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**The performance of beef cattle bulls in the Vrede district of
Mpumalanga, South Africa**

by

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ABSTRACT

The performance of beef cattle bulls in the Vrede district of Mpumalanga, South Africa

by

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The objective of this study was to investigate the growth performance, feed conversion efficiency and other production traits of beef cattle performance tested on the farm. Performance testing records (collected from 2000 to 2004), of 444 bulls comprising of six breeds [viz. Aberdeen Angus (n = 42), Beefmaster (n = 135), Bonsmara (n = 97), Drakensberger (n = 64), Nguni (n = 50) and Simbra (n = 56)] from the eastern Free State, Veld Bull Club (VBC) were obtained and analysed. Bulls were performance tested on the farm (Poortje in Vrede district) for 205 days (16.53 s.d.) and finished-off in a feedlot for 100 days. Upon the completion of the entire test period, the bulls were auctioned.

Traits studied were: average daily gain (ADG), Kleiber ratio (KR) and veld feed conversion ratio (VFCR), body conditions score (BCS), muscling score (MS), temperament score (TS), tick count (TC), scrotum circumference (SC) and selling price (SP). An analysis of variance with the General Linear Model (GLM) was used to determine the significance within a breed between years, between breeds within a year, the interaction of year x breed, and breeders (breed x year) for all the dependent variables.



Aberdeen Angus bulls showed a significant difference for all traits analysed except for SC and SP. Beefmasters did not only differ in BCS and TS. Bonsmaras differed in all traits analysed except for FWT, SC and SP. Unlike the other breeds, the Drakensberger had more traits that they showed no significant differences viz. IWT, FWT, MS, TS and SP. The Nguni showed significant difference in all traits analysed except for IWT, TS and SC. Finally, the Simbra also did not differ significantly in five of the eleven traits measured viz. FWT, MS, TC, SC and SP. According to these results, there is a significant variation within beef cattle breeds on rangeland in certain performance and other production traits such those measured in this study. This suggests that, although selection for desirable traits within-breed may be slow, the within-breed selection and exploitation has a role to play in improving long-term herd functional efficiency. During the feedlotting period, none of the breeds showed a significant difference in ADG, suggesting that, given a favourable environment, each animal will have an equal opportunity to perform at its optimum genetic potential. This further implies that in a production environment where feed resource is not the limiting factor, higher production efficiency may well be accomplished by each animal.

Key words: Beef cattle bulls, performance testing, performance parameters, on-farm.



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ABBREVIATIONS/ACRONYMS

ADA	Average daily gain per day of age
ADG	Average daily gain
ARC-AII	Agricultural Research Council – Animal Improvement Institute
ATC	Average tick count
BCS	Body condition score
BMR	Basal Metabolic Rate
CV	Coefficient of variation
DMI	Dry matter intake
DoA	The Department of Agriculture
EU	European Union
FCE	Feed conversion efficiency
FCR	Feed conversion ratio
FI	Feed intake
FWT	Final weight
GDP	Gross Domestic Product
GIP	Gastrointestinal parasites
GIT	Gastro intestinal tract
GLM	General Linear Model
h^2	Heritability
IFAD	International Fund for Agricultural Development
IWT	Initial weight
KR	Kleiber ratio
LSU	Large stock unit
LWT	Liveweight
MEI	Metabolisable energy intake
MME	Metabolic weight equivalent
MS	Muscling scores
MWT	Metabolic midpoint weight
NAMPO	National Maize Producers Organisation
NBCPPTS	National Beef Cattle Performance and Progeny Testing Scheme



PEG	Partial efficiency of growth
r_e	Environmental correlation
r_g	Genetic correlation
r_p	Phenotypic correlation
RFI	Residual feed intake
RGR	Relative growth rate
RSA	Republic of South Africa
RTU	Real time ultrasound
SADC	Southern African Development Community
SAFA	South African Feedlot Association
SAMC	Southern African Marketing Cooperation
SAWB	South African Weather Bureau
SC	Scrotum circumference
SD	Standard deviation
SP	Selling price
SRW	Standard reference weight
TC	Tick count
TS	Temperament scores
TVC	Testicular vascular cone
UK	United Kingdom
USA	United State of America
VBC	Veld Bull Club
VDMI	Voluntary dry matter intake
VFCR	Veld feed conversion ratio



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CHAPTER I

1. General introduction

1.1 Livestock production in Southern Africa

Livestock production plays an important role in shaping the living standard of many people in developing countries. To date, about 60% of the population of the Southern African Development Community (SADC) depend directly or indirectly on livestock production for their livelihood (IFAD, 2002; Kohler-Rollefson, 2004). Cattle in particular, are kept *inter alia* as a source of income, meat and milk, insurance, manure and draught power.

