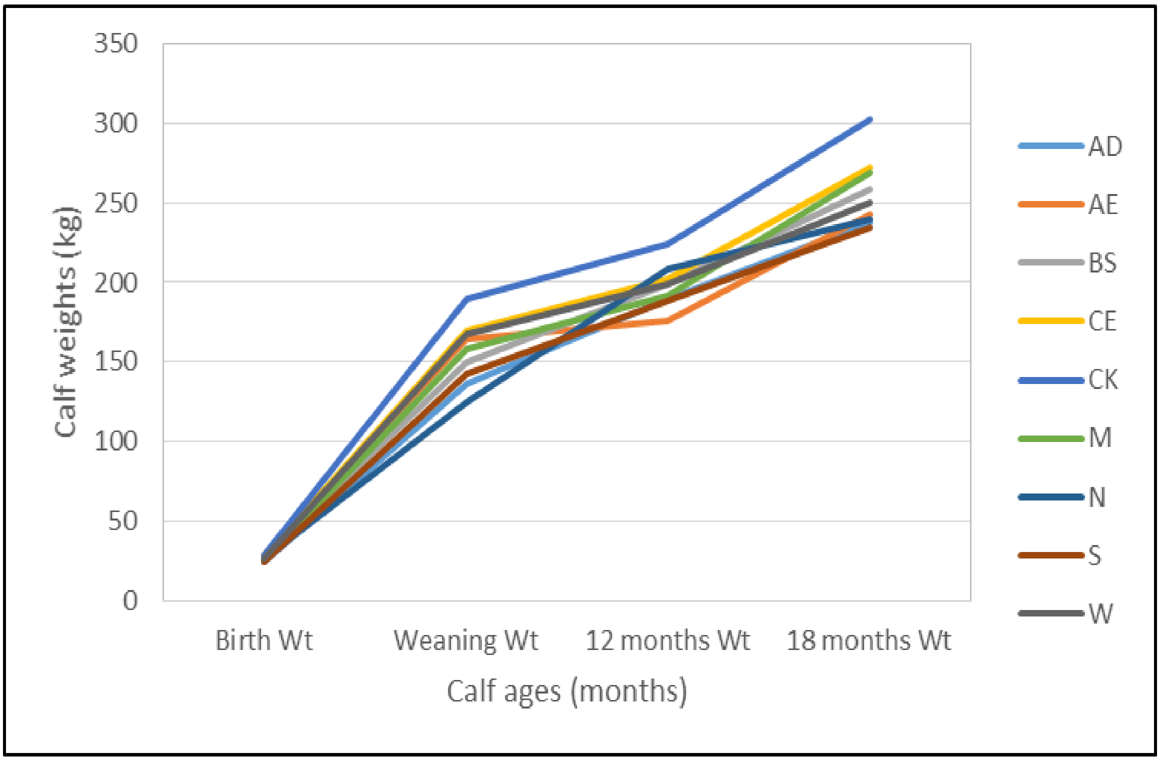

Figure 7.7: Effect of breeder on calf growth weights in the Sub-Escarpment (bioregion 4)

7.3.1.5 (b) *Effects of breeder on mean ICP of cows in Savannah Sub-Escarpment*

In the Sub-Escarpment of the Savannah Biome, the cow mean ICP ranged from 388 days for breeder CE to the longest ICP of 496 days for breeder AD. Figure 7.8 and Table 7.4 show the variation of ICP's between the different breeders.

Table 7.4: Cow and calf performance for Nguni breeders in the Savannah Sub-Escarpment bioregion and also including ICP of the cows (mean ± SD)

Br Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
AD	25±3.9	137±27.0	189±29.4	238±32.2	496±101.3	349±43.2
AE	28±27	164±24.6	176±31.4	243±21.7	434±117.4	341±41.5
BS	27±4.0	150±23.9	199±33.0	259±34.2	444±92.6	329±46.2
CE	28±3.8	169±24.9	202±27.1	272±20.8	388±63.3	353±49.9
CK	29±4.1	190±24.2	224±28.4	302±35.8	409±79.3	413±58.9
M	25±3.5	158±27.3	192±31.7	269±37.5	402±79.9	395±59.5
N	26±4.0	124±28.6	208±30.7	239±28.1	426±112.6	329±47.5
S	24±5.3	143±38.3	188±32.1	235±30.1	411±55.7	303±46.0
W	27±2.9	167±25.7	199±29.3	250±28.0	412±96.1	357±43.0

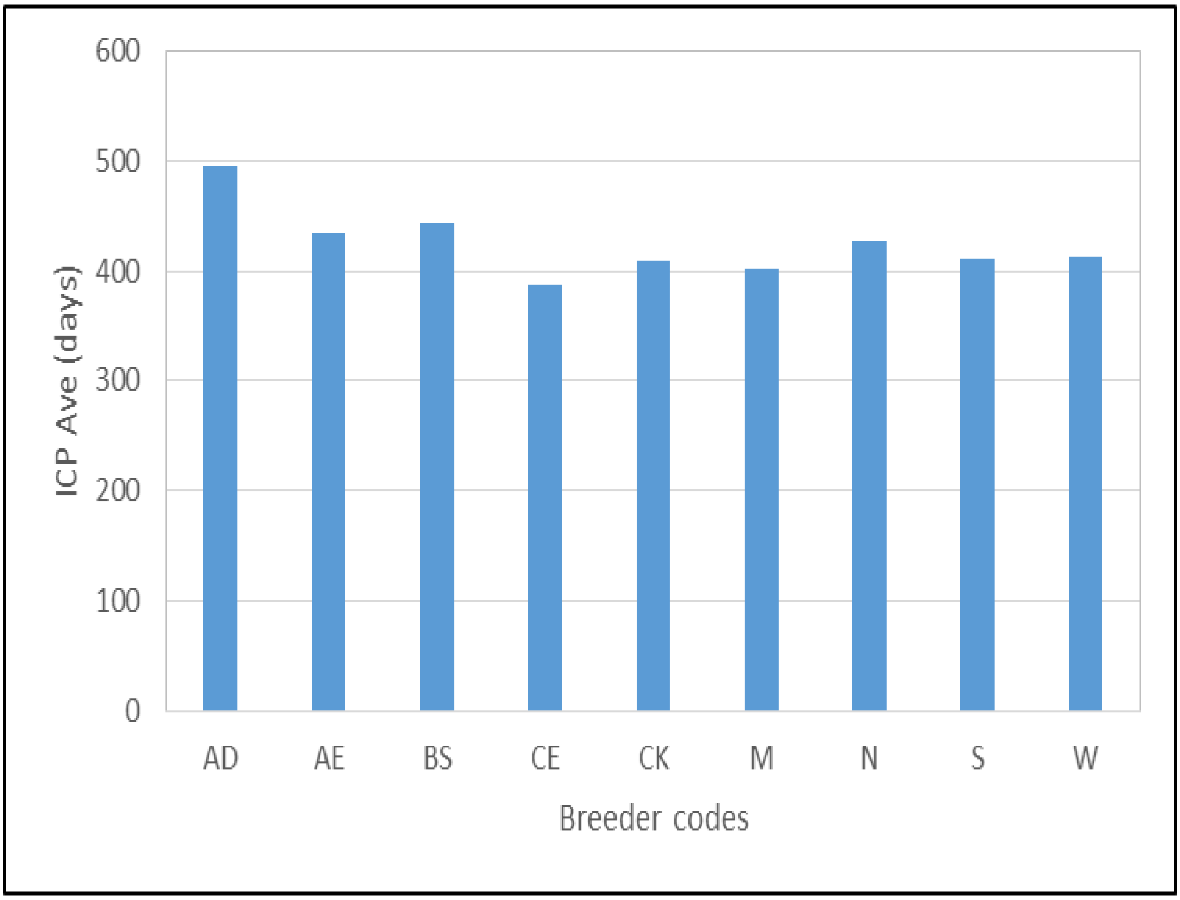

Figure 7.8: Effect of breeder on mean ICP of cows in the Sub-Escarpment (bioregion 4)

