

**Influence of agro-ecological region on selected  
anthropometrical measurements of Nguni cattle  
in South Africa**

**By:**

**Boichoko Duncan Botsime**

**Submitted in partial fulfillment for the requirement of the Degree  
Magister Institutionis Agrariae (Animal Production)**

**PROMOTER: Prof. E.C.Webb**

Department of Animal and Wildlife Sciences  
Faculty of Natural and Agricultural Sciences  
University of Pretoria  
Pretoria  
South Africa

**OCTOBER, 2005**

**Influence of agro-ecological region on selected anthropometrical measurements of Nguni cattle in South Africa**

**By:**

Boichoko Duncan Botsime

PROMOTER: Prof. E.C. Webb (University of Pretoria, Pretoria, 0002)  
DISSERTATION FOR THE DEGREE: Magister Institutionis Agrariae (Animal Production)

**ABSTRACT**

The primary objective of this research was to study the effects of agro-ecological regions (as represented by the veld types in four different areas), sex, season of birth, the interaction between sex and season of birth as well as the interaction between veld type and season of birth on selected anthropometrical measurements (body dimension measurements). The correlations between these selected anthropometrical measurements were also investigated in this study.

Data from four herds of Nguni cattle comprising of 416 animals (Loskop South, Fort Hare, Kroonstad and Warmbaths with 115, 106, 97, and 98 animals respectively) was analysed. Measurements were taken in different seasons at each area or location. Statistical analyses of the data were done using the general linear model (GLM) procedure of the Statistical Analysis System (SAS, 2002).

The results of this study indicate that veld type, sex and the interaction between sex and veld type did not significantly ( $P < 0.05$ ) affect the growth (selected anthropometrical measurements) of Nguni cattle. In all the four agro-ecological regions (veld type in the different regions), season of birth, the interaction between sex and season of birth (Sex\*BS) and the interaction between season of birth and

veld type (V\*BS) showed a significant effect ( $P < 0.05$ ) on selected body dimensions.

Animals that were born during the winter and spring seasons were heavier ( $P < 0.05$ , 333.37 kg and 336.95 kg respectively) than those born in summer (270.35 kg) and autumn (286.29 kg). The same can be said of other body dimensions (M, L, HW, HG, SH and HH), whereby the animals that were born during winter and spring seasons had higher values ( $P < 0.05$ ) than their counterparts born in summer and autumn. This tendency was also observed for SC although the difference was not statistically significant.

In conclusion, the study suggested that season of birth, the interaction between sex and season of birth (Sex\*BS) and the interaction between veldtype (agro-ecological region) and season of birth (V\*BS) are important sources of variation in growth of beef cattle, with special reference to Nguni cattle. It is therefore recommended that season of birth and its interaction with both veld type and sex should be given considerable attention in any extensive beef production system (with special reference to the Nguni breed) employed in South Africa. Knowledge of the influence of agro-ecological factors on the growth of beef cattle is of great importance for measuring production capacity, designing and implementing strategies to alter the extensive beef production system and thus to increase the output to ensure a more sustainable economic advantage.

**KEY WORDS:** season of birth, agro-ecological factors, veld type, sex, growth, Nguni, anthropometrical measurements.

## DECLARATION

I declare that the dissertation hereby submitted in partial fulfillment for the requirements of the degree Magister Institutionis Agrariae (Animal Production) at the University of Pretoria has not been submitted by me for other degree at any other institution

Name and Surname: Boichoko Duncan Botsime

Signature : \_\_\_\_\_

Date : \_\_\_\_\_

## **Dedications**

- I would like to dedicate this dissertation to my late mother Mrs J.K.M. Botsime for encouraging me to undertake both undergraduate and postgraduate studies. Auntie, your last wish have been fulfilled, may your soul rest in peace.
- To my sister Mrs D.K. Setlhogomi for her invaluable support both financially and emotionally through out my studies. I would never have been where I am today, were it not because of you.
- To my wife Agatha Botsime for her support, patience and understanding throughout my studies.
- To all my friends for their support and encouragement.

## **ACKNOWLEDGEMENTS**

1. My sincere gratitude and appreciation to Prof. E.C. Webb (my promoter), for his exceptional guidance, encouragement and support which was invaluable in this study. If it was not for you, I would never have been academically where I am today. I thank you Prof.
2. To Mrs Rina Owen (Department of Statistics, UP) for the invaluable support and friendly guidance in the analysis of the data
3. To Dr. A Nephawe (ARC-Animal Improvement Institute) for his support and friendly guidance in the statistical interpretation of the data.
4. To Limpopo Department of Agriculture (Bohlabela District) for allowing me to continue and complete this study.

## TABLE OF CONTENT

CONTENT	PAGE
• Abstract	i
• Declaration	iv
• Dedications	v
• Acknowledgement	vi
• List of tables	ix
• List of abbreviations	x

## CHAPTER 1 INTRODUCTION AND MOTIVATION

1.1. Project theme	1
1.2. Project title	1
1.3. Aim of the study	1
1.4. Motivation	2
1.5. General Introduction	3

## CHAPTER 2 LITERATURE REVIEW

2. Factors that affect the growth of beef cattle	6
2.1. Introduction	6
2.2. The effect of different veld types on the performance of beef cattle	8
2.2.1. Sourveld	9
2.2.2. Sweet grassveld	9
2.2.3. The effect of area differences and veld types on the growth of cattle	10
2.3. The effects of genetic and environmental interactions on beef cattle	11
2.4. The effect of sex on growth of beef cattle	13
2.4.1. Sex differences in mature size and growth rate	13
2.4.2. Sex by environment interaction	14
2.5. Linear body measurements of cattle	14
2.5.1. The relationships between linear body dimensions	14

2.5.2. Correlation between linear body measurements and body weight	15
2.5.3. Relationships between growth parameters and scrotal circumference	17
2.6. The effect of season on the growth of cattle	18
2.6.1. The effect of season of birth on the growth of cattle	18
2.6.2. Month of birth and seasonal effect on growth at weaning	19
2.6.3. Seasonal effects on growth at 12 months	21
2.6.4. Seasonal effects on growth at 18 months	21
2.7. The effect of temperature on the growth of cattle	22
2.7.1. The relationship between cold temperatures and the growth of cattle	24
2.8. Conclusions	24

### **CHAPTER 3 MATERIAL AND METHODS**

3.1. Origin of Data	26
3.2. Measurement	27
3.3. Data analysis	28

### **CHAPTER 4 RESULTS AND DISCUSSION**

4.1 Summary statistics	29
4.2. The effect of veld type and sex on body measurements	30
4.3. The effect of season of birth, sex, veld type and their interaction on body dimensions	31
4.4. The effect of season of birth on body dimensions	34
4.5. The effect of the interaction between sex and season of birth on body dimensions	36
4.6. The effect of the interaction between veld type and season of birth on body dimensions	38
4.7. Correlation between body measurements	41
4.8. Conclusion and recommendations	43
4.9. Critical evaluation	45



**LIST OF TABLES**

- Table 1 Classification of seasons according to months of birth.
- Table 2 Means, standard deviation (SD), minimum (Min) and maximum (Max) values for body measurements for males and females.
- Table 3 Least square means for veld type and effect of sex on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and scrotal circumference (SC).
- Table 4 Analysis of variance for mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and Scrotal circumference (SC).
- Table 5 The effect of season of birth on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and scrotal circumference (SC).
- Table 6 Sex by season of birth effect on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH).
- Table 7 Veld type by season of birth effect on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and scrotal circumference (SC).
- Table 8 Pearson Correlation coefficients between body measurements for males.
- Table 9 Pearson Correlation coefficients between body measurements for females.

## **LIST OF ABBREVIATIONS**

BS	Season of birth
M	Mass
HW	Hip width
SH	Shoulder height
HH	Hip height
V	Veld type
L	Body length
HG	Heart girth
So	Sourveld
Sw	Sweetveld
cm	Centimetres
kg	kilograms
SC	Scrotal circumference

## **CHAPTER 1**

### **1.1. Project theme**

Livestock ecology and growth of domestic animals

### **1.2. Project title**

The influence of agro-ecological region on selected anthropometrical measurements of Nguni cattle in South Africa

### **1.3. Aim of the study**

The aim of the study was to quantify the effect of agro-ecological region (veld type), in relation to other known influential factors such as the season of birth, sex, the interaction between sex and season of birth as well as the interaction between the season of birth and veld type on the growth of Nguni cattle under extensive conditions of South Africa.

To understand the differences between agro-ecological regions and/or veld types in relation to beef production in order to manipulate, where possible, the environment for economic advantage.

To provide the basis for recommendations on possible future extensive beef cattle production systems in areas under consideration and in other similar parts of South Africa and thus developing baseline data for future intervention programs.

#### 1.4. Motivation

Growth is a complex biological process that must be evaluated carefully if a profitable combination of growth and efficiency is to be realized. Knowledge of the quantitative rate of increase in weight and the way in which changes in shape and body composition occur in different animals and breed groups is vital to the animal scientist and the farmer alike (Nadarajah, Marlowe and Notter, 1984). An understanding of how cattle grow may lead to methods for manipulation of the process towards improved efficiency or a more desirable product (Berg and Butterfield, 1978).

Knowledge of environmental influences on growth of farm animals and the nature of the magnitude of their effects is required to facilitate management decision making and also required in genetic improvement programmes. Keeping of livestock that are in harmony with the environment in which they are maintained results in the maximum utilisation of the natural resources (Taylor, 1995; Mabesa, 1994; Bosman and Harwin, 1967).

The southern African subcontinent is characterised by enormous variations in the agro-ecological factors that affect the viability of beef production systems. Some factors like the regional and seasonal variation in rainfall, species of grass, shrubs and trees and their accompanying nutritional value are responsible for constant fluctuations in beef production potential (Maree and Casey, 1993). This emphasizes the importance of studying and understanding the influence of agro-ecological region on growth of Nguni cattle in South Africa.

Bioregion (agro-ecological region), through its main environmental factors (rainfall, temperature and topography) is a significant ( $P < 0.01$ ) source of variation and explain 6.8% and 3.4% of the variation in pre-weaning and weaning mass respectively (Ronchietto, 1993). Dooley, Dinkel, McPeake and Lasley, (1982) also found that region affected weaning mass significantly ( $P < 0.05$ ) while Tredeen,

Weis, Rahnefeld, Lawson and Newman (1982) found that pre-weaning growth rate differed by between 10% and 13% between locations.

This study therefore aims to evaluate the effect of agro-ecological regions on the selected anthropometrical measurements of Nguni cattle under extensive conditions in South African.

### **1.5. General Introduction**

Almost since the beginning of written history man has been concerned with the size of his farm animals. The physical laws of nature dictate limits within which various body dimensions of our cattle may vary. Animals that are too large for a particular environment are less well adapted. It is therefore necessary to find animals that are well adapted to the environment of each farm and describe their type by objective measurement. Defining differences between animals is necessary if genetic progress is to be made. Measurements allow detection of changes that occur in the herd or breed earlier than they may be detected visually. Measurement therefore quantifies change over time. They serve as supplemental information to performance test results (Bosman, 1997).

Indigenous cattle in Southern Africa were in the past mainly used as foundation stock for upgrading with *Bos Taurus* cattle, which were thought to be superior (Vorster, 1962; Kars, Erasmus and Van der Westhuizen, 1994). These attempts failed in tropical and subtropical regions and attention then became focused on various purebred indigenous cattle breeds (Bonsma et al., 1950, Walker, 1964 quoted by Kars et al., 1994). The ability of the Nguni to produce and reproduce under harsh environmental conditions (Scholtz, 1988), their natural immunity against endemic diseases (Spikelett and Scholtz, 1985) and sustainability as a dam line in terminal crossbreeding (Scholtz, 1988) have generated interest in the breed amongst many cattle farmers. In 1983 the Nguni became a recognized breed under the Livestock Improvement Act (Act 25 of 1977), (Kars et al., 1994).