The dominance of the beef industry within the livestock sectors has been well-documented. Its contribution to GDP in countries such as Namibia, Botswana and South Africa is well above the average in comparison with other agricultural sectors. In Namibia, the beef industry is one of the biggest foreign currency earners with almost 80% of all beef and beef products exported to the Republic of South Africa (RSA) and EU countries (Meatco, 2005). Nearly 50% of the agricultural GDP in the RSA is derived from the sale of beef and beef products (ARC-AII, 2001). In Botswana, beef processing accounts for about 80% of agricultural output and over 95% of production is exported (SAMC and SADC Secretariat, 2005).

The terms ‘efficiency and productivity’ are the drivers in the beef industry. Nowadays breeding programs are tailored towards improving profitability/productivity of enterprises rather than the general preference of an individual breeder. Enterprise performances are evaluated on the basis of economic returns. In extensive grazing systems, the efficiency and productivity of beef enterprises are, however, determined by how well the animals are adapted to the prevailing environmental conditions. In the tropics and subtropics, factors such as the seasonality and variability of rainfall, high ambient temperature and insufficient grazing (Van Zyl *et al.*, 1993) dictates the performance of beef enterprises. To date, many rangeland farmers occasionally change between breeds of cattle with the

purpose to identify a breed or breeds best suited to their production systems and adapted to the environmental conditions in which they find themselves. High performing bulls are often selected to parent offspring that are expected to perform well in the prevailing environmental conditions.

Most commercial farmers obtain their breeding bulls through direct purchase from stud breeders or at bull auctions. Purchasing the appropriate bull is, however, a challenging exercise especially at auctions where there are more cattle to see and the social aspects of meeting friends can be disruptive (Sundstrom *et al.*, 2000). For this reason, buyers are recommended to acquaint themselves with the performance testing data catalogues before participating in the auction. The performance catalogues provide information regarding the traits measured during the testing period *inter alia* body condition and temperament scores, growth and economic indices. The Veld Bull Club (VBC) in the Vrede district of Mpumalanga in the Republic of South Africa records valuable data every year on the performance of young bulls tested on the farm. The data collected are made available to farmers on auction days (as calculated values of different production traits measured during the testing period) in order to help them identify the bull(s) of their choice.

1.2 Project objectives

Using the performance data from the VBC, the purpose of this study was to investigate the postweaning growth performance and other performance parameters (i.e. temperament, body condition score, tick count and muscling scores) of beef cattle bulls on the farm.

Specifically the study investigated

- The within breed variation in performance and other production traits in beef cattle on rangeland and in a feedlot at test centres
- The influence of breed type on performance of beef bulls at performance testing centres and
- the relationship between selling price at auctions and performance parameters measured during the test



CHAPTER II

2. Literature review

2.1 Importance of performance testing

The aim of performance testing is to allow comparisons of beef bulls from different herds under uniform conditions so as to identify the genetically superior bulls for use in commercial herds (Liu, 1993). It simply involves the comparisons of bulls at one location under uniform conditions (e.g. central testing station or on-farm) that were reared at different farms/locations. Although performance testing of bulls in the breeder herd is also possible, the smaller herd size limits the thorough evaluation of the results (Kräusslich, 1974). Dalton *et al.* (1978) reviewed the central performance testing of beef bulls in New Zealand. He indicated that the aim of any performance testing and selection programme is to identify animals as parents of the next generation that are likely to contribute to increased herd net income. Kräusslich (1974) argued that the concept of performance and progeny testing relies on the fact that traits under investigation can be measured and are heritable. Kräusslich (1974) stated that the objective of performance testing is to estimate a bull breeding value for progeny merit through its own achievement during performance testing.