7.3.1.6 (a) *Effects of breeder on calf growth weights in the Drakensberg*

Only three breeders were compared in the Drakensberg bioregion; however the variation is still evident. Breeder CQ had the highest calf weights especially post weaning, as is shown in Figure 7.9.

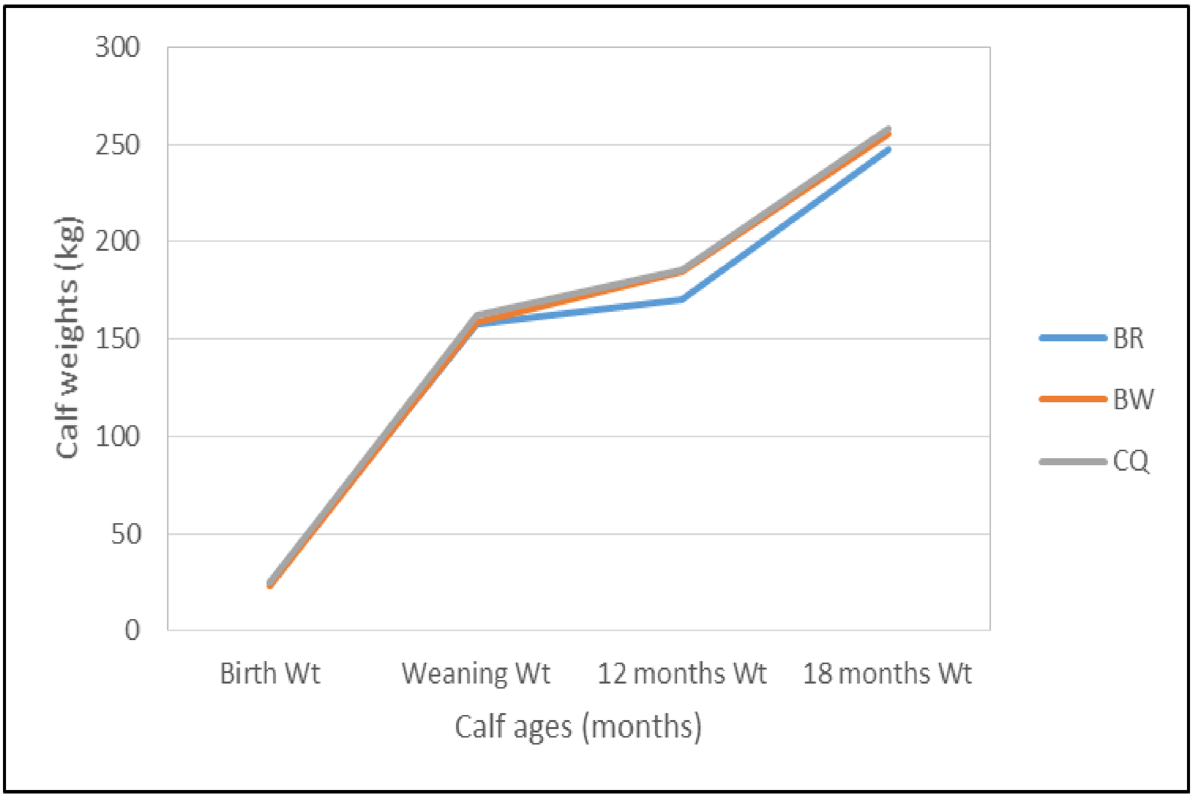

Figure 7.9: Effect of breeder on calf weights in the Drakensberg (bioregion 5)

7.3.1.6 (b) *Effects of breeder on mean ICP of cows in the Drakensberg*

The Drakensberg is included within the Grassland Biome. Breeders in this bioregion were compared to see the impact of the breeder management on the mean ICP of their cows. The cows of all the breeders compared in the bioregion had mean ICP levels below 409 days, and only one had cows with a long mean ICP of 397 days, even though this was still below the maximum ICP which is the Nguni breed average. In the evaluation done for cow efficiency discussed in Chapter 4 of this study, the Drakensberg bioregion showed the best cow efficiency even when different equations were used to do the evaluation. The good mean ICP levels of cows in this bioregion confirmed the status of the farms in this bioregion in terms of cow efficiency. This also suggests that although breeder effects have an impact on cow performance, an adapted breed like the Nguni in this study will produce and reproduce successfully without the specific interventions of the breeder.

Table 7.5: Cow and calf performance of Nguni breeders in the Drakensberg bioregion and also including ICP of the cows (mean ± SD)

Breeder Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
BR	25 ±3.9	158 ±19.3	170 ±24.8	247 ±33.9	390±44.7	367±49.0
BW	24 ±3.0	159±25.0	185±31.5	255±36.7	397±77.4	345±45.7
CQ	25 ±3.6	162±28.7	186±31.3	258±35.3	390±81.2	375±58.3