Animal response and/or performance are determined by two factors namely: genetics and environment. Environment usually refers to physical factors such as climate; topography, nutrition and it can also include any non-genetic influences on performance such as management and economics (Hammack, undated). An interaction between the genotype and the environment occur when the difference in performance between the two or more genotypes changes from environment to environment. For many species, genotype by environment interaction plays an important role in determining the most appropriate biological type for a given environment (Lasley, 1978; Bourdon, 1997). Several studies on cattle indicate that genotype-environment interaction may influence reproduction; weights and weight gain, depending on the magnitude of the differences between environments (Burns, Koger, Butts, Pahnish and Blackwell, 1979; Theron, 1997). Mathur and Horst (1994) also found such an interaction in chickens.

Productivity in terms of reproduction and growth in all livestock production systems is the most important indicator that animals are adapted to their environment (Maree and Casey, 1993). Environmental influences contribute up to 75% of the phenotypic variation for growth up to weaning (Paterson, 1981).

Growth is a complex biological process that must be evaluated carefully if a profitable combination of growth and efficiency is to be realized. Knowledge relating mature weight to birth weight, maturing rate and the point of inflection of the growth curve in various breeds and crosses used for beef production should enable producers to select breed combinations that will produce the most efficient growth pattern for the operations or production systems. Also knowledge of quantitative rate of increase in weight and the way in which changes in shape and body composition occur in different animals and breed groups is vital to the animal scientists and farmers alike (Nadarajah, Marlowe and Notter, 1984). Generally, rapid growth or weight gain is related to economical and efficient beef production, since it is associated with feed utilization and with increased turnover within the beef enterprise (Preston and Willis, 1974; Dooley et al., 1982, Ronchietto, 1993).

While growth is commonly measured as an increase in body mass per unit time, the composition of the body tissues which together compromise the increased body mass is also of importance, particularly so when growth is compared between animals of different ages (Ronchietto, 1993).

The weight at which the sigmoidal growth curve levels off is taken as mature weight of the individual, and the average rate of maturity is represented by how rapidly the immature weight approaches the mature weight. These two characteristics (mature weight and rate of maturity) of growth have an important impact on the production traits of an individual. Rate of maturing should not be confused with rate of gain because rate of gain will indicate rate of maturing only when the animals being compared are growing to the same mature weight. Rate of maturing for weight is economically important because it only affects how soon heifers can be bred, but it also affects certain offspring-dam relationships that results in calving difficulty, the efficiency of use of feed by steers in the feedlot and the acceptability of steers carcasses. Most breeders are aware of the relationship of mature weight to maintenance costs but seem less aware that different patterns of growth can influence cost of development. At any given age, a specific weight must be maintained to reach that age. Therefore, comparisons of the pattern of growth of different individuals indicate differences in feed required for development at any given age or weight. The proportion of mature weight attained at any given age or weight may also be used to indicate differences in physiological maturity among individuals. Certain body dimensions can be helpful in evaluating the pattern of development of the skeletal frame. As weight increases, bone and muscle develop first. As maturity for bone is approached, the fattening process increases. Monitoring these changes objectively, with body dimensions and fat measurements can aid in guiding a breeding program (Brown, Brown Jr, and Johnson, 1983).

A compromise is necessary, considering that weights at all ages are positively correlated and that selection to increase market weight at weaning or slaughter tends toward selection for increased birth weight (which may increase calving

difficulties), increased maturing rate (which delays sexual maturity and the onset of fattening). The best compromise with reference to weight will vary as requirements for adaptation to different climates, feed resources and market demands change (Brown et al., 1983).



## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2. FACTORS THAT AFFECT THE GROWTH OF BEEF CATTLE**

##### **2.1. INTRODUCTION**

Livestock in South Africa is characterized by diversity. The wide range of species and breeds of farm animals found in South Africa, in one sense reflects the great heterogeneity of the natural environment in which animal production takes place, and the continuing efforts of the producer to obtain a type best suited to his own environmental circumstances. The concept that the farm and animal type of animal production undertaken in a given country or part of a country should be in harmony with the prevailing environmental conditions is accepted worldwide (Ronchietto, 1993).

Knowledge of environmental influences on growth of farm animals and the nature of the magnitude of their effects is required to facilitate management decision making and also required in genetic improvement programmes. Keeping of livestock that are in harmony with the environment in which they are maintained results in the maximum utilization of the natural resources (Taylor, 1995; Mabesa, 1994; Bosman and Harwin, 1967).

To achieve improvement in the efficiency of animal production, the capacity of animals for reproduction and growth, particularly as influenced by season, environment and behaviour must be taken into account (Bonsma and Skinner, 1969).

Growth is a very complex process characterized not only by increase in size but also changes in form and functions of different parts of the body. Growth commences at conception and continues until the animal achieves the mature size characteristic of the breed and species. The increase of body mass with time, which characterizes the growth process, is normally accompanied by changes in

the rate at which basic materials are deposited. Beef is produced by the growth of body tissues of cattle such as muscle, fat and bone (Berg and Butterfield, 1978). The tissues of the body (bone, muscle and fat) grow at varying rates from conception to death. In cattle, before birth, bone development is very fast, while muscle development is slow, and fat development is exceptionally slow, resulting in the birth of a calf that is tall, lacking in muscle and with almost no fat at all. After birth, muscle tissue grows fast relative to bone tissue, while fat grows at a slow rate until the animal nears mature size, when fat deposition accelerates (Paterson, 1992).

An understanding of how cattle grow may lead to methods for manipulation of the process towards improved efficiency or a more desirable product (Berg and Butterfield, 1978).

More detailed studies are necessary to understand why the observed level of animal production is obtained and why it may vary within and between years, and the relevance of the information to other areas and situations (Corbett, 1979).

## **2.2. The effect of different veld types on the performance of beef cattle**

The grazing ruminant exists in a highly dynamic situation. Its performance in terms of growth, milk and wool production is determined not only by changes in nutrient requirements, but also by the physical environment as well as quantity and quality of available pastures (Reid and Jung, 1982 quoted by de Waal, 1990).

The South African veld types are extremely diverse in botanical composition (Acocks, 1975), dry matter (DM) production potential and therefore nutritive value (i.e. ability to sustain animal production). Generally in South Africa the season of use of veld is described by using the terms sweet, mixed and sour. By definition sweet is veld that remains palatable and nutritious even when mature, whereas sour veld provides palatable material only during the growing season and the mixed veld is intermediate between these two extremes (Scott 1947 quoted by Tainton, 1999).

### **2.2.1. Sourveld**

Sourveld of South Africa extends to about 13 million ha and is estimated to carry 1,5 million cattle and about 6 million sheep. Sour grass veld provides palatable and nutritious grazing material for only six to nine months of the year, from about October/ November to May/June. The palatability and quality decline rapidly as the plants mature so that its feed value is low in winter, particularly where rainfall is high since here the grasses tend to mature early in the growing season. In such areas livestock lose mass during winter, even when provided with a protein rich supplement. Most classes of cattle are well adapted to produce on sour grass veld during spring and summer. Yearling beef animals will normally gain between 70kg and 110kg per animal during the period October/ November to March/April, and beef cows, which calve in spring, will wean calves weighing between 180kg and 240kg in April/May. The cows will maintain condition provided they are stocked at an appropriate stocking rate (Tainton, 1999).

### **2.2.2. Sweet grassveld**

The sweet grassveld of South Africa are tufted climatic- climate grassveld. They occupy about 45% of the potential grassveld and are of about 44 million ha. Less than 35% of this area remains as open grassveld, with the majority having been invaded by Karoo pioneers (Acocks 1975). The semi-arid grasslands are typified by an extremely variable rainfall, both within and between years. Dry matter (DM) produced therefore varies considerably from year to year and from season to season.

Forage quality in sweet grassveld is higher than in sourveld and remains fairly uniform throughout the year. Growing stock tends to maintain condition during winter and may continue to gain mass.

Average daily gains in the range of 1.0 kg /day in summer and 0.8kg to 0.9kg in winter may be expected and yearling beef animals may gain between 150kg and

200kg over spring and summer. Beef cows that calve in spring will wean calves of between 210kg and 250 kg in April or May (Drewee 1991 quoted by Tainton, 1999).

### **2.2.3. The effect of area differences and veld types on the growth of cattle**

Approximately 33% of the land area in the world is either arid or semi-arid. These areas are characterized by seasonal fluctuations in forage quality and quantity, resulting in cyclic weight losses and gains in livestock (DeNise and Ray, 1987).

In a grazing experiment conducted at Mara Research Station in which its grazing veld was divided into two types, i.e. "Haak-en-steekveld" (*Acacia tortilis*) which is typically a sweet veld type and "Rooibosveld" (*Combretum apiculatum*) which is a mixed veld type. The results of this experiment showed that Afrikaner oxen had a liveweight of 425 kg at three and half (3½) years of age on Rooibosveld and those on the Haak-en-steekveld weighed 523 kg at the very same age (Bonsma, 1980). Leighton, Wilham and Berger (1982) stated that location is only one of the components that would cause variation in weaning growth, of biological importance.

Bioregion (agro-ecological region), through its main environmental factors (rainfall, temperature and topography) is a significant ( $P < 0.01$ ) source of variation and explains 6.8% and 3.4% of the variation in pre-weaning and weaning mass respectively (Ronchietto, 1993). Dooley et al., (1982) also found that region affected weaning mass significantly ( $P < 0.05$ ), while Tredeen et al., (1982) found that pre-weaning growth rate differed by between 10 and 13% between locations ( $P < 0.0001$ ).

Burfenning, Kress and Friedrich (1982) found that location also had a significant effect on ease of calving and birth mass, whilst Mwandotto, Carles, Smith and Cartwright (1983) noted that region of birth had a significant effect on post weaning growth (18 months).

Everitt et al. (1969) cited by Ronchietto (1993) found that 54% of total variation in mass of meat produced is due to between farm variations in terms of size, topography, fertility and productivity.

Large variations in dry matter yield of veld, primarily due to differences in annual rainfall as well as its distribution occur at any specific site between years and are invariably reflected in animal performance (de Waal, 1990).

According to Eloff and Pienaar (1965), sweetveld regions with an average rainfall of from 350 mm to 450 mm per annum are suitable for the breeding of beef and dual-purpose breeds. Breeding cows do better in these regions than in areas with lower rainfall. At Mara Research Station, with an average rainfall of 400 mm per annum, the average fertility of Afrikaner cows was approximately 78%, while at Messina Experimental Station, with an average rainfall of 300 mm per annum the average fertility dropped to 71%. The average weaning weight of Afrikaner calves at 8 months of age also differed considerably at these two areas. At Mara the average was approximately 405 lb ( $\approx$ 184 kg), and at Messina was 345 lb ( $\approx$ 157 kg). During favourable and good seasons oxens in the Mara area were well finished for marketing from veld at 3½ years of age. On the sweetest veld in this area, however, oxen can achieve super and prime grades even at 2½ years of age without supplementary feeding. In less favourable seasons oxen do not achieve first and primes grade before 4½ years.

### **2.3. The effect of genetic and environmental interactions on beef cattle**

Animal response or performance is determined by two factors namely: genetics and environment. Environment usually refers to physical factors such as climate, topography, nutrition and it can also include any non-genetic influences on performance such as management and economics (Hammack, undated and Bourdon, 1997). For, many species, genotypes by environment interaction play a critical role in determining the most appropriate biological type for a given environment.