While on test, the bulls are mainly evaluated on their growth rate and feed conversion efficiency (FCE). Research has shown that FCE and growth rate as well as carcass composition are the most heritable factors that influence the economics of beef production (Kräusslich, 1974). Other traits of economic importance such as feed intake, back-fat measurement, body condition score, temperament score, scrotum circumference are also measured (Kräusslich, 1974; Dalton *et al.*, 1978). Kräusslich (1974) pointed out that the selection of bulls from performance tests should be based on the superiority of those traits that will be needed in the progeny. Therefore, if for example the progeny are to be slaughtered at a particular weight, the evaluation point for performance test should be at that point.



Pre-testing the environment (also known as the ‘adjustment period’) has been used as a means to; 1) overcome the pre-test environmental and management influences (Kräusslich, 1974) and 2) oust any biasness that may arise in the genetic evaluation of gain-on-test or final weight (Dalton *et al.*, 1978). Although there is no optimal period for the adjustment period, it is however, required that the period should be sufficiently long to largely overcome the pre-test influences (Kräusslich, 1974). According to Kräusslich (1974) in Britain, for example; the whole test is considered as an adjustment period and growth performance is assessed by the weight at 400 days of age. Little emphasis is placed on daily gain during the test period. On the contrary, in Swedish tests the first 30 days are regarded as the adjustment period and then bulls are assessed through an index based on weight at the end of the adjustment period and daily gain on test. The index gives a relatively high weighting to daily gain (Kräusslich, 1974).

The advantage of performance testing as compared to progeny testing is that it permits the evaluation of bulls at an earlier age, hence the generation interval is minimised especially if the test is terminated when the bulls reach sexual maturity (Kräusslich, 1974). The progeny testing, on other hand, requires more facilities than performance testing to test the same number of bulls. Progeny testing is most useful where carcass traits or maternal characteristics are important (Kräusslich, 1974). The progeny testing approach may be applied to the selection of terminal sires, the selection of sires to be used in pure breeding herds or to female selection. In terms of genetic progress the overall advantages of progeny testing over performance testing are small for traits such as growth rate and feed conversion efficiency which can be measured in the live animal and have reasonably high heritabilities.

A major problem known in performance testing is the identification of a bull breeding value based on phenotypic measurement (Dalton *et al.*, 1978). In addition, performance testing results are known to be environment and time specific. An animal that performed excellently on station will not necessarily show similar performance after the test in a different environment at a given period. Hence, the recommendation to use performance test results in line with Breed Associations’ records (Barham, 2003). Finally, selection based on the high correlation that exists between the starting (200-day) and end (400-day)

weights ($r_p = 0.8$) has its own implications on selecting the appropriate bulls (Dalton *et al.*, 1978). This is due to the fact that the starting weight (200-day) is affected by managerial differences (Dalton *et al.*, 1978).

2.1.1 National Beef Cattle Performance and Progeny Testing Scheme (NBCPPTS)

The station performance testing scheme in the RSA was started in 1959 (Bosman, 1994) and the major purpose is to supply breeders and the beef industry at large with valuable cattle performance information in order to improve the efficiency of beef production (Bergh, 1999). The scheme consists of five phases (A, B, C, D & E) in which both the economic and biological efficiency of performance tested animals are thoroughly evaluated.

Phases A & B involve the measurements of the cow herd and their calves' performance (e.g. pre-weaning growth), whilst at the owner's farm. Data of calf birth and weaning weight (at approximately 7 months) and data of their mothers at both occasions are recorded during Phase A. During Phase B, the weight of steers, heifers and young bulls is recorded at twelve and eighteen months old. The scrotal circumference of the bulls is also recorded.

Post-weaning performance (i.e. growth rate and feed conversion ratio) or Phase C is measured under standardised intensive conditions at central bull testing centres (i.e. C1: ARC testing centres, C2: Private testing centres, C3: Automated on-farm testing centres) immediately after weaning. The testing is carried out over a period of 84 days following an adaptation period of 28 days. The animals are about 10 months old when the test ends. Linear measurements (height at withers, body length and scrotal circumference) of the bulls are also recorded.