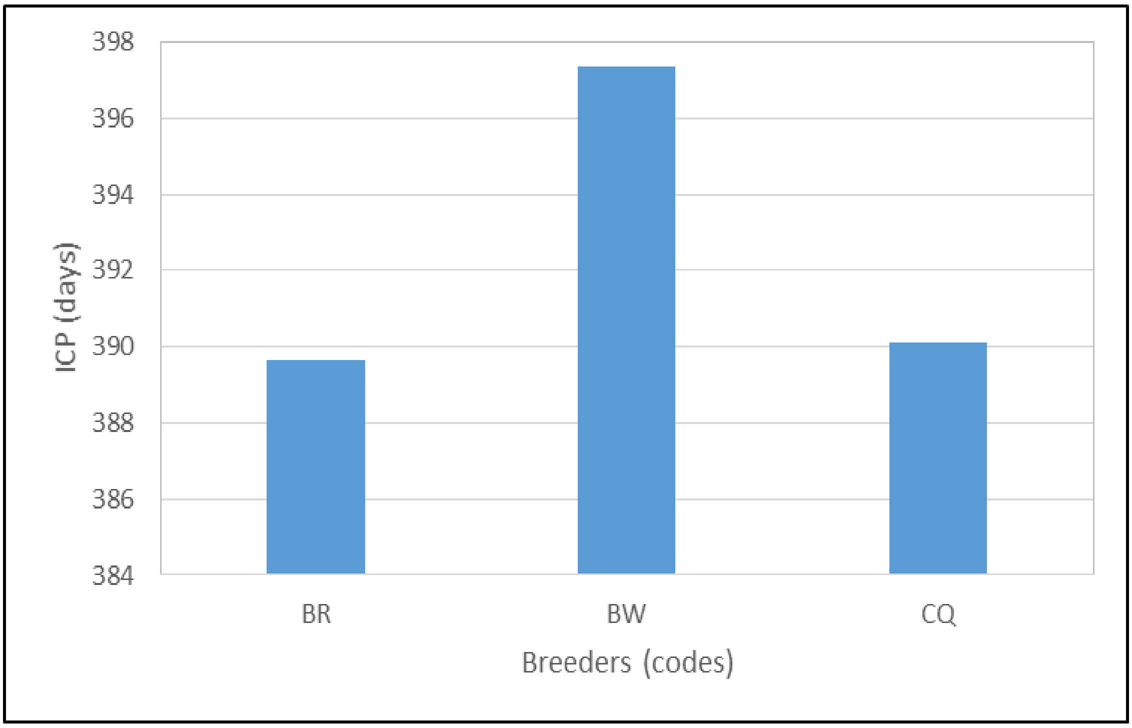

Figure 7.10: Effect of breeder on mean ICP of cows in the Drakensberg (bioregion 5)

7.3.1.7 (a) *Effects of breeder on calf growth weights in the Dry Highveld*

The Dry Highveld bioregion, is also located in the Grassland Biome. In Figure 7.6 (a) below, uniformity of mean birth weights is apparent; however as calves grew older differences could be seen in the weights.

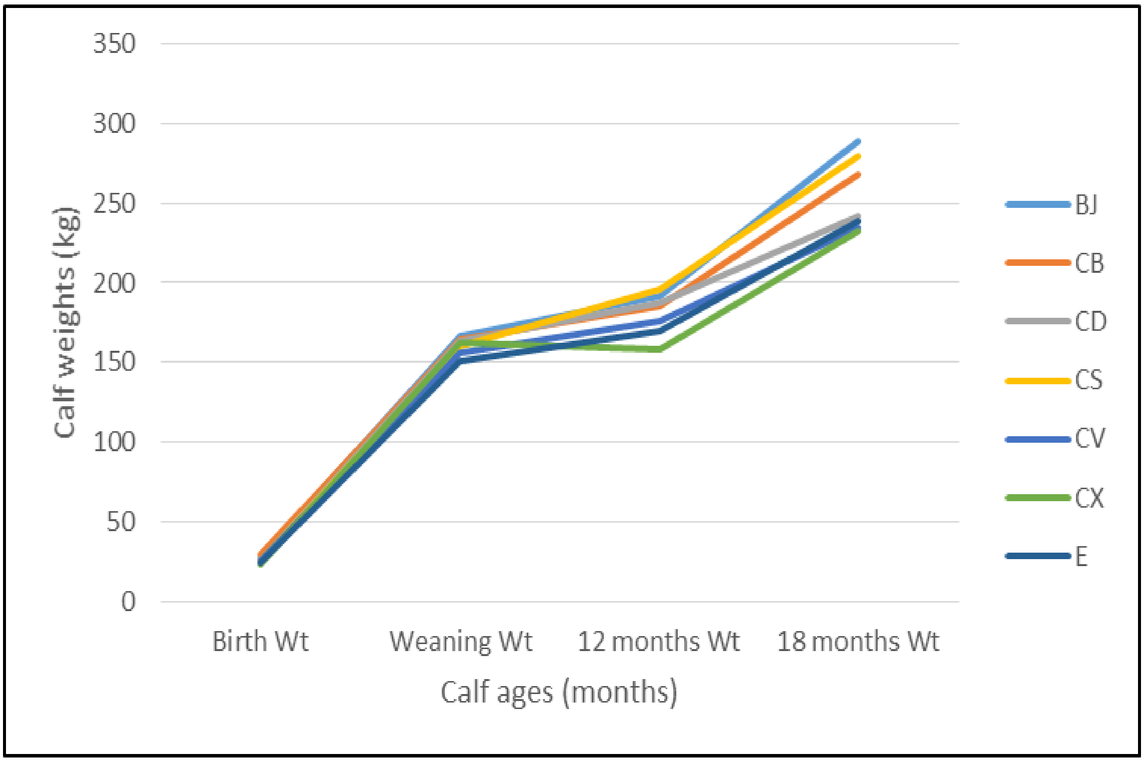

Figure 7.11: Effect of breeder on calf weights in the Dry Highveld bioregion (6)

Table 7.6: Cow and calf performance of Nguni breeders in the Dry Highveld bioregion and also including ICP of the cows (mean ± SD)

Breeder Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
BJ	27±4.1	166±17.0	192±36.8	289±61.3	394±87.8	316±40.1
CB	29±5.6	164±25.1	185±28.6	268±38.9	388±78.9	357±50.2
CD	25±3.2	163±26.4	188±22.1	242±25.1	398±58.6	320±37.8
CS	25±3.4	160±17.5	196±27.2	280±27.9	355±17.5	353±45.9
CV	25±2.1	156±22.6	176±27.9	235±34.7	417±77.3	340±47.9
CX	24±4.8	162±26.7	158±21.0	232±30.1	411±59.1	357±60.0
E	24±1.1	150±27.3	170±30.9	239±31.3	389±81.2	312±49.8

7.3.1.7 (b) *Effects of breeder on mean ICP of Nguni cows in the Dry Highveld*

Calf weights were compared for breeders in bioregion 6 to evaluate the effect on the mean ICP of their cows. ICP's of cows in bioregion 6 varied from 355 days (breeder CS) to 417 days (breeder CV). As this is within the same bioregion, the explanation of the variances could include management of the herd, breeding period and feeding strategy of the breeder. So these effects can be viewed as possibly the result of breeder management.