The interaction between heredity and environment means that animals of a certain genotype may perform more satisfactorily in one environment than in another. In other words, one environment permits the expression of the genetic characters in a breed or strain, while another does not (Lasley, 1978).

According to Lasley (1978), phenotypic variations due to environment are important because of the following reasons:

- They are not transmitted from parents to offspring.
- They overshadow variation due to heredity.
- The proper environment is necessary for an individual to reach its genetic potential.
- Rapid improvements can be made in the efficiency of livestock production by providing or creating uniform and superior environmental conditions to breeding animals and those used for commercial production.

According to Bishop (1993) genotype environment interactions for gain or lean gain in beef cattle are likely to be small, for environments which essentially differ only in the quality of nutrition available and probably will not be an important factor in making selection decisions where environments differ sufficiently to make adaptation to environmental stresses necessary, e.g. under tropical conditions. Bishop (1993) concluded that genotype – environment interactions may be an important factor, which need to be considered when undertaking genetic improvement.

The results from the study conducted by Theron (1997), suggested that the genetic correlations between post weaning growth traits of bulls on a concentrate diet and heifers on pastures are different from unity. A genetic correlation of unity means that no interaction is present and that the two traits are the same (Robertson, 1959 quoted by Theron, 1997).

The best possible inheritance will not result in a superior herd or flock unless the proper environment is also supplied so that the animals can attain the limit set by their inheritance. Half-starved and neglected purebreds are truly a disappointment to livestock men, in their appearance as well as in their performance.

Nevertheless, the best possible environment will not develop a superior herd or flock unless the proper inheritance is also present in the animals (Lasley, 1978).

## **2.4. The effect of sex on growth of beef cattle**

### **2.4.1. Sex differences in mature size and growth rate**

There is consensus among researchers that, generally, male calves are heavier than their female counterparts and the difference increase as the calves grow older. Sex differences in mature size are well documented (Mabesa, 1994; Lubout, 1987; Mwandotto et al., 1988; Nahaus, 1992; Gilbert, Bailey and Shannon 1993; Koster, 1994).

Galbraith and Topps, (1982) quoted by Robelin and Tulloh, (1992) summarized the differences in growth rate as follows: the rate of gain is 10 – 20% higher in bulls than in steers, it is similar in steers and heifers, and it is 5% higher in heifers than in spayed heifers.

The results obtained by Gilbert et al., (1993) showed that sex of calf effects were significant for all measurements, that is, (hip height, wither height, hip width, body length, head length, head width, muzzle width, cannon bone circumference) except heart girth ( $P < 0.04$ ).

According to Köster (1994) sex of calf influenced growth and efficiency. Bull calves and/or steers in the study were significantly ( $P \leq 0.01$ ) heavier than heifers, as well as the ratio for bull:cow mass at birth and weaning. However, according to Lubout (1987), differences in mass between sexes seemed to be less under stressful and extensive conditions.

### **2.4.2. The effect of the interaction between sex and environment**

The effect of sex of calf on pre-weaning growth is so considerable, particularly, in the latter part of the suckling period. Bull calves have greater growth potential than heifer calves, therefore, it is possible to exploit its potential superiority to a greater extent. All factors influencing the environment, particularly the nutritional aspect, should allow for the existence of an interaction effect (Paterson, 1978).

The performance of both bull and heifer calves from lines previously selected for lean growth rate on a concentrate diet, was evaluated on a grassland diet over a period of three years in an Australian study by Bishop (1993). The genetic correlation between lean growth rate measured on a concentrate diet and measured on a grassland diet, was 0.57 for lean gain on test and 0.56 for total lean gain. However, if only males were considered, these correlations rise to 0.80 and 0.70, respectively. Bishop (1993) therefore concluded that although the same evidence for genotype-environment and genotype-sex interactions exist, selection for growth on a concentrate regime will still be effective in improving grassland performance under circumstances.

## **2.5. Linear body measurements of cattle**

### **2.5.1. The relationships between linear body dimensions**

Numerous studies have examined various body dimensions in beef cattle to describe more thoroughly biological variation and to interpret the relationships with measures of performance, productivity and carcass characteristics (Brown, Brown and Butts 1973 a,b. and Brown, Brown Jr and Johnson, 1983).

Surface measurements (length, height, width, etc) have been made since the beginning of the 19<sup>th</sup> century. These measurements are effective for recording major differences between genotypes in skeletal size and proportions.



Body measurement, such as hip or wither height, could be used to study development. Hip height is a trait indicating maturity at an early age, followed by wither height and shoulder width (Brown et al., (1983).

### **2.5.2. Correlation between linear body measurements and body weight**

According to Meyer (1995), correlations of early skeletal measures with individual weights were highest for weights at the time of measurement, in the order of 0.6 to 0.7 for both  $r_A$  (genetic correlations) and  $r_P$  (phenotypic correlation) in Hereford and Charolais x Brahman bulls with Friesian x Angus or Hereford cows, "Wokalups" for short. These are in agreement with those reported by Atkins and Thompson (1986) for  $r_A$  and  $r_P$  between CB (cannon bone length) and body weight in sheep, both measured at 8 weeks of age, of 0.55 and 0.73 respectively. Estimates of  $r_A$  between CB and mature size by either measure were of similar magnitude, i.e., CB provides a good, early predictor of mature size and as univariate analyses fitting weight as a coverable showed, exhibited considerable genetic variation independent of weight.

However, cannon bone length (CB) and rate of maturation (K) showed a negative genetic correlation of about 0,5 meaning that faster maturity animals (large value of K) tended to have shorter cannon bones at birth. While correlations with hip height (HH) in Wokalups were similar to those for CB, there appeared to be little genetic association between HH and weight post weaning or rate of maturation in Herefords. Correlations between the two measurements of mature size i.e MW (mature weight) and A (average mature weight maintained) were high, about 0.9 genetically and 0.8 phenotypically. A genetic correlation of about 0.7 between A (Average mature weight maintained) and canon bone length, together with habitability ( $h^2$ ) estimates for CB of 0.29 (Herefords) and 0.44 (Wokalups) suggested that cannon bone length, measured in early life, might be a good skeletal measurement to predict mature size.

The results of the study conducted by Enevoldsen and Kristensen (1997) showed how the unadjusted correlation indicated that hip width was the strongest single

predictor for the estimation of BW, which should have been expected because hip width is the body dimension that is developed last and thus exhibits the most variation.

Köster (1992) found a high positive genetic correlation between birth mass and length of metatarsus ( $r_g = 0.810 \pm 0.172$ ) as well as between birth mass and body length ( $r_g = 0.912 \pm 0.152$ ) at 1 year of age. Cannon bone length was also positively correlated ( $r_g = 0.706 \pm 0.233$ ) to average gain per day age (ADA) at 365 days.

Magnabosco et al. (2002) also found that the genetic correlation among all body measurements (hip width, hip-pin width, anterior height, posterior height, body length, thorax perimeter, scrotal circumference and weight) were consistently positive and high, ranging from 0.64 to 1.00. Although other measurements showed a high genetic correlation with weight, thorax perimeter combines a high value (0.70) with ease and repeatability, making it a useful field measurement to estimate body weight when scales are not available.

Naude (1959) quoted by Koster (1992) studied the growth and development of studbook Hereford in three climatic areas). He evaluated the Hereford present at that time in South Africa according to body mass and certain body measurements. The average hip height for an 18-month bull was 113.7cm.

Naude (1959) reported hip height for Hereford stud cattle at different ages-for males: 94 cm at weaning, 106.8 cm at 1 year, 113.7cm at 18 months and 117,4cm at 2 years. Hip height for females was 92.3 cm, 104.7cm, 110.9cm and 114.4cm weaning, 1 year, 18 months and two years respectively. Thus the cattle under the study by Köster (1992) were therefore taller than the average Hereford studied by Naude (1959).

A study by Long, Steward, Cartwright and Jenkins (1979) reported least square means for hip height of Hereford bulls as 1073 mm and 1170 mm at 360 and 540 days respectively.

The results of the study conducted by Maiwashe et al., (2002) showed that simultaneous selection for body measurements and growth traits is feasible.

The practical application of their results is that body measurements may be useful as selection criteria for performance traits in those instances where weight measurements might not be feasible, such as small-scale and emerging farmers, who do not have weighing scales.

### **2.5.3. Relationships between growth parameters and scrotal circumference**

Information on the relationship between growth rate and scrotal circumference (SC) would be helpful when growth rate and testes size are both considered in selection of young bulls. Scrotal circumference has been reported to be a highly heritable trait, with most estimates to be around 0.60 (Coulter, 1982).

According to Swanepoel and Heyns (1986), highly significant correlations ( $P < 0.01$ ) existed between initial body mass and scrotal circumference ( $r = 0.321$ ) as well as between final mass and scrotal circumference ( $r = 0.388$ ).

By using the regression equation of  $y = a + bx$ , it was clear that for each 4.85 kg increase in body mass there was an increase of 1cm in scrotal circumference in young bulls for their specific test. Those results were in agreement with those of Venter, et al (1977) who worked with Afrikaner, Hereford and Simmental bulls as well as those of Makarechian, Farid and Berg (1984).

Significant correlations ( $P < 0.05$ ) exist between scrotal circumference and age ( $r = 0.150$ ) and between SC and average daily gain per day of age ( $r = 0.147$ ), which can be explained because ADA (average daily gain per day of age) is a function of age (Swanepoel and Heyns, 1986).

According to Makarechian et al. (1984), SC was positively correlated with body weight at the end of feedlot test in the four breeding groups. Body weight and SC are correlated primarily because of their mutual association with age and growth traits.

Body length, as measured from the shoulder (tuberositas major) to the pin bone (tuber ischium), showed a highly significant correlation with end of test SC ( $P < 0.01$ ),  $r = 0.285$ . SC exhibited a highly significant ( $P < 0.01$ ) correlation of 0.4917 with ADG (Average daily gain) over the 140-day test period.

This correlation of SC and ADG was contrary to what Swanepoel and Heyns (1986) found. They found no significant correlation between SC and ADG (van Rooyen and Wilke, 1990).

Thompson, Thrift and Nicholas (1985) cited by Köster (1992) indicated a hip height of 1280 mm and a scrotal circumference of 35.9 cm at 365 days of age respectively for Hereford bulls involved in a central bull test program at Kentucky university.

## **2.6. The effect of season on the growth of cattle**

### **2.6.1. The effect of season of birth on the growth of cattle**

In South Africa calves born in winter and early summer have been found to be generally lighter than calves born in summer (Bosman and Harwin, 1966). Manipulation of the calving season is therefore essential to ensure the most favourable conditions for both the cow and the calf (Venter, 1977). Heyns (1974) and Venter (1977) reported that although the birth mass of calves born later in summer was lighter, these cows (dams) lost more weight than cows calving earlier.

Season of birth had a highly significant effect on birth weight. Calves born early in the season were significantly lighter than calves born later in the season (Bosman and Harwin, 1966). Hartzenberg (1971) found in his study (data from Mara Research Station) that calves born in late summer (January, February, March) had heavier birth mass while those born in winter (May, June, July, August) were the lightest in terms of birth mass. This difference could be attributed to the poor condition of cows during the last trimester of gestation period. Heavier calves might be due to good feeding and thus improved condition of cows during the last trimester of gestation period.