Phase D (D1 & D2) is also carried out over a period of 84 days or longer (270-days) depending on growth rates of bulls. Similar measurements are taken as in Phase C, but under extensive conditions, either at owner's farm or at a central venue.

In Phase E, the quantitative and qualitative carcass traits (i.e. carcass weight, lean to bone ratio, marbling score) of a few selected progeny's (at least 8 of the same sex) of a herd sire or AI are evaluated (Bosman, 1994; Bergh, 1999).

2.2 Growth rate

The importance of growth rate in beef cattle production has received ample attention from various researchers (Dalton, 1980; Liu *et al.*, 1993; Owens *et al.*, 1993; Bosman, 1994; Grings *et al.*, 1996; Arthur *et al.*, 2001b; Lawrence *et al.*, 2002). In general, high growth rate is favoured because of earlier marketable weight obtained as compared to slow growth. Growth rates is determined using various techniques i.e. liveweight measurement, body measurement, visual appraisal of live animal conformation, video image analysis, urinary creatine excretion (Lawrence *et al.*, 2002). Of all liveweight measurement is being considered as the most convenient method.

Liveweight measurement is, however, a variable parameter because of gut-fill. In ruminants, the contents of the rumen and reticulum proportionately account for at least 10 to 15% and frequently up to 23% of the total liveweight of the animal (Lawrence *at al.*, 2002). In non-ruminant animals, for example pigs in particular, studies have shown that the gastro intestinal tract (GIT) contents may vary between 2% for a 90kg and 5% for a 20kg pig. With empty gut body weight, the variability between live animal weights is reduced and hence is the most preferred when comparing liveweights. An empty gut body weight is obtained from viz. fasting, water deprivation and standardised time for livestock weighing. As far as extensive grazing is concerned, standardised weighing is probably the most convenient method. This is because, in grazing animals, the digesta present in the GIT are likely to be minimal in quantity and least variable at the beginning of the day and highest and most variable at the end of the day (Lawrence *et al.*, 2002).

Growth rate is influenced by several factors such as variation in production systems, experimental treatment [e.g. breed, age and sex] (Moyo, 1996), plane of nutrition, hormonal status and environment (Owens *et al.*, 1993). The *Bos indicus* cattle, for example, tend to reach puberty later compared to *Bos taurus* because of their exposure to

the adverse environmental conditions and poor nutrition in the tropics. Large frame-sized cattle (i.e. Simbra and Simmental) tend to reach puberty later than small frame size (i.e. Aberdeen Angus, Hereford and Santa Gertrudis) cattle due to a slow rate of maturity. A recent study by Chase *et al.* (2001) found that F₁ bulls produced from Brahman bulls bred to Angus cows reached puberty later compared to those sired by Senepol and Tuli (Sanga) bulls (small frame) in Florida. Vargas *et al.* (1998) reported that small and medium frame size Brahman females reach puberty earlier compared to the large frame-size ones.

2.3 Feed conversion efficiency (FCE)

2.3.1 Feedlot testing

2.3.1.1 Feed Conversion Ratio (FCR)

The efficiency of feed utilisation in feedlot testing of beef cattle is based on FCR, which is the amount of feed consumed divided by the liveweight gain (feed intake / weight gain) (Arthur *et al.*, 2001a, Sainz *et al.*, 2004). Variation in feed intake (FI) in ruminants is associated with maintenance requirements. According to Herd *et al.* (2004a), as feed intake increases the amount of energy expended to digest the feed increases due in part to the change in size of the digestive organs. The amount of energy expended by the tissues themselves also increases per unit weight of the animal, hence the heat increment.

In the contexts of the RSA beef industry, the FCR is an important selection trait since more than 50% of all cattle slaughtered are finished in feedlots (Scholtz, *et al.*, 1998). Numerous studies have shown that FCR is strongly negatively correlated with average daily gain (ADG). This implies that the selection for lower FCR would result in higher growth rate or *vice versa* (Scholtz *et al.*, 1998; Arthur *et al.*, 2001a; Nkrumah *et al.*, 2004; Sainz *et al.*, 2004). In a study of young Angus bulls and heifers performance tested in a feedlot, Arthur *et al.* (2001a) reported a negative genetic and phenotypic correlation between FCR and ADG ($r_g = -0.62$ and $r_p = -0.74$, respectively). Nkrumah *et al.* (2004) obtained a phenotypic correlation of -0.63 between ADG and FCR in hybrid cattle.