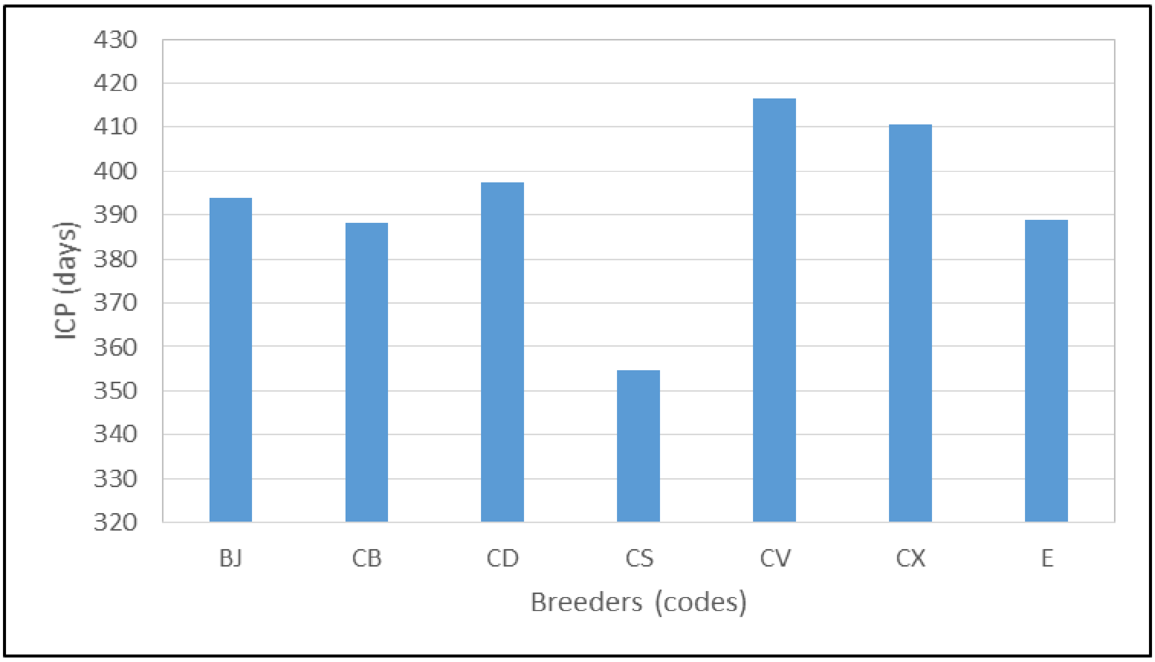

Figure 7.12: Effect of breeder on mean ICP of Nguni cows in the Dry Highveld (bioregion 6)

7.3.1.8 (a) *Effects of breeder on calf growth weights in the Mesic Highveld*

Mesic Highveld is in the Grassland Biome. Birth weights varied between breeders and this continued until weaning, as shown in Figure 7.13. In the evaluation of cow performance discussed previously, cows in the Mesic Highveld did not achieve the best results. However this specific analysis shows consistency of the achievement of good calf weights for all the breeders in the bioregion.

This suggests that the environment in this bioregion may have more influence on the performance of the cows than the breeder or the management style. Breeders such as BV and AA had calves with higher weights which at 18 months of age were the highest weights in the bioregion. The variation in calf weights is also shown in Table 7.7.

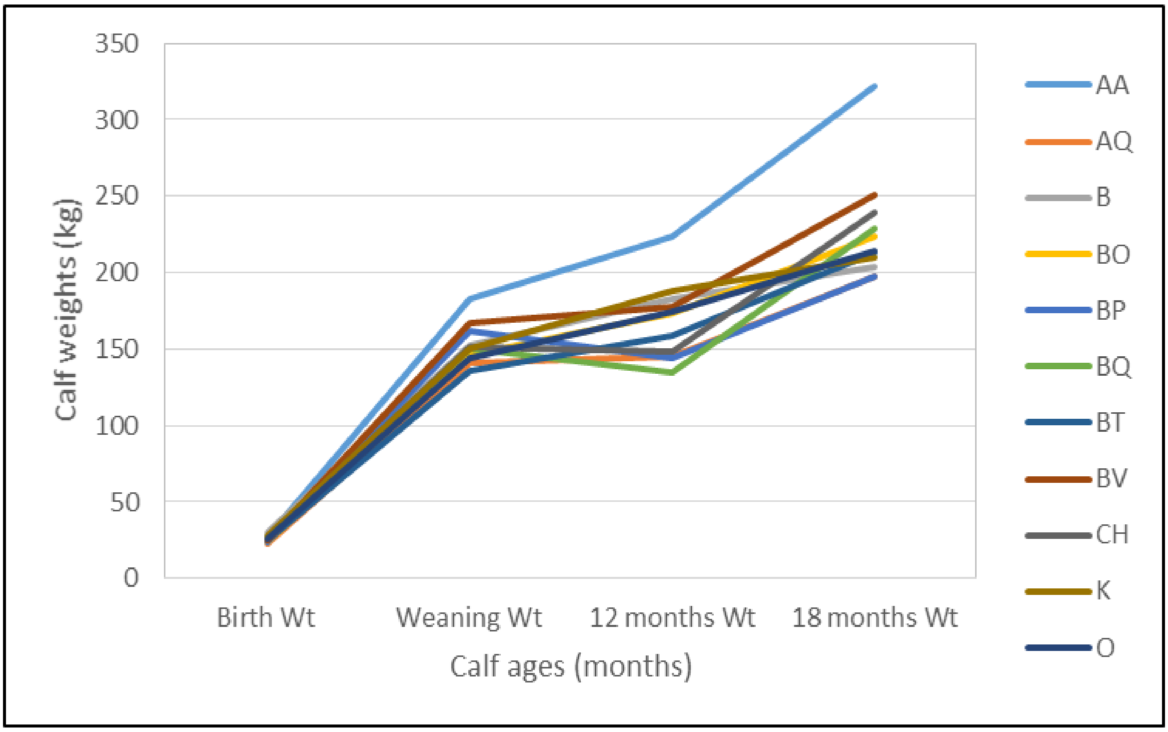

Figure 7.13: Effect of breeder on calf weights in the Mesic Highveld bioregion (7)

7.3.1.8 (b) *Effects of breeder on mean ICP of cows in Mesic Highveld*

The cow ICP values differed between the various breeders in the Mesic Highveld bioregion (7), from 375 days to 502 days. Table 7.7 shows that the cows of breeder AA had the lowest ICP compared to those of all the other breeders. As this performance is within a bioregion, the variation is an indication of different management practices of breeders.

Table 7.7: Cow and calf performance of Nguni breeders in the Mesic Highveld bioregion and also including ICP of the cows (mean ± SD)

Breeder Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
AA	27±1.8	183±27.1	223±31.5	322±35.8	375±66.5	414±53.7
AQ	23±2.8	141±24.1	145±22.5	198±33.4	502±151.9	292±36.6
B	30±3.1	153±20.7	183±23.4	204±26.6	441±82.8	340±49.5
BO	24±3.0	146±22.5	174±31.1	224±35.1	407±79.6	354±50.1
BP	24±2.6	162±18.7	144±19.3	197±25.4	438±81.3	349±26.0
BQ	27±3.1	150±21.9	135±13.3	229±26.4	452±108.9	361±42.8
BT	25±3.3	136±29.9	159±29.5	213±39.2	385±63.6	336±53.4
BV	25±4.8	167±25.6	178±25.9	251±53.4	407±92.4	357±55.5
CH	27±4.5	151±25.2	148±29.8	240±34.1	415±79.4	361±50.4
K	28±5.1	150±27.5	188±35.6	210±41.8	470±85.9	320±54.8
O	26±3.5	144±17.8	175±18.9	214±31.0	468±89.0	307±44.6

This is in agreement with the good performance observed in calf growth measurements, as is also demonstrated in Figure 7.14. Breeders who had high 18 months calf weights also had low mean ICP values. This can be attributed to the management style of a breeder, specifically on the nutrition and management of the herd. While the condition of the calves is kept at a good level, the body condition of the cow is also managed to ensure re-conception which is supported by the recommendations of Meaker, *et al*. (1980).