Bosman and Harwin (1966) showed that calves born at the beginning of the calving season (November to January) were 5 kg and 7 kg lighter in two herds than those born at the end of the season. Lombard (1971) indicated that the difference

is in the order of 3.5 kg. Venter (1977) has shown that calves born in the middle of the season were heavier than those born either early or late in the summer season. Van Zyl (1982) also found that calves born in spring or early summer are heavier than other calves born late in summer

Winter born calves may be lighter than summer calves (Bonsma and Skinner, 1969; Hatzenberg, 1971) but Venter (1977) reported winter born calves to be heavier than early, mid or late summer calves although the results were not statistically significant. Paterson (1978) therefore concluded that birth mass tends to be low in September and October increasing to April after which it decreases to August. This pattern of increasing and decreasing birth mass appears to follow that of feed availability very closely which would indicate that the birth mass is influenced by the cow mass at calving (Joubert and Bonsma, 1957 quoted by Paterson 1978). On the contrary, Mabesa (1994) found that the season of birth had no significant effect on the birth mass of calves. This could be attributed to strict selection against high birth masses and a high level of pasture management, which was practiced on the farm, thereby decreasing the effect of season on the birth masses.

### **2.6.2. Month of birth and seasonal effect on growth at weaning**

Normal calving season in South Africa is in the spring (August to November). Calves born later in the summer (after December) perform poorly up to weaning (Bosman and Harwin 1967) because they pass through a poorly supplemented winter prior to weaning.

Late winter and spring calves had the highest weaning mass and late summer and autumn calves the lowest, although the effect of the month of birth varied between years. The effect of the linear and quadratic regressions of weaning mass on month of birth was highly significant (Lubout, 1987). These results were in agreement with those of other authors (Bosman and Harwin, 1966, 1967; Paterson, 1978; Swanepoel, 1986; Viljoen, 1986).

Venter (1977) reported that winter calves have a heavier weaning mass than that of spring and summer calves while Wilson et al. (1983) reported non-significant effects for season of birth on weaning mass.

Vorster (1962) found that the weaning weight of calves dropped significantly ( $P < 0.01$ ) from 343 lb (ca. 155.59 kg) for calves born in December to 259 lb (ca. 117.48 kg) for calves born in March. Since all calves in the study by Vorster (1962) were weaned at the same time every year this decrease in weight could be ascribed to variations in age and to the fact that calves born later in the season (summer calving season) naturally tend to grow more rapidly than those that were born later (autumn and winter) when the veld was deteriorating in nutritive value.

Van Zyl (1982) found that calves born in spring and early summer had heavier weaning mass than calves born during late summer calving season although their birth mass were lower. Where there is no specific calving season, Bishop (1978) found that calves born in spring had heavier weaning mass than calves born in the other seasons of the year.

The seasonal variation in climate influences the nutrient availability to the calf by the way of dam's milk supply, grass growth and availability of crop residues and preserved fodder. Thus differences in calf growth will occur according to the season of birth.

Cundiff et al., (1966b), in the study conducted in America reported that calves born in winter and spring months, December to May have higher pre-weaning growth than those calves born in the summer and autumn months, June to November.

The results of the study conducted by Lubout (1987) showed that the effect of the linear and quadratic regressions of weaning mass on month of birth was significant ( $P < 0.05$ ), but the quadratic regression of 205-day mass on month of birth was found to be non-significant. The results of the study by Lubout (1987) compared well to those reported by Van Zyl (1982), and Wilson et al. (1983), where the effect of season of birth was significant on actual weaning mass, but not on 205-day mass. This is in contrast to most of the other results observed in the literature that showed significant effects for month of birth on adjusted weaning mass (Burfening, 1974; Paterson 1978; Bosman and Harwin, 1967; Swanepoel, 1986).

### **2.6.3. Seasonal effects on growth at 12 months**

Significant effect of season of birth on 365-day mass of beef calves has been reported (Van Zyl 1982; Lubout et al., 1986; Lubout, 1987; Nauhaus, 1992).

Calves born in spring have a higher 12-month mass than those born in late summer (Van Zyl, 1982; Lubout and Swanepoel, 1990; Nauhaus, 1992). Winter-born calves displayed heavier 365-day and 540-day mass than their summer counterparts (Mabesa, 1994).

### **2.6.4. Seasonal effects on growth at 18 months**

Studies by various researchers have found a significant effect of calving season on 18 months mass (Lubout et al., 1986; Els and Venter, 1990; Lubout, 1987).

Els and Venter, (1990) reported that differences in 18 months masses due to season of birth could be in some way attributed to the feeding regimes of the cows and the grazing potential, as well as the ability of the calf to utilize milk and grazing available.

Generally the calves born in November to January had the highest 540-day mass while those born in May to July had the lowest 540-day mass. The effect of month of birth varied from year to year (Lubout, 1987).

Lubout et al. (1986) reported that November born Nguni and Pedi calves weighed 3kg and 6kg respectively more than the December-born Nguni and Pedi calves.

## **2.7. The effect of temperature on the growth of cattle**

Temperature is the most important factor in determining which type of animal can be maintained in a particular area. In areas where the atmospheric temperature is high and where the average annual isotherm (the average temperature of the year) is high, unadapted cattle will degenerate (Bonsma, 1980).

Few British breeds of livestock can thrive in areas where the average annual isotherm is above 18.3 °C. If it exceeds 21.1 °C, all British breeds of livestock will suffer from tropical degeneration. Tropical degeneration is characterized not only by stunted growth but also by a marked reduction in fertility. Animals not tropically adapted, which cannot withstand high temperatures, become hyperthermic and often show a rise in body temperature as high as 40 °C to 41.1 °C. Young animals from birth to one year of age suffer appreciably more than older animals.

The pre-natal thermal environment prior to birth can influence the growth and development of the fetus. Pregnant cows exposed to Florida summers with no shade produced calves with significantly smaller body weight at parturition (Collier et al., 1982). Dam pre-parturient weight was 598 kg in shade and 589 kg in no shade conditions. Calf weight was 39.7 kg versus 36.6 kg for no shade.

The young animal's thermoregulatory mechanism does not function properly at first, only when the animal is approximately one year old does the unadapted animal become able to maintain a body temperature a few degrees lower than in its first year.

According to Bonsma (1980), animals that show signs of hyperthermia are tremendously retarded in growth and Shorthorn, Hereford and Aberdeen Angus cattle at the Messina Research Station often had a mass of as little as 318 kg at three years of age, whereas the adapted animals that are heat-tolerant had a mass of 499 kg or more.

Growth and development are associated as closely with the environmental temperature as they are with food and water. Animals are able to survive only within a certain temperature range. Within that range is a smaller one over which growth and development proceed optimally, and a certain amount of suitable food producing the maximum growth rate (Batt, 1980).



The speed of growth and pattern of development reflect the suitability of the environmental temperature as much as the nature of the diet it affords.

As the temperature rises, there is a sparing action on the food. Initially, a rise in temperature may cause an acceleration of growth going on to an elevated growth plateau, such as it occurs in pigs. Eventually a temperature is reached at which growth is depressed. This approaches a point where the constant core temperature of the animal is threatened or tends to rise. The cells of some tissues have a small range of temperature within which they can metabolize or survive. Above this temperature range, the animal is said to be in a condition of heat stress, which is characterized by loss of appetite, increased respiratory rate and heat production, and in some species increased perspiration or salivation. These processes necessitate increased water consumption at the expense of food consumption. The growth rate of animals kept near to heat stress is depressed to some degree, young animals tolerating heat less well than adult. Depression of growth will depend on the severity of the stress and the degree to which the individual has adapted physiologically to a high environmental temperature.

The ultimate purpose of growth of livestock in any bioclimate is to convert animal feedstuff for human consumption. The rate and efficiency of this conversion as affected by the environment is economically important to producers and consumers (Ames, 1980 cited by Johnson, 1987).

The slower growth at 27 °C is due to high temperature depression of appetite. If hot bioclimate is a constraint to maintenance of normal body temperature, a reduction of feed intake confers obvious benefit to a heat stressed animal by a reduction of endogenous heat production. Reduced feed intake, as well as increased thermoregulatory demands and altered hormonal states reduce the ability of cattle to achieve their genetic potential for growth (Lampkin and Quarterman, 1962 cited by Johnson, 1987).

### **2.7.1. The relationship between cold temperatures and the growth of cattle**

A post-weaning 7-year study by Milligan and Christison, 1973 cited by Johnson, 1987 showed that winter (December to February) in western Canada markedly reduced the productivity of feedlot steers. Average daily gain was reduced by 30% and feed efficiency by 33% compared to the remainder of the year.

The physiological factors involved in the cold effects for beef cattle may be a reduced apparent digestibility of dry matter (DM) (Christopherson, 1976). Beef calves fed chopped hay and grain had 8% lower digestibility at outdoor (-6 to -10 °C) than thermoneutral (heated barn). The decrease was 0.21% per 1 °C decline in temperature.

## **2.8. CONCLUSION**

Growth is a complex biological process that must be evaluated carefully if a profitable combination of growth and efficiency is to be realized. Knowledge relating mature weight to birth weight, maturing rate and the point of inflection of the growth curve of various breeds and crosses used for beef production should enable producers to select breed combinations that will produce the most efficient growth pattern for their operations. Knowledge of the quantitative rate of increase in weight and the way in which changes in shape and body composition occur in different animals and breeds is also vital to the animal scientist who is studying the economics of production.

The selection for body measurements, which have strong genetic correlations with weight, could be a useful selection aid because of the opportunity for indirect selection for weight. This is especially important when scales are not available, a relatively common problem in most of South Africa's rural beef cattle production areas.

The results in many studies show us that, although cattle should be able to adjust to the environment to be productive, it would be unrealistic to assume that the same breed (genotypes) will perform at the same level under different environmental conditions.

Knowledge of the major effects and their influence on growth, within a location or area, is of great importance for measuring production capacity, implementing strategies to alter the extensive beef production system and thus to increase the output to more sustainable economic production system.

The relative influence of these factors (season, month of birth and year of birth) varies with breed as well as with environment and therefore a need exists for further investigation using different breeds and/or types in different parts of the country. Due to the large variation in growth of various beef breeds between years and season of birth, an improved system of management should be adopted. The calving season should be regulated to such an extent that the cow and the calf will both have the advantage of the favourable nutritional variation in the feed status of the natural pasture, and merely prevent culling of good breeding animals due to poor condition.

## **CHAPTER 3**

### **Materials and methods**

### 3.1. Origin of Data

Growth data was collected from the Nguni herds, at Fort Hare 32° 41' S, 26° 5' E in the Eastern Cape, Loskop South 25° 18' S, 29° 20' E in Mpumalanga, Warmbaths 24° 55' S, 28° 15' E in Limpopo and Kroonstad 27° 40' S, 28° 15' E in Free State.

Animals were managed extensively and had to survive on natural occurring pastures with no supplementary feeding.

The Loskop South farm is situated 25° 18' S and 29° 20' E in a Bushveld region, south-east of Groblersdal, in the province of Mpumalanga. The vegetation can be described as tree savannah consisting of fairly dense bush as well as sourgrass types, which form the main grazing component (Acock, 1975). The farm has a rainfall range of between 350 mm and 650 mm per year.

The Warmbaths farm is situated 24° 55' S and 28° 15' E in the Bushveld region in Limpopo Province. The vegetation can be described as sourish mixed Bushveld (Acock, 1975). The farm has an annual average rainfall of 620 mm with the range of between 380 mm to 800 mm per year.