Nkrumah *et al.* (2004) also reported a relatively high phenotypic correlation between FCR and dry matter intake (DMI) ($r = 0.49$) in the same cattle. In terms of the correlations between FI and FCR, Arthur *et al.* (2001a) reported a moderate correlation between the two traits ($r_g = 0.31$ and $r_p = 0.23$).

2.3.2 On-farm testing

2.3.2.1 Kleiber ratio (KR)

Unlike in feedlots, it is difficult to determine the FI of grazing cattle. An alternative ratio, the relation of growth rate to metabolic mass (the Kleiber ratio; KR) was developed to address rangeland animals (Arthur *et al.*, 2001b). Bergh (1994) indicated that KR is highly heritable ($h^2 = 0.50$), which suggests that herd feed efficiency could be improved through a selection process. The selection for KR is known to have fewer negative results than for ADG, since it has a lower correlation with other traits such as birth weight, final weight, average daily gain per day of age (ADA), shoulder height and body length (Bergh, 1994).

In an experiment on young Charolais bulls, Arthur *et al.* (2001b) reported a lower heritability estimate for KR ($h^2 = 0.31$) but obtained a strong genetic and phenotypic correlation with FCR ($r_g = -0.81$ and $r_p = -0.67$) and ADG ($r_g = 0.82$ and $r_p = 0.83$). In view of the fact that KR was less correlated with most of the other measures of feed efficiency viz. FI, RGR (relative growth rate), RFI (residual feed intake), LWT (liveweight), PEG (partial efficiency of growth), it was concluded that it would allow KR to be independently selected without compromising other FCE traits (Arthur *et al.*, 2001b). Nkrumah *et al.* (2004) reported similar results in hybrid cattle (Table 2.3.2.1), although substantial correlation was found between KR and RGR ($r_p = 0.96$).



Table 2.3.2.1 Phenotypic correlations of the Kleiber ratio with other measures of feed efficiency in hybrid cattle (steers and bulls)

Kleiber ratio (r_p)	Other measures of feed efficiency
0.85	ADG
0.73	FCR
0.36	DMI
0.03	MWT
0.53	MEI
0.04	RFI
0.32	PEG
0.96	RGR

(Nkrumah *et al.*, 2004)

Where: MWT = metabolic midpoint weight; MEI = metabolizable energy intake per unit metabolic weight; RFI = residual feed intake; PEG = partial efficiency of growth; RGR = relative growth rate.

2.3.2.2 Veld Feed Conversion Ratio (VFCR)

The energy derived from food consumed is used for various functions necessary for life in the animal body e.g. for maintenance (e.g. mechanical work of essential muscular activity), chemical work (i.e. movement of dissolved substances against concentration gradients), synthesis of expended body constituents (i.e. enzymes and hormones) and production. Excess energy leaves the body in the form of heat. Energy produced from digestion and metabolism of food constituents (e.g. heat increment due to feeding) and from voluntary muscular activities of the animal, is also released in the same manner (McDonald *et al.*, 2002). The minimum or lowest amount of heat can be produced when the animal is not given food (fasting) for a period of at least four days and is kept in a thermoneutral environment with minimum movement/activity. The minimum heat produced is known to equal the quantity of chemical energy used for body maintenance. This gives the direct estimate of maintenance energy requirement - also known as the



“basal metabolism”- of the animal (McDonald *et al.*, 2002). As opposed to human beings, farm animals do not reach a level of zero movement. As a result, a much more relative term “fasting metabolism” (a state of acceptable minimum movement carried out by the animal) is often preferred to “basal metabolism” in estimating maintenance energy requirements in farm animals. The standard formula for calculating basal metabolic rate (BMR) - the energy requirement for immobile, empty guts and not-growing animal- is given by Kleiber (1975) as cited by Owen-Smith (2000) as:

$$\text{BMR} = 293 M^{0.75} \text{ kilojoules/day (where M is the liveweight in kg).}$$

Although, BMR may be influenced by various factors (i.e. activity of the animal, reproduction status, protein requirements