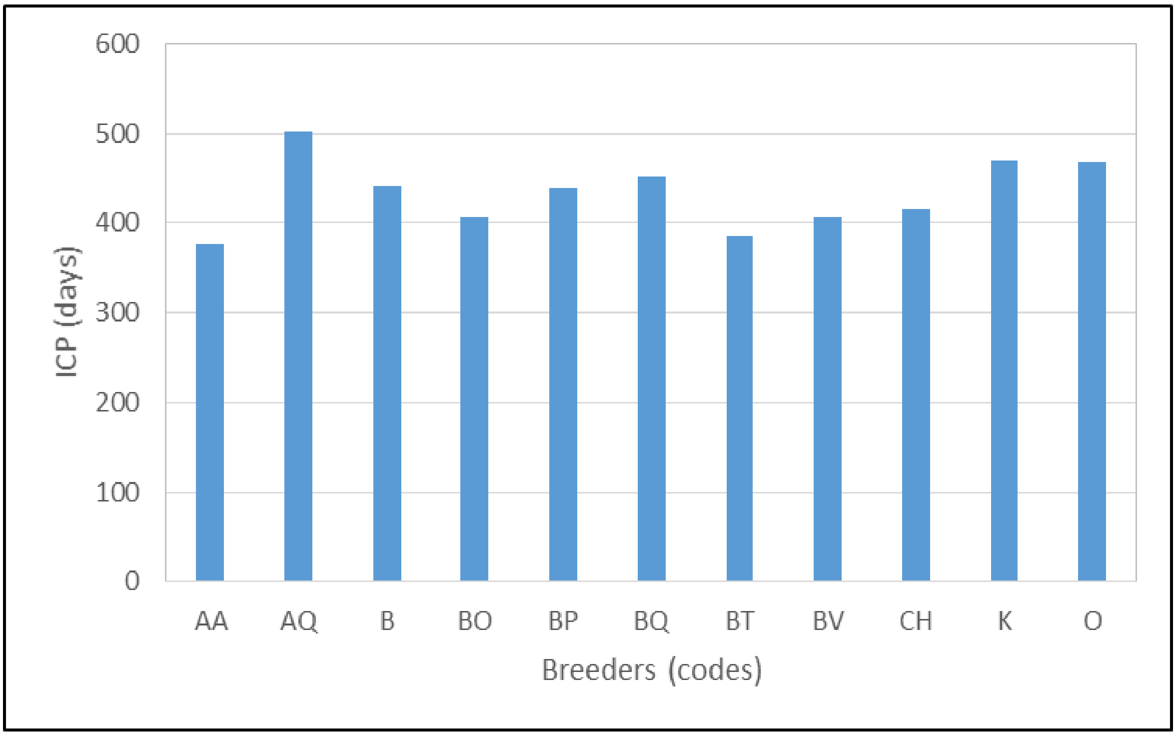

Figure 7.14: Effect of breeder on mean ICP of cows in the Mesic Highveld (bioregion 7)

7.3.1.9 (a) *Effects of breeder on calf growth weights in the Grassland Sub-Escarpment*

In the Sub-Escarpment of the Grassland Biome, calf weights varied though not widely. Some breeders whose calves showed a decreasing trend at weaning remained with relatively low weights until 18 months. After weaning, calf growth is influenced by the genetic make-up of the calf, the nutrition and the management of the breeder. Another factor that plays a role in the calf weights is the ecotype of the breed. The factors mentioned above could possibly explain the decrease in calf weights, as observed in calves of some breeders. However, breeders such as AW had high calf weights from birth until 18 months, as shown in Table 7.8. This can be regarded as a sign of a breeder effect.

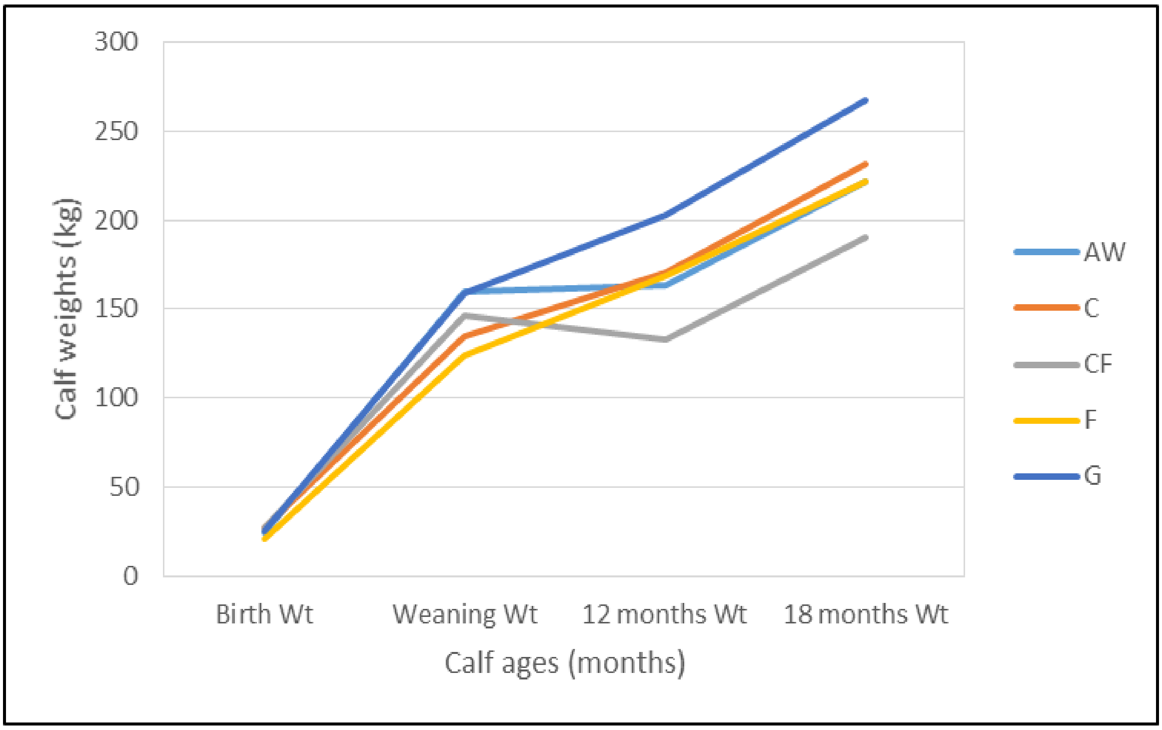

Figure 7.15: Effect of breeder on calf weights in the Grassland Sub-Escarpment bioregion (8)

7.3.1.9 (b) *Effects of breeder on mean ICP of cows in the Grassland Sub-Escarpment*

The ICP of cows in the Sub-Escarpment of the Grassland Biome was found to vary similarly to the calf weights. There was no relationship found between calf growth measurements of performance of the different breeders and the ICP of their cows. However, cow ICP's varied between the different breeders, with the lowest ICP for breeder CF at 398 days and the highest ICP for breeder C at 432 days.