Kroonstad is situated 27° 40' S, 28° 15' E in the Highveld grassland in Free State at the altitude of between 1400 and 1600 mm. The vegetation can be described as the cool moist highveld grassland (grassland biome), with predominantly *Themeda triandra*, *Cymbopogon* and *Eragrostis curvula* species forming most part of the grazing component (Acock, 1975; Cowling, Richardson and Pierce, 1997). The farm has an annual average rainfall range of between 600 mm and 700 mm most of which rains during summer.

The Fort Hare farm is situated 32° 41' S and 26° 5' E in the Valley Bushveld region in Eastern Cape Province. The vegetation can be described as dense tree savanna, with predominantly sour grasses forming the major part of grazing. The farm has an annual average rainfall of 612.5 mm per annum with the range of between 332 mm and 990 mm per year.

### 3.2. Measurements

Data comprised of records of 416 (Loskop South, Fort Hare, Kroonstad and Warmbath with 115, 106, 97, and 98 respectively) animals.

The following data were recorded for each of the animals in each herd and all body measurements were taken when the animal was standing with head raised and weight on all fours.

- Birth mass was measured in kilograms by means of weighing cattle scale.
- Length (Body length) – the average of the left and right side measurements (using a tape) of the distance between the point of the shoulder (lateral tuberosity of the humerus) and the pinbone (Tuber ischii).
- Hip height, which represents the vertical distance from the rump to ground level, was measured in centimetres using a vertical standard equipped with a crossbar and a level. The hip height measurement was taken at a point directly over the hip bones with the animal standing on a level surface.
- Shoulder height – was measured on the dorsal midline at the highest point on the withers in centimeters, using a wooden tape that was attached to a horizontal sliding bar of a restraining chute above the animal equipped with a level. It represents the vertical distance from the highest point on the withers to ground level.
- Heart girth, which represents the circumference of the chest immediately posterior to the front leg, was measured with a tape.
- Hip width was measured from the left to the right pinbone (ischium) using a caliper.
- Scrotal circumference was measured by firstly palpating the testicles from top to the bottom of the scrotum (to ensure that both testicles have descended into the scrotum), and was measured with the aid of the scrotal tape.

The classification of seasons according to months of birth is shown in Table 1.

Table. 1. Classification of seasons according to months of birth.

<b>Season</b>	<b>Month of birth</b>
Summer	November
	December
	January
Autumn	February
	March
	April
Winter	May
	June
	July
Spring	August
	September
	October

### 3.3. Data analysis

Analysis of Variance (Anova) and least square means of variance using the General Linear Models Procedure of Statistical Analysis System (SAS, Usage Version 8.2, 2002) was used to analyse the data.

The model of analysis included effects due to veld type, sex, season of birth, the interaction between sex and season of birth as well as the interaction between veld type and season of birth and Pearson correlation coefficient between age, mass, length, shoulder height, hip height, hip width, heart girth and testicle circumference. The significance of difference between least square means was determined at the 5 percent level by means of Tukey's test.

## CHAPTER 4

### Results and discussion

#### 4.1. Summary statistics

Summary statistics, that is the means, standard deviation, minimum and maximum values for age, mass, length, shoulder height, hip height, hip width, heart girth and scrotal circumference are presented in Table 2. These measurements are provided for both males and females.

Table. 2. Means, standard deviation (SD), minimum (Min) and maximum (Max) values for body measurements for males and females

<b>Variables</b>	<b>n</b>	<b>Mean</b>	<b>SD</b>	<b>Min</b>	<b>Max</b>
<b>Males</b>					
Age (years)	164	2.10	1.94	0.19	9.55
Mass (Kg)	169	316.19	180.37	60.00	850.00
Length (cm)	168	127.12	29.20	70.00	192.00
Shoulder height (cm)	168	76.30	9.98	52.30	100.30
Hip height (cm)	168	114.99	15.13	82.30	153.40
Hip width (cm)	168	36.68	11.52	16.00	62.00
Heart girth (cm)	168	156.79	32.32	92.00	222.00
Scrotal circumference (cm)	165	27.59	8.75	11.40	46.50
<b>Females</b>					
Age (years)	252	3.60	3.40	0.19	14.13
Mass (Kg)	288	300.59	119.69	50.00	550.00
Length (cm)	289	125.56	21.64	62.60	164.00
Shoulder height (cm)	287	76.14	8.59	54.00	114.00
Hip height (cm)	287	114.19	12.09	81.20	173.60
Hip width (cm)	289	37.41	8.77	15.80	52.00
Heart girth (cm)	289	154.67	25.00	82.30	192.00

#### 4.2. The effect of veld type and sex on body measurements

The descriptive statistics for the relevant body measurements are presented in Table 3. This table also shows the effect of veld type and that of sex on body measurements.

Table 3. Least square means for veld type and effect of sex on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and scrotal circumference (SC)

Sources	M		L		HW		HG		SH		HH		SC	
	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
<b>Veld type</b>														
So	97	291.24	97	126.80	97	39.86 <sup>a</sup>	97	152.14	97	75.12	97	116.73 <sup>a</sup>	37	29.92 <sup>a</sup>
Sw	204	300.88	204	121.66	204	36.68 <sup>b</sup>	204	157.37	203	74.864	203	112.15 <sup>b</sup>	72	25.15 <sup>b</sup>
<b>Sex</b>														
Male	110	307.29	110	123.64	110	37.62	110	156.03	110	75.08	110	114.67		
Female	191	292.29	191	123.14	191	37.76	191	152.56	190	74.87	190	113.02		

Means with different subscripts within variables are significantly different ( $P < 0.05$ ).

n = no of observations

So = Sourveld

Sw = Sweetveld

According to Table 3, veld type had no significant effect on mass, length, heart girth and shoulder height with the exception of scrotal circumference, hip width and hip height.

It can be deduced from this table that, scrotal circumference of cattle measured in the sweetveld was significantly ( $P < 0.05$ ) smaller (25.153 cm) than those of the sourveld with a scrotal circumference of 29.92 cm. Cattle in the sweetveld were found to be narrower at the hips (hip width = 36.68 cm) than those in the sourveld, with a hip width of 39.863 cm.

Sourveld type animals were significantly ( $P < 0.05$ ) shorter at the hips (112.45cm) than sweetveld animals with a hip height of 116.734 cm. Sweetveld type animals tended to be heavier (300.88 kg) than sourveld type animals (291.24 kg) although the difference was not statistically significant. This might be due to the fact that sourveld provides palatable material only in the growing season as compared to sweetveld, which remains palatable, and nutritious throughout the year. Animal



growth during the winter period in sourveld regions is predominantly negative, while in the sweetveld positive growth can occur in winter (Scott, 1947 cited by Du Plessis and Hoffman, 2004).

Sex had no significant effect on body dimensions although there was a tendency for males to have higher body dimension values than females. This is in accordance with the findings by Lubout (1987) that differences in mass between sexes seemed less under stressful and extensive conditions.

#### 4.3. The effect of season of birth, sex, veld type and their interaction on body dimensions

According to Table 4 (ANOVA results), veld type, sex as well as the interaction between sex and veld type were not statistically significant and this implies that these factors have no effect on the variables and thus the production characteristics measured in this study.

Season of birth, the interaction between sex and season of birth (Sex\*BS) and the interaction between veld type and season of birth (V\*BS) showed a significant ( $P < 0.05$ ) effect on mass, body length shoulder height, hip height, hip width, heart girth, and scrotal circumference. However season of birth had no effect on body length and heart girth. Veld type by season of birth interaction had no effect on scrotal circumference.

Table. 4. Analysis of variance for mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and Scrotal circumference (SC)

	Variables	M	L	HW	HG	SH	HH	SC
<b>Sources</b>								
Veldtype	P < F	0.1305	0.4249	0.0821	0.2863	0.6222	0.2609	0.0764
	F	2.30	0.64	3.04	1.14	0.24	1.27	3.20
	Significance	ns	ns	ns	ns	ns	ns	ns
Sex	P < F	0.2206	0.3772	0.8063	0.0784	0.3975	0.2075	

	F	1.51	0.78	0.06	3.12	0.72	1.60	
	Significance	ns	ns	ns	ns	ns	ns	
Veld type*Sex	P < F	0.7781	0.2740	0.8280	0.1696	0.7951	0.8994	
	F	0.08	1.20	0.05	1.9	0.07	0.02	
	Significance	ns	ns	ns	ns	ns	ns	
Birth season(BS)	P < F	0.0426	0.0605	0.0332	0.2788	0.0035	0.0019	0.6927
	F	2.76	2.49	2.95	1.29	4.63	5.09	0.49
	Significance	*	ns	*	ns	**	**	ns
Vedtype*BS	P < F	0.0017	0.0001	0.0001	0.0001	0.0020	0.0001	0.0001
	F	5.17	7.58	9.53	9.13	5.05	10.42	8.76
	Significance	**	***	***	***	**	***	***
Sex*BS	P < F	0.0007	0.0071	0.0096	0.0476	0.0001	0.0067	
	F	5.82	4.11	3.88	2.67	7.15	4.15	
	Significance	***	**	**	*	***	**	

\* (P<0.05) \*\* (P<0.01) \*\*\* (P<0.001)

n = Non significant

BS = Birth Season

#### 4.4. The effect of season of birth on body dimensions

Table. 5. The effect of season of birth on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and scrotal circumference (SC)

	M	L	HW	HG	SH	HH	SC
Sources of variation							

---

Autumn	286.29 <sup>ab</sup>	127.49 <sup>a</sup>	40.40 <sup>ab</sup>	158.36	76.64 <sup>a</sup>	117.70 <sup>a</sup>	27.78
Spring	336.37 <sup>a</sup>	130.47 <sup>a</sup>	40.96 <sup>a</sup>	161.67	77.61 <sup>a</sup>	117.92 <sup>a</sup>	29.85
Summer	270.35 <sup>b</sup>	119.56 <sup>b</sup>	36.42 <sup>b</sup>	152.47	72.09 <sup>b</sup>	110.68 <sup>b</sup>	28.15
Winter	333.95 <sup>a</sup>	128.63 <sup>a</sup>	38.64 <sup>ab</sup>	159.53	75.41 <sup>ab</sup>	118.57 <sup>a</sup>	30.84

---

Subscripts: a - b

Means with different subscripts within variables are significantly different ( $P < 0.05$ )

These findings are contrary to those reported by other authors (Bosman and Harwin, 1966, Hartzenburg, 1971 Heyns, 1974, Venter, 1977, Vanzyl, 1982, Lubout et al., 1986, Lubout, 1987). It was also observed that differences between autumn and summer born animals for mass, hip width, heart girth and scrotal circumference was not significant.

Calves born in the winter and spring were statistically ( $P < 0.05$ ) heavier (333.95 kg and 336.37 kg respectively) than those born in autumn (286.29 kg) and summer (270.35 kg). The same can be said of other body dimensions (length, hip width, heart girth, shoulder height and hip height) with the exception of scrotal circumference for which this tendency was observed, although the difference was not statistically significant.

These findings are in agreement with those that have been reported by other authors (Mabesa, 1994; Van Zyl, 1982; Lubout et al., 1986; Lubout, 1987; Nahaas, 1992). The effect of calving season can be associated with climatic conditions (Swanepoel, 1986; Mabesa, 1994).

The significant effect of season of birth on one year and 18 months mass of beef calves has been reported (Van Zyl, 1987; Lubout et al., 1986; Lubout, 1987; Nauhaus, 1992; Els and Venter, 1990). Differences in growth from year to year have been attributed to changes in the climatic conditions, which influence both the quality and the quantity of forage available (Lubout, 1987).

The differences due to season of birth could probably be traced back to feeding regimes of the cows and the grazing potential as well as the ability of the calf to utilize milk and grazing available (Els and Venter, 1990).

By contrast, Mabesa (1994) found that season of birth had no significant effect on the birth mass of calves. Miles (1972) also found the season of birth to have no influence on the three weights (i.e., cow mass after calving, at weaning and the average of these two weights) of the cows ( $P < 0.05$ ).

#### **4.5. The effect of the interaction between sex and season of birth on body dimensions**

There is a general consensus among researchers that male calves are heavier than their female counterparts at 540 days and the difference increase as the calves grow older and sex differences in mature size are well documented (Lubout, 1987; Lubout and Swanepoel, 1990; Nauhaus, 1992, Mabesa, 1994).

The effect of the interaction between sex and season of birth is demonstrated in Table 6. In this study, male animals appeared to be superior to their female counterparts in most observations with exception of the males born in summer.

Table. 6. Sex by season of birth effect on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH)

	M	L	HW	HG	SH	HH
<b>Source</b>						
Female-Autumn	286.51 <sup>ad</sup>	125.71 <sup>abd</sup>	39.48 <sup>a</sup>	154.42 <sup>ab</sup>	74.38 <sup>ab</sup>	116.84 <sup>ab</sup>
Female-Spring	310.46 <sup>ab</sup>	127.52 <sup>ad</sup>	40.37 <sup>ac</sup>	156.21 <sup>a</sup>	76.98 <sup>a</sup>	116.49 <sup>ab</sup>
Female-Summer	314.62 <sup>ab</sup>	126.28 <sup>ad</sup>	39.49 <sup>a</sup>	156.78 <sup>a</sup>	75.71 <sup>ab</sup>	113.68 <sup>a</sup>
Female-Winter	266.16 <sup>ad</sup>	120.97 <sup>ab</sup>	36.46 <sup>ab</sup>	151.43 <sup>a</sup>	72.65 <sup>bd</sup>	113.79 <sup>ac</sup>
Male-Autumn	286.06 <sup>abd</sup>	129.27 <sup>ad</sup>	41.32 <sup>a</sup>	162.30 <sup>ab</sup>	78.90 <sup>a</sup>	118.56 <sup>ab</sup>
Male-Spring	362.29 <sup>b</sup>	133.42 <sup>acd</sup>	41.55 <sup>ad</sup>	137.13 <sup>b</sup>	78.25 <sup>a</sup>	119.36 <sup>b</sup>
Male-Summer	226.08 <sup>d</sup>	112.85 <sup>b</sup>	33.35 <sup>b</sup>	148.17 <sup>a</sup>	68.48 <sup>d</sup>	107.67 <sup>c</sup>
Male-Winter	401.75 <sup>e</sup>	136.29 <sup>d</sup>	40.82 <sup>a</sup>	167.62 <sup>b</sup>	78.17 <sup>ad</sup>	123.36 <sup>b</sup>

Subscripts: a - e

Means with different subscripts within variables are significantly different ( $P < 0.05$ ).

Bull calves born in winter were significantly ( $P < 0.05$ ) heavier (401.75 kg) than heifers born in autumn, spring, summer and winter. This is in accord with the results by (Kars et al., 1994; Kassa-Mersha and Arnason, 1986; Lubout et al., 1986).

Lubout et al. (1986) found that Nguni bull calves were 2kg heavier than heifers at birth and were 18 kg heavier than heifers at 205 days of age. Kars et al. (1994) found that Nguni bulls were 7.95% and 4.8% heavier at 365 and 540 days of age respectively. However, a non-significant effect of sex on 540-day mass of Nguni calves was reported by Lubout et al. (1986). At 24 months of age Kassa-Mersha and Arnason (1986) found that gains in corresponding differences were estimated at 17.6 kg and 4.5 kg respectively in favour of the male sex.

In this study, for animals born in autumn there was a tendency for males to have higher body dimension values than females although the difference was not statistically significant ( $P < 0.05$ ).

The results obtained in this study also shows that sex by season of birth interaction effect was significant ( $P < 0.05$ ) for males and females born in winter for some measurements, i.e. mass, length, heart girth and hip height. Male animals were superior for all the measurements with the exception of hip width and shoulder height. This is in agreement with the results by (Gilbert et al., 1983, Köster, 1994).

For females, summer born animals were heavier (314.62 kg) in terms of mass than their winter born counterparts (266.08 kg). Mabesa (1994) found that summer born animals were heavier than winter born animals at weaning. Lubout (1987) also found that calves born from November to January had the highest 540-day mass while those born from May to June had the lowest 540-day mass. Lubout et al. (1986) reported that November born Nguni and Pedi calves weighed 3kg and 6kg respectively more than the December born Nguni and Pedi calves.

Winter born male animals had higher values for mass (401.75 kg) than their summer counterparts (226.08 kg). This is similar to the findings of Van Zyl (1982), Lubout (1987) and Lubout and Swanepoel (1990) who found that winter born calves displayed heavier 365-day and 540-day mass.

It was also observed in this study that females born in summer were significantly ( $P < 0.05$ ) superior than their male counterparts born in summer in terms of mass, length, hip width, shoulder height and hip height with the exception of heart girth. This observation might be due to a loss of condition of males in the breeding season, which could also lower the average of all other body dimensions.

De Waal (1990) found that weaning weight of calves decreased by 2.86 kg per week for calves born after the 1<sup>st</sup> October.

The differences in body dimensions between sexes for other seasons were not significant ( $P < 0.05$ ). It was evident in this study that there was no difference in mass for animals born in autumn. The mass for males and females were 286.06 kg and 286.51 kg respectively and were almost the same. This is in accord with the findings

of Lubout (1987) that differences in mass between sexes seemed less under stressful and extensive conditions.

#### 4.6. The effect of the interaction between veld type and season of birth on body dimensions

Table.7. Veld type by season of birth effect on mass (M), length (L), hip width (HW), heart girth (HG), shoulder height (SH), hip height (HH) and scrotal circumference (SC)

	M	L	HW	HG	SH	HH	SC
<b>Source of variance</b>							
Sourveld-Autumn	272.18 <sup>acd</sup>	127.86 <sup>a</sup>	40.87 <sup>a</sup>	161.42 <sup>a</sup>	74.98 <sup>ac</sup>	117.24 <sup>a</sup>	28.25 <sup>ab</sup>
Sourveld-Spring	305.04 <sup>a</sup>	128.29 <sup>a</sup>	39.98 <sup>a</sup>	157.00 <sup>a</sup>	75.93 <sup>a</sup>	116.90 <sup>a</sup>	29.92 <sup>a</sup>
Sourveld-Summer	311.57 <sup>ace</sup>	132.80 <sup>a</sup>	42.95 <sup>a</sup>	168.91 <sup>a</sup>	75.55 <sup>ac</sup>	118.87 <sup>a</sup>	38.33 <sup>b</sup>
Sourveld-Winter	271.18 <sup>ad</sup>	122.85 <sup>a</sup>	37.54 <sup>ad</sup>	153.49 <sup>ad</sup>	73.98 <sup>a</sup>	115.85 <sup>a</sup>	27.18 <sup>a</sup>
Sweetveld-Autumn	300.39 <sup>ab</sup>	127.12 <sup>a</sup>	39.93 <sup>a</sup>	155.30 <sup>ad</sup>	78.30 <sup>ac</sup>	118.16 <sup>a</sup>	27.31 <sup>a</sup>
Sweetveld-Spring	367.70 <sup>ce</sup>	132.65 <sup>a</sup>	41.94 <sup>ac</sup>	166.34 <sup>ab</sup>	79.29 <sup>c</sup>	118.94 <sup>a</sup>	29.77 <sup>a</sup>
Sweetveld-Summer	229.13 <sup>d</sup>	106.32 <sup>b</sup>	29.89 <sup>b</sup>	136.03 <sup>c</sup>	68.64 <sup>b</sup>	102.48 <sup>b</sup>	17.96 <sup>d</sup>
Sweetveld-Winter	396.72 <sup>e</sup>	184.41 <sup>a</sup>	39.73 <sup>a</sup>	165.56 <sup>a</sup>	76.84 <sup>ac</sup>	121.29 <sup>a</sup>	34.50 <sup>ab</sup>

Subscript: a - e

Means with different subscripts within variables are significantly different ( $P < 0.05$ )

The effect of the interaction between veld type and season of birth on body dimensions is presented in Table 7. Bioregion (agro-ecological region), through its main factors (rainfall, temperature and topography) is a significant source of variation and explains 6.8% and 3.4% of the variation in pre-weaning and weaning mass respectively (Ronchietto, 1993; Dooley, 1982; Burfenning et al., 1982). Leighton et al. (1982) also stated that location is only one of the components that would cause variation in weaning growth, of which biological importance. Dooley et al. (1982) found that region affected weaning mass significantly ( $P < 0.05$ ), while Treden et al. (1982) found that pre-weaning growth rate differed between 10% and

13% between locations ( $P < 0.0001$ ). On the other hand Burfenning et al. (1982) found that location had a significant effect on ease of calving and birth mass, whilst Mwandotto et al. (1983) noted that region of birth had a significant effect on post weaning growth. This well-established variation was also observed in this study.

According to Table 7 it can be deduced that summer born animals in the sweetveld had significantly ( $P < 0.05$ ) lower values in terms of length (106.32 cm), HW (29.89 cm), HG (136.03 cm), SH (68.64 cm), HH (102.48 cm) and SC (17.96 cm) compared to other seasons of birth and veld types. The same trend was observed for mass, although the difference in mass for those animals born in summer in the sweetveld and those born in autumn and winter in the sourveld was not statistically significant. Table 7 also shows that animals born in winter in the sourveld were heavier in terms of mass compared to other seasons of birth in both veld types. This trend was also observed for length and hip height for all seasons.

With regard to the shoulder height (SH), animals born in spring in the sweetveld had the highest value than other animals in other seasons in both veld types.

Significant ( $P < 0.05$ ) differences were found in body dimensions of animals from both veld types born during different seasons. Animals born during summer in the sweetveld had the lowest values for all body measurements as compared to other animals from both the sweetveld and sourveld that were born during the other seasons.

Animals born in summer in the sweetveld were significantly ( $P < 0.005$ ) lighter (229.13 kg) than their counterparts in the sourveld (311.57 kg). The same trend was also observed for other body measurements between sourveld and sweetveld for all seasons. These results are similar to the findings of Ronchietto (1993), who earlier reported that the highveld-sourveld had an average weaning mass of 185.4 kg with a calving percentage of 83.2%, while in the sweetveld the weaning mass was 172.7 kg and the calving percentage was only 73.3%. Large variations in dry matter yield of veld, primarily due to differences in annual rainfall as well as its distribution occur at any specific site between years and are invariably reflected in animal performance.

Summer born animals in the sweetveld had lower heart girth values than all animals that were born during other seasons in both veld types.



Spring born calves in the sweetveld had significantly higher heart girth values than those animals born in winter and autumn in sourveld and sweetveld respectively. Summer born animals in the sweetveld had the lowest scrotal circumference values ( $P < 0.05$ ) than all animals born during all seasons in both sourveld and sweetveld. Summer born animals in the sourveld had the highest scrotal circumference values than those animals born during spring and winter in the sourveld and also animals born in autumn, spring and summer in the sweetveld.

#### 4.7. Correlation between body measurements

The Pearson's correlation coefficients given in Table 8 and 9 were all positive and 53.5% in Table 8 (males) of the correlations were greater than 90% and in Table 9 (females) 71.4% were greater than 80%.