Table 7.8: Cow and calf performance of breeders in the Grassland Sub-Escarpment bioregion and also including ICP of the cows (mean ± SD)

Breeder Code	Birth Wt (kg)	Weaning Wt (kg)	12 months Wt (kg)	18 months Wt (kg)	ICP (days)	Cow Wt at Wng (kg)
AW	25±3.6	160±21.7	163±33.7	221±28.6	409±126.4	360±49.0
C	27±4.6	135±23.4	171±27.9	232±40.0	432±119.9	349±55.2
CF	27±3.4	146±34.9	133±18.1	190±29.1	398±79.1	338±45.8
F	21±4.8	124±25.5	169±33.6	221±39.8	412±91.0	341±50.7
G	26±3.8	159±23.7	203±32.7	267±39.5	428±111.9	357±48.6

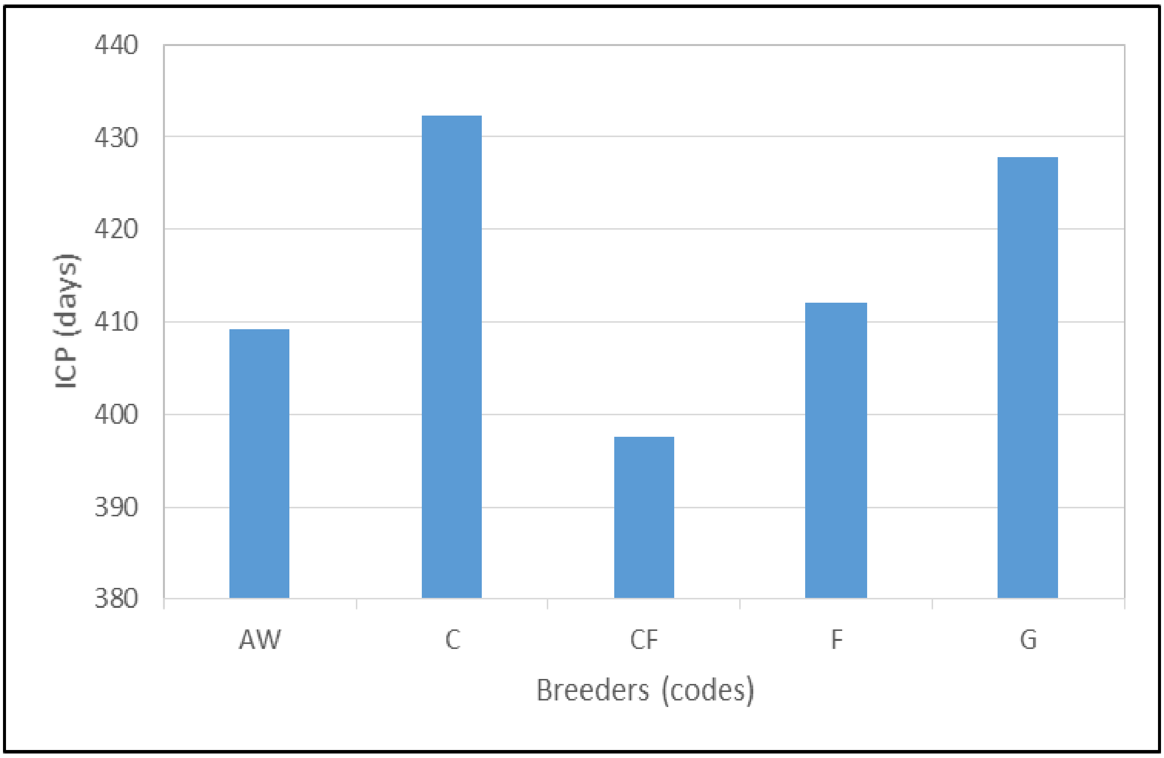

Figure 7.16: Effect of breeder on mean ICP of cows in the Grassland Sub-Escarpment (bioregion 8)

7.3.1.3 *Effects of calf sex, season and year groupings on birth weight of calves*

Breeders were categorized according to the bioregions. Calf sex was not significantly affected by the breeder effects. As discussed previously, male calves were significantly heavier than the female calves. The effect of season and year groupings was found to be consistent to the results of the non-genetic factors analysis on birth weight. (See previous sections) Birth weight of calves for all the breeders was significantly heavier in year grouping 1. Between the eight bioregions, differences were noticeable in the birth weights. However, as birth weight is largely an indication of the genetic potential of the dam, differences could not be attributed to the breeder effects, except in so far as their cows and bulls differed in genetic potential. Hence, the differences were likely to be the result of a combination of the genetic and environmental effects.

7.4 Conclusions

This study was aimed at establishing whether the breeders evaluated had an effect on an adaptable breed like the Nguni. A study done by Webb *et al.* (2017) to establish the effect of the production environment on the production efficiency of Bonsmara cattle proved that the environment had an influence on the performance of the breed, specifically the weather effects such as rainfall, heat and humidity. This study also revealed that the management of the breeder had the greatest influence on the performance of the Bonsmara cattle. The Bonsmara breed was initially developed for adaptability by crossing the adaptable Afrikaner with Shorthorn and Hereford breeds. It has therefore through the years improved in adaptability and should be less affected by variations in the production environment. While the Nguni breed is liked by most breeders for its hardiness and adaptability to harsh conditions, and it should be less affected by the variations in the production environment, this study has showed that it is also affected by the climatic region of production. In this study, effects of the differences in herd management were also apparent. The differences observed in calf growth weights suggested that this was the result of different management styles of the breeders. Research has shown that the age at puberty is highly influenced by feeding of the heifer (Mukasa-Mugerwa, 1989, Van Niekerk *et al.,* 1986), irrespective of the breed. If a heifer has reached puberty and starts to produce early in its life, it becomes critical to ensure proper feeding of the particular animal to lessen the potential adverse effects of such early production. If is further critical to ensure adequate feeding of a cow after the birth of the calf to contribute to ensure the involution of the uterus preparing the cow for the next pregnancy (Mukasa-Mugerwa, 1989). Correct nutrition for the cow continues to be critical to ensure good body condition so that cows conceive during the breeding season (Meaker *et al.,* 1980). Furthermore, improved feeding of the pregnant cow contributes towards increased milk production of the cow, this can be realized in higher weaning weight of the calf (McDonald *et al*., 1988). Where differences are noticed within a bioregion, it is assumed that nutritional supplementation and management is the reason for the variation in cow and calf performance.

Management of the cow herd varies from one breeder to another. In the current study, it was not possible to confirm the type or extent of supplementation of the cows as this would mean knowing the details a farmer's management system. However, factors such as ICP and calf weights after weaning are clear indications of breeder effects. In Chapter 7, the process of comparing breeders within bioregions was able to indicate the effect of the breeder. In cases where calves started with high birth weights and continued with high weights after weaning until 18 months of age, the management of nutrition must have been a factor. This could be seen when calves in the same bioregion had lower weights at 18 months of age while they had started at similar birth weights compared to those of the calves of other breeders. The study has shown that, as it was demonstrated with Bonsmara cattle, the environment plays a role in the performance of cattle but the breeder has the most influence. For Nguni breeders this is a clear message that being in the same environment does not guarantee similar performance of the cattle despite their adaptability to harsh environmental conditions and scarcity of feed. Each breeder needs to take measures to ensure that their cattle continue to produce and reproduce efficiently, in their specific production environment. This principle does not differ in the different ecotypes. The study of Maciel *et al.* (2016), proved that having different Nguni ecotypes does not reduce the effects of the environment on production and reproduction efficiency of the Nguni cattle.