Table. 8. Pearson Correlation coefficients between body measurements for males

		Age	Mass	Length	Shoulder height	Hip height	Hip width
<b>Mass</b>	r	0.92***					
	n	(164)					
<b>Length</b>	r	0.80***	0.91***				
	n	(163)	(168)				
<b>Shoulder height</b>	r	0.69***	0.83***	0.91***			
	n	(163)	(168)	(168)			
<b>Hip height</b>	r	0.76***	0.88***	0.94***	0.91***		
	n	(163)	(168)	(168)	(168)		
<b>Hip width</b>	r	0.79***	0.90***	0.91***	0.86***	0.93***	
	n	(163)	(168)	(168)	(168)	(168)	
<b>Heart girth</b>	r	0.84***	0.92***	0.93***	0.84***	0.91***	0.93***
	n	(163)	(168)	(168)	(168)	(168)	(168)
<b>Scrotal Circumference</b>	r	0.78***	0.92***	0.80***	0.69***	0.90***	0.90***
	n	(161)	(165)	(165)	(165)	(165)	(165)

\*\*\* =  $P < 0.001$ ,

n = no of observations,

r = correlation coefficient

It can be deduced from Table 8 (males) that age was highly correlated to mass, heart girth and body length. A very high correlation between age and mass ( $r = 0.92$ ,  $P < 0.001$ ), age and heart girth ( $r = 0.84$ ,  $P < 0.001$ ) as well as between age and body length ( $r = 0.80$ ,  $P < 0.001$ ) implies that mass, body length and heart girth could serve as good indicators of growth in male animals.

Table.9. Pearson Correlation coefficients between body measurements for females

		<b>Age</b>	<b>Mass</b>	<b>Length</b>	<b>Shoulder height</b>	<b>Hip height</b>	<b>Hip width</b>
<b>Mass</b>	r	0.77***					
	n	(251)					
<b>Length</b>	r	0.71***	0.93***				
	n	(252)	(288)				
<b>Shoulder height</b>	r	0.66***	0.85***	0.85***			
	n	(250)	(286)	(287)			
<b>Hip height</b>	r	0.61***	0.84***	0.85***	0.81***		
	n	(250)	(286)	(287)	(287)		
<b>Hip width</b>	r	0.68***	0.91***	0.90***	0.82***	0.86***	
	n	(252)	(288)	(289)	(287)	(287)	
<b>Heart girth</b>	r	0.66***	0.92***	0.90***	0.82***	0.84***	0.91***
	n	(252)	(288)	(289)	(287)	(287)	(289)

\*\*\*  $P < 0.001$ ,

n = no of observations

r = correlation coefficient

For the females (Table 9) age was more closely correlated to mass (0.77) than any other body measurement in the group. The correlation values between age and other body measurements as outlined in Table 9, were also relatively high and varied between 0.71 and 0.61. A high correlation was also observed between body mass and length (0.93) as expected. The relationship between age and hip height had the lowest correlation value (0.61), which implies a weaker association between the two body measurements.

A high correlation between age and mass ( $r = 0.77$ ,  $P < 0.001$ ) as well as between age and body length ( $r = 0.71$ ,  $P < 0.001$ ) implies that mass and body length could serve as good indicators of growth in female animals.

If age is excluded, mass, hip width, body length and heart girth show the largest consistent relationship to the other measurements for both males and females. The correlation between mass and heart girth ( $r = 0.92$ ,  $P < 0.001$ ) was the same for both males and females. These results are consistent with those of Brown et al. (1983), in which they found heart girth to be closely associated ( $r = 0.77$ ) with mass in female Angus cattle.

There was a sex difference for correlations between body dimensions with the female group showing a consistently lower relationship between body measurements than their male counterparts.

For the males, scrotal circumference was more strongly correlated to other linear body measurements, with the exception of shoulder height. This was in agreement with the findings by several researchers (Swanepoel and Heyns, 1986; Venter, Rossow and Neville, 1977). High significant correlations ( $P < 0.05$ ) exist between scrotal circumference and mass ( $r = 0.92$ ) in this study. This is in agreement with the results by Makarechian et al. (1984) who found scrotal circumference (SC) to be positively correlated with body weight at the end of the feedlot test in the four breeding groups. Body weight and SC are correlated primarily because of their mutual association with age and growth traits.

#### **4.8. Conclusion and recommendations**

Beef production under extensive farming system faces problems in relation to dealing with harsh environmental factors. Such problems posed by the extensive system are of economic importance and results in production inefficiencies and poor and/or a lack of an effective program for breed improvements.

It is therefore important to identify environmental factors that can be considered for the improvement of cattle performance, and to derive means to deal and cope with those environmental factors and their effects.

Season of birth, sex and veld type all have significant effects on the growth traits of Nguni cattle. These factors should therefore be considered to enhance productivity of the Nguni herd. Animals that were born in winter in the sourveld had the lowest values for all the body dimensions whilst those born in winter in the sweetveld had the highest values and vice versa. Based on the results of this study, it is recommended that in the sweetveld, the breeding season must be such that most calves are born during the spring calving season, whilst in the sourveld the breeding season must be such that most calves are born during the summer calving season.

The high correlation values obtained between body dimensions in this study, although variable, suggests that breeders and farmers can through selection for one body measurement change size and growth in either direction.

Pearson correlation coefficients between body dimensions obtained for the male group appear to be higher than that of the female group, so it looks like male animals are a better indicator of the potential of the environment. It is therefore hypothesised that careful selection of beef cattle for growth and skeletal sizes using body dimensions (HG, HW, SH, HH, L) under study can form an integrated part of growth trait improvement in beef cattle farming with special reference to the Nguni breed.

It is recommended that future investigations or attempts be made to combine agro-ecological regions (veld types) throughout South Africa with their relative growth/production data in order to determine more accurately the environmental factors influencing growth in Nguni cattle and also to pinpoint the variance for each anthropometrical measurement, paving the way to alter them to a higher productivity level.

#### 4.9. Critical evaluation

In general the study suggests that season of birth and not agro-ecological region *per se* affect the growth of extensive beef cattle. However the effect of the interaction between agro-ecological region and season of birth has a significant effect on growth of cattle. This suggest that season of birth is an important source of variation in the growth of cattle that must never be overlooked under extensive farming systems.

The results of the study may be used by the public and private sector and also by both the communal and commercial farmers in the extensive beef production systems to develop management programmes that may result in increased productivity.

The supervisor was fully dedicated to the project from the beginning to the end of the study. Lack of data for other seasons in other areas like the metacarpal length and age was detrimental to the student and the Department of statistics. Unfortunately the effect of age on body dimensions was not analysed because the dates of birth for other animals were not recorded, which I think would have shown a significant effect on growth. The inclusion of age in the analysis of the data would have made it possible to determine the age at which a specific size or magnitude of any body dimension was reached and also to determine the optimum size of Nguni cattle in different agro-ecological regions.

Data was collected for only one breed (Nguni) and it would have been interesting to test the effect of agro-ecological regions on other beef cattle breeds and compare the performance in terms of growth. This however emphasizes the necessity for more research using other breeds and veld types.

To me as a student the project's contribution was immense. It improved my scientific knowledge and complemented my existing knowledge on livestock improvement (performance testing of beef cattle) thus enabling me to execute my duties as an animal scientist more effectively.

The study taught me how to plan and organize a research project and resulted in improved experience in office work. It also helped me a lot in time management since my productivity at my workplace was not affected in any way by the study.

#### 4.10. REFERENCES

Acocks, J.P.H., 1975. Veld types of South Africa. Memoirs of the botanical survey of South Africa. No. 40.

Ames, D.R., 1980. Thermal environment affects production efficiency of livestock. *Bioscience*.30 ;457

Atkins, K.D and Thompson, R., 1986. Predicted and realized response to selection for an index of bone length and body weight in Scottish Blackface sheep. I. Responses in the index and component traits. *Anim. Prod.* 43: 421.

Batt, R.A.L., 1979. Influences of growth and development. Studies in Biology series no. 116. Edward Arnold (Publishers) Ltd. Queen's Gate, London.

Berg, R.T. and Butterfield, R.M., 1976. New concepts of cattle growth. Sidney University Press, Letchworth, England.

Bishop, E.J.B., 1978. The performance of a beef breeding herd subjected to continuous mating in the valley bushveld of the Eastern Cape. *S. Afr. J. Anim. Sci.*8, 15.

Bishop, S.C., 1993. Grassland performance of Hereford cattle selected for rate and efficiency of lean gain on a concentrate diet. *Anim. Prod.* 56: 311

Bonsma J., 1980. Livestock production: A global approach. Tafelburg Publishers Ltd. S.A. 146.

Bonsma, J.C. and Skinner, J.D., 1969. Factors influencing birth date, birth weight and preweaning growth rate of Afrikaner, Bonsmara and Hereford cattle in the subtropics. *Proc. S. Afri. Anim. Prod* 8:161.

Bosman, D.J., 1997. Body measurements and their application in beef cattle. National Beef Cattle Performance Testing Scheme. News Letter No. 79: 9.

Bosman, D.J. and Harwin, G.O., 1966. Genetic and environmental factors affecting pre-weaning traits in beef cattle under extensive ranching conditions. Proc. S. Afri. Soc. Anim. Prod 6:213.

Bosman, D.J. and Harwin, G.O., 1967. Variation between herds in respect of the influence of year, sex, season and age of cow on weaning weight of beef cows. Proc. S. Afri. Anim. Prod 6:213.

Bourdon, R.M., 1997. What is the "Best" animal. In: Understanding Animal Breeding. Prentice –Hall, Inc. New Jersey.

Brown, C.J., Brown, J.E. and Butts, W.T., 1973a. Evaluating relationships among immature measures of size, shape and performance of beef bulls. II. The relationships among immature measures of size, shape and feedlot traits in young beef bulls. J. Anim. Sci. 36 : 1021.

Brown, C.J., Brown, A.H., Jr and Johnson, Z., 1983. Studies of body dimensions of beef cattle. Arkansas Exp. Station. Bull. 863. Univ. of Arkansas, Fayetteville.

Brown, J.E., Brown, J.C. and Butts, W.T., 1973b. Evaluating relationships among immature measures of size, shape and performance of beef bulls. I. Principal components as measures of size and shape in young Hereford and Angus bulls. J. Anim. Sci. 36 : 1010.

Burfenning, P.J., 1974. Dairy-beef crossbreeding: I. Growth to weaning. J. Anim. Sci. 38:6, 1319. (Abstract).



Burfenning, P.J., Kress, D.D. and Friedrich, R.L., 1982. Sire x region of U.S and herd interactions for calving ease and birthweight. *J Anim. Sci.* 55:765

Burns, W.C., Koger, M., Butts, W.T., Pahnish, O.F and Blackwell, R.L., 1979. Genotype by environment interaction in Hereford cattle: II. Birth weight and weaning traits. *J. Anim. Sci.* 49 (2) : 403.

Christopherson, R.T., 1976. Effects of prolonged cold and the outdoor winter environment on apparent digestibility in sheep and cattle. *Can. J. Anim. Sci.* 56, 212.

Collier, R.J., Doelger, S.G., Head, H.H., Thatcher, W.W and Wilcox G., 1982. Effects of heat stress during pregnancy on maternal hormone concentrations, calf birth weight and post partum milk yield of Holstein cows. *J. Anim. Sci.* 54, 303.

Corbett, J.L., 1979. Measuring animal performance: In, *Measurements of grassland vegetation and animal production*. Edited by L. t'Mannetje. Commonwealth Agricultural Bureaux, England.

Coulter, G.H., 1982. This business of testicle size. *Proceedings from annual conference on artificial insemination and embryo transfer in beef cattle*. Denver, Colorado Nat. Ass. Anim. Breeders. Columbia Missouri.

Cowling, R.M., Richardson, D.M. and Pierce, S.M., 1997. *Vegetation of Southern Africa*. Cambridge University, United Kingdom.

Cundiff, L.V., Willham, R.L and Pratt, A., 1966. The effects of certain factors and their two-way interactions on weaning weight in beef cattle. *J. Anim. Sci.* 25, 972

DeNise, S.K, and Ray, D.E., 1987. Postweaning weights and gains of cattle raised under range and gain test environments. *J. Anim. Sci.* 64:969.

De Waal, H.O., 1990. Animal production from native pasture (Veld) in the Free State Region – A perspective of the grazing ruminant. *S. Afr. J. Anim. Sci.* 20(1):1.

Dooley, V., Dinkel, C., McPeake, C.A. and Lasley, E.L., 1982. A survey evaluation of South Dakota beef cattle production. *J. Anim. Sci.* 55:224

Du Plessis, I and Hoffman, L.L., 2004. The effect of chronological age of beef steers of different maturity types on their growth and carcass characteristics when finished on natural pastures in the arid-subtropic of South Africa. *S.A. J. Anim. Sci* 34 (1)

Ellof (Mannie), H.P. and Pienaar, A.J., 1965. Cattle farming systems: In, Beef cattle farming in Transvaal Bushveld. Bulletin No. 376. Government Printer, Pretoria.

Els, H.C. and Venter, H.A.W., 1990. Factors influencing the weaning mass of Africander, Hereford, Bonsmara and Simmental calves in the Northern Transvaal Bushveld. Proc. 4<sup>th</sup> World Congr. Gen. Appl.Livest.Prod. Edinburgh, XIV:394.

Enevoldsen, C. and Kristensen, T., 1997. Estimation of body weight from body size measurements and body condition scores in dairy cattle. *J. Dairy. Sci.* 80 : 1988.

Gilbert, R.P., Bailey, D.R.C. and Shannon, N.H., 1993. Body dimensions and carcass measurements of cattle selected for postweaning gain fed two different diets. *J. Anim. Sci.* 71 : 1688.

Hammack, S.P, undated. Genetic – Environmental interaction in beef production. Texas. Agricultural Extension Services.

<http://www.agpublications:tamu.edu/pubs/as/15239.pdf>

Hartzenberg, F., 1971. Statistiese analise van faktore wat die vroeë groei van vleisbeeste beïnvloed. D.Sc (Agric)-Proefskrif. Univ. Pretoria.

Heyns, H., 1974. Genetiese en omgewings parameters van Afrikaner kalwers. D.Sc (Agric). Proefskrif. Univ. Pretoria.

Johnson, H.D., 1987. Bioclimatology and the adaptation of livestock. World Animal Science. B.5. Elsevier, 35

Kassa-Mersha, H. and Arnason, T., 1986. Non-genetic factors affecting growth of cattle. World Review of Anim. Prod. Vol XXII. No.2: 45.

Kars, A.A., Erasmus, G.L and Van der Westhuisen, J (1994). Variance component and heritability estimates for growth traits in Nguni cattle stud at Bartlow Combine. J.Anim.Sci. 24(4), 129 -132.

Köster (van Marle), E., 1992. Genetics studies in a Hereford stud. M.Sc.(Agric), thesis. Univ. of Orange Freestate.

Köster, H., 1994. Omgewingsfaktore wat die produksie van vleis beeste in die Noord-Traansvalse gemengde bosveld beïnvloed. M.Sc.(Agric) thesis, Univ of Pretoria.

Lasley, J.F., 1978. Variations in economic traits. In: Genetics of livestock improvement, 3<sup>rd</sup> Edition. Prentice-Hall, Inc. New Jersey.

Leighton, E.A., Wilham, R.L and Berger, P.J., 1982. Factors influencing weaning weights in Hereford cattle and adjustment factors to correct records of these effects. J. Anim. Sci.54:957.

Lombard, J.H., 1971. Genetic and environmental factors affecting production of beef cattle in the highlands sourveld areas. D.Sc (Agric)-Thesis. Univ. Pretoria.

Long, C.R., Stewart, T.S., Cartwright, T.C. and Jenkins, T.G., 1979. Characterization of cattle of a five breed diallel : I. Measures of size, condition and growth in bulls. J. Anim. Sci. 49(2) : 418.

Long, C.R., Stewart, T.S., Cartwright, T.C. and Baker, J.F., 1979. Characterization of cattle of a five breed diallel : II. Measures of size, condition and growth in heifers. J. Anim. Sci. 49(2) : 432.

Lubout, P.C., 1987. Environmental and genetic factors influencing production in a herd of Pedi cattle. M.Sc.(Agric), dissertation. Univ. of Pretoria.

Lubout, P.C. and Swanepoel, F.J.C., 1990. Genetic parameters of Sanga cattle in developing areas. Proc. 4<sup>th</sup> World. Congr. Gen. Appl. Livest. Prod. Edinburgh. XIV: 386.

Lubout, P.C., Lepen, J.M. and Venter, H.A.W., 1986. Factors affecting the performance of Nguni and Pedi cattle. Proc. 3<sup>rd</sup> World. Congr. Gen. Appl. Livest. Prod. Nebreska, USA. XI: 499.

Mabesa, H.T., 1994. Environmental factors influencing production in a herd of Bonsmara cattle. M.Inst. Agrar.(Agric), dissertation. Univ. of Pretoria.

Magnabosco, C.D.U., Ojala, M., De los Reyes, A., Sainz, R.D., Fernandes, A. and Famula, T.R., 2000. Estimation of environmental effects and genetic parameters for body measurements and weight in Brahman cattle raised in Mexico. J. Anim. Breed. Genet. 119 : 221.

Maiwashe, A.N., Bradfield, M.J., Theron, H.E. and Van Wyk, J.B., 2002. Genetic parameter estimates for body measurements and growth traits in South African Bonsmara cattle. *Livestock Prod. Sci.* 75(3) : 293.

Makarechian, M., Farid, A. and Berg, R.T., 1984. Relationship between growth parameters and scrotal circumference in young beef bulls. *Theriogenology*, Vol 22(6): 667.

Maree, C. and Casey, N.H., 1993. *Livestock production systems: Principles and practice.* Agri-Development foundation. Brooklyn.

Mathur, K.P. and Horst, P., 1994. Methods for evaluating genotype-environment interactions illustrated by laying hens. *J. Anim. Breed. Genet.* 111, 265.

Meyer, K., 1995. Estimates of genetic parameters for mature weight of Australian beef cows and its relationship to early growth and skeletal measures. *Livestock. Prod. Sci.* 44 : 125.

Miles, G., 1972. Factors influencing reproductive performance of four breeds of cattle under extensive ranching conditions in the Northern Cape. M. Sc (Agric). Thesis. University of Pretoria.

Mwandotto, B.J., Carles, A.B., Smith, G.M. and Cartwright, T.C., 1983. Weaning and 18 months weights of weights of different cattle breed types in semi and Kenya. *J. Anim. Sci.* 62:51.

Nadarajah, K., Marlowe, T.J. and Notter, D.R., 1984. Growth patterns of Angus, Charolais, Charolais x Angus and Holstein x Angus cows to maturity. *J. Anim. Sci.* 59 : 957.

Nauhaus, W.K., 1992. Evaluasie van die staats Simmentaler-stoeterie in Namibie. M.Sc. (Agric)-dissertation, Univ. Pretoria.

Paterson, A.G., 1978. Statistical analyses of factors affecting pre-weaning growth of beef cattle under intensive pasture conditions. M.Sc (Agric)-dissertation. Univ. Pretoria.

Paterson, A.G., 1981. Factors affecting post weaning growth and reproduction of crossbred cattle under an intensive production system. D.Sc.Agric.-Thesis. University of Pretoria.

Paterson, A.G., 1992. Maturity type in beef cattle and its importance in beef production: In, Beef in Natal. Dept of Agric Dev, Pietermaritzburg, Natal.

Preston, T.R and Willis, M.B., 1974. Intensive beef production. Pergamon Press. New York.

Robelin, J. and Tulloh, N.M., 1992. Patterns of growth of cattle. : In.World Anim. Sci. C5. Beef cattle production, Edited by Jarrige, R. and Beranger, C. Elsevier Science Publishers, Amsterdam

Ronchietto, P.C., 1993. The effect of agro-ecological regions on beef production in Natal. M.Sc (Agric) Thesis, Univ. of Pretoria.

SAS, 2002. Statistical Analysis Systems user's Guide, Version 8.2. SAS. Institute. Inc. Cary, North Carolina, USA.

Scholtz, M.M., 1988. Selection possibilities of hardy beef breeds in Africa: The Nguni Example. Proc. 3<sup>rd</sup> World Congr. Sheep Beef Cattle breeds, Paris. 303.

Spickett, A.M. and Scholtz, M.M., 1985. Research on tick resistance of European and indigenous cattle under minimal control conditions. Onderstepoort VRI, Newsletter.3.17.

Swanepoel, F.J.C., 1986. Genetiese en omgewingsparameters van 'n vleisraskudde. PhD-Thesis. Univ. Pretoria.

Swanepoel, F.J.C., and Heyns, H., 1986. Relationships between growth parameters and scrotal circumference in Simmentaler bulls. S.A. J. Anim. Sci. 16 (4) : 218.

Tainton, N., 1999. Veld management in South Africa. University of Natal Press, Pietermaritzburg.

Taylor, W.T., 1995. Relationship of lifetime fertility of Bonsmara cows with the growth and scrotal circumference of their calves. M.Sc (Agric)-Thesis. Univ. Pretoria.

Theron, H.E., 1997. The genetics of sexual dimorphism in growth of beef cattle. PhD (Agric) – Thesis. University of Pretoria.

Tredean, H.T., Weis, G.M., Rahnefeld, G.W., Lawson, J.E. and Newman, J.A., 1982. Environmental and genetic effects on pre-weaning performance of calves from first cross cows. II Growth traits. Can. J. Anim. Sci. 62:51

Van Rooyen, P. and Wilke, P.I., 1990. Relationship between scrotal and body measurements in Bonsmara bulls. World Review of Animal Production, Vol XXV(2) :51.

Van Zyl, J.G.E., 1982. 'n Evaluasie van die gevolge van teel- en seleksiemetodes soos toegepas dier die Bonsmarabees-telersgenootskap. M.Sc (Agric)- Proefskrif. Univ. Pretoria.

Venter, H.A.W., 1977. Die doeltreffendheid van voorspeense groei by sekere vleis-, dubbeldoel- en kruis-rasse in die Noord Transvaalse soetbosveld. D.Sc (Agric) Proefskrif. Univ. Pretoria.

Venter, H.A.W., Rossouw, A.F. and Neville, W.J., 1977. Liggaamsmassa en testesgrootte van Afrikaner, Hereford en Simmentalerbulle. S. Afr. J. Anim. Sci. 7:43.

Viljoen, J.J., 1986. Die invloed van genetiese- en omgewings faktore op produksie eienskappe van Afrikanerbeeskudde. M.Sc (Agric). Univ. van Orange Vrystaat.

Vorster, T.H., 1962. Factors influencing the growth, production and reproduction of different breeds of beef cattle under range conditions in Southern Rhodesia. D.Sc (Agric)-Thesis. Univ. of Stellenbosch.

Wilson, L.L, Abdul-Jamak, E, Le Van, P.J, Todd, R.F, Watkins, J.L and Ziegler, J.H., 1983. Effect of season of birth, breed of sire, and sex of calf in a single-suckled Aberdeen Angus-Holstein beef herd. Anim. Prod. 37: 365.