Chapter 8

GENERAL DISCUSSION AND CONCLUSIONS

The objective of the study was to investigate the production and reproduction of Nguni cattle in different geographical regions of South Africa. The hypothesis that the environment has an effect on the performance of Nguni cattle was tested using data collected in different geographical regions of South Africa. Regions were categorized into biomes and bioregions within the biomes. Each of the two biomes selected had four bioregions, between which the performance of the cattle was tested and compared.

Statistical analysis as performed by GLM of SAS (2017), version 9.3 revealed highly significant effects for different parameters that were evaluated as factors affecting the performance of these Nguni cattle within the different climatic regions. Parameters tested were calf weights (birth, weaning, 12 -month and 18-month weights), calf sex and inter-calving period (ICP). Table 8.1 illustrates the effect of the environment on the growth parameters of calves.

The differences within the biomes were found to have highly significant effects on the growth of the calves. Calves born and raised in the Savannah Biome performed better than those in the Grassland Biome. Pre- and post-weaning growth measurements showed superior performance of calves in the Savannah Biome at all times. Comparing the growth measurements of calves before and after weaning in the study to the Nguni Cattle Breeders Society standards showed differences especially after weaning. In this study, weaning weights were below the average as stipulated by the Nguni Cattle Breeders Society in both biomes, as shown in Table 8.1.

Table 8.1: Comparison between calf weights for both biomes (mean ± SD)

	Savannah Biome	**n**	**Grassland Biome**	**n**	**Av Wt Nguni Stds[1]**
Birth weight	25.7kg ±3.93[a]	20608	25.1kg ±3.82[b]	13735	25kg
Weaning weight	152.4kg ±26.60[a]	18041	148.8kg ±26.69[b]	12308	155kg
12-month weight	190.5kg ±33.95[a]	8421	180.6kg ±32.21[b]	6599	N/a
18-month weight	250.0kg ±40.30[a]	5225	237.2kg ±42.09[b]	4800	230kg

[a,b] Row means with different superscripts differ (P<0.0001)

[1] Source: www.ngunicattle.info

Additionally, bull calves were consistently heavier than heifer calves at all ages: birth, weaning, 12-month and 18-month weights (see Table 8.2).

Table 8.2: Comparison between calf weights for both sexes (mean ± SD)

	Female	**n**	**Male**	**n**
Birth weight	24.9kg ±3.79^{b}	17490	26.0kg ±3.90^{a}	16853
Weaning weight	145.4kg ±24.74^{b}	15427	155.7kg ±27.30^{a}	14922
12-month weight	176.2kg ±30.45^{b}	9565	194.9kg ±35.70^{a}	5455
18-month weight	228.2kg ±36.37^{b}	6916	259.0kg ±45.93^{a}	3109

^{a,b} Row means with different superscripts differ (P<0.0001)

Between the Savannah and Grassland Biomes, calf weights differed significantly (P<0.0001) between the two sexes. When calf growth parameters were compared after weaning, male calves in the Savannah Biome were heavier than their female counterparts in the Grassland Biome. According to literature, the Savannah Biome is characterized by a thick layer of grass and an upper layer, which is dominated by woody plants (Figure 8.1). Depending on the nature of the woody layer, the vegetation can present itself as shrubveld or bushveld (Low & Rebelo, 1996, Rutherford & Westfall, 1986). The disadvantage in this biome might be the lack of sufficient rainfall, which could result in less new growth, and less permanence of ground cover. However, the nature of vegetation is such that heavy grazing and fires cannot destroy the ground cover completely, and regrowth is possible after the summer rains. This type of vegetation is appropriate for grazing by cattle and wildlife. This explains the better performance of cattle kept in the Savannah Biome compared to those kept in the Grassland Biome. The rainfall averages show generally more rain in the spring and summer seasons. In some years, more rain was observed in autumn. But autumn rains are not as effective in vegetation re-growth because of the low temperatures, and therefore might not result in improved performance of cattle.

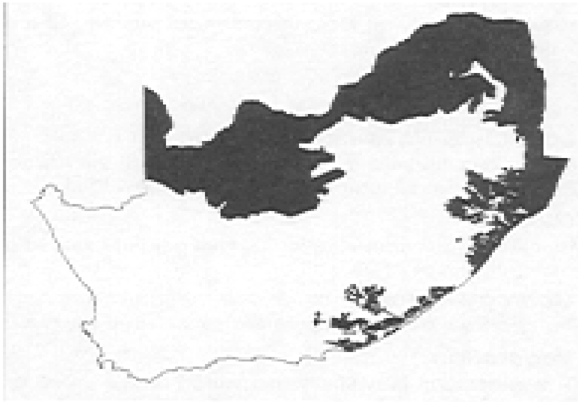

Figure 8.1: Savannah Biome in South Africa (Rutherford & Westfall, 1986)

The Grassland Biome on the other hand is characterized by a layer of grasses with less variety and has few woody plants in comparison to the Savannah Biome (Figure 8.2). While there are sweet grasses, which have a low fibre content, there are also sour grasses which have a high fibre content. Both the sweet and sour grasses are both suitable for grazing, but the condition of animals grazing on these differs. Depending on the amount of rainfall, high rainfall results in lower soil pH and grazing which is less palatable and nutritious, especially after the rainy season.

Figure 8.2: Grassland Biome in South Africa (Rutherford & Westfall, 1986)

While cattle farming is practiced and appropriate in both biomes, the vegetation types, rainfall patterns, temperature and humidity affect the productivity of livestock. Cattle in the Savannah Biome perform better than cattle in the Grassland Biome due to intrinsic differences between the two biomes. The effects of the biomes on calf weights are summarized in Table 8.3

Table 8.3: Comparison between calf weights as affected by calf sex and biome (mean ± SD)

	Savannah Biome		Grassland Biome	
	Female	Male	Female	Male
Birth weight	25.1kg ±3.84	26.3kg ±3.90	24.6kg ±3.68	25.6kg ±3.86
Weaning weight	147.0kg ±24.59	157.8kg ±27.14	143.9kg ±24.82	153.7kg ±27.33
12-month weight	180.6kg ±31.45	200.4kg ±28.18	171.8kg ±28.18	189.4kg ±35.78
18-month weight	231.6kg ±35.56	268.4kg ±43.46	224.8kg ±36.17	249.6kg ±48.39

Bioregions within each of the two biomes were compared for calf growth before and after weaning. In the Savannah Biome, cows and calves in the Sub-escarpment Savannah bioregion had the highest performance while the lowest performance was observed in the Lowveld bioregion. In the Grassland Biome, cows and calves in the Drakensberg Grassland bioregion had the best performance in terms of weights while in the Sub-Escarpment Grassland bioregion they had the lowest performance in terms of weights.

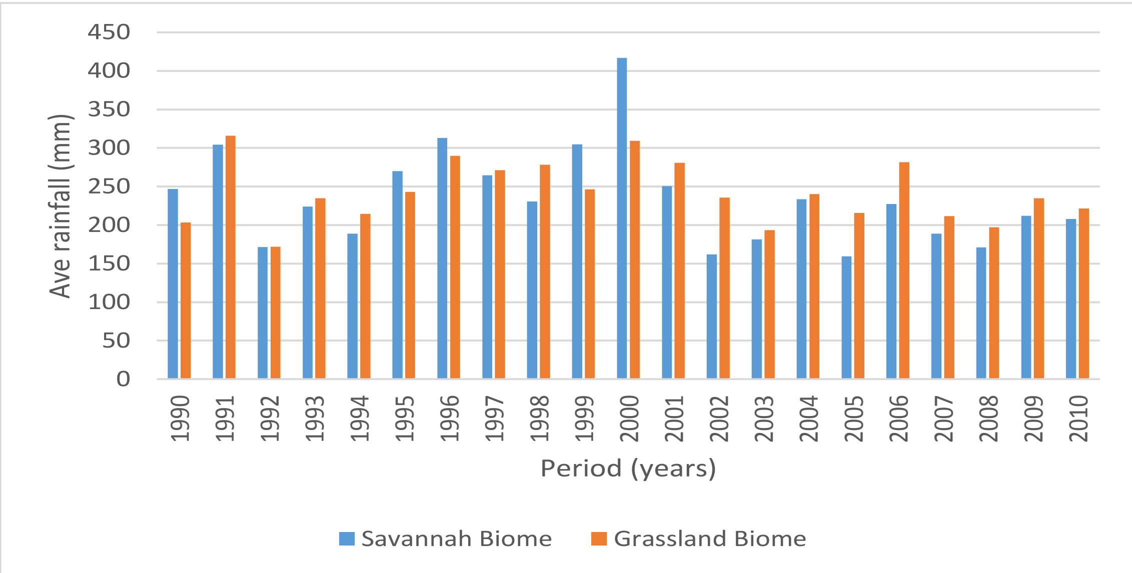

Figure 8.3: Annual rainfall average in the Savannah and Grassland Biomes- 1990-2010 (ARC Weather data)

According to the ARC weather records, from 1990 to the beginning of 1995 the country experienced drought. However, in 1995 rainfall started to improve as shown in Figure 8.3, with the Savannah Biome receiving more rainfall than the Grassland Biome. This could partly explain the improved performance in the calf weights. However, the distribution of the rainfall within the rainy season can also have an important effect on grass growth. This aspect was not studied.

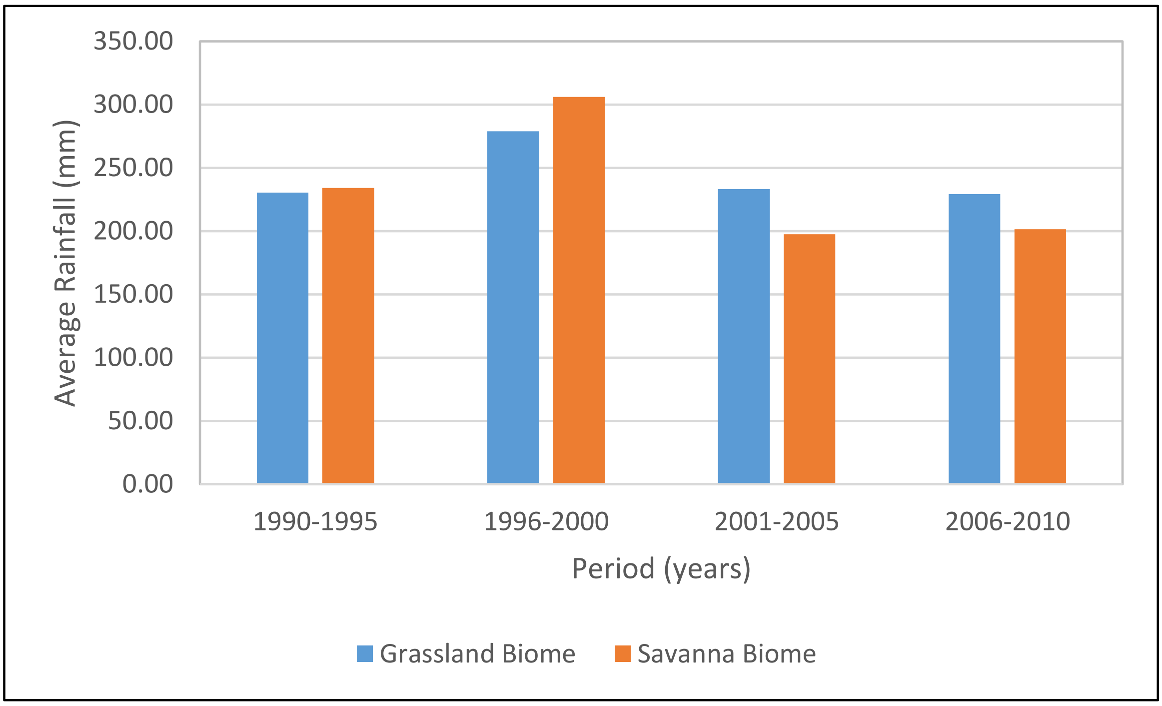

Figure 8.4: Annual rainfall average in the Savannah and Grassland Biomes in year groupings (ARC Weather data)

Year grouping 1 (1990-1995), showed the best performance of calves for all the weight categories, with calves in the Savannah Biome performing better than those in the Grassland Biome. However where the biomes and year effects influences the factors affecting growth, calves in the Grassland Biome performed better between 1990 and 1995. The difference in performance as shown in Figure 8.4.

The study therefore, for the specific Nguni herds selected, was successful in supporting the theory that vegetation is key to the productive performance of cattle. The two biomes, Savannah and Grassland are both suitable for keeping cattle and producing efficiently. Important factors for beef cattle production in these biomes are the result of climatic factors such as the rainfall, (humidity and cold spells) which could unfortunately could not be specifically quantified in the current study. Another major factor in beef production which has a great influence on the productivity of beef cattle is the management practice of the owner, as shown by Van Niekerk *et al*. (2004b).

Many researchers have emphasized the importance of the body condition of the cow for continued productivity in the herd. Good body condition does not only support continued efficient production of the cow, it also ensures good calf growth up until weaning as this is influenced by the milk production of the dam. Even though the Nguni breed is an adapted breed, finer details such as ecotypes within the breed have implications on the productive performance of the breed, as was found by Maciel *et al.* (2016) in a study conducted to see if different ecotypes living in the same environment will differ in cow productivity and reproductive efficiency.

It is further acknowledged that the difference in performance might be affected by geographic area of origin, as noted by Van Niekerk *et al.* (2004b). The findings of Van Niekerk *et al.* (2004b), might also explain the smaller differences in the production performance of cattle which are kept in the same biome but in different bioregions. However, between biomes there are issues of adaptation especially for cattle which have come from different geographic areas. What comes out clearly in this study is the principle established by other researchers, that despite the adaptability features of the Nguni breed, the environment still plays a role in the productive efficiency of the breed.

In the current study, the data set was voluminous but there were many aspects which resulted in exclusion of data. There were cases of incomplete and incorrect data which were excluded from analysis, but the dataset was still large enough for a scientific study.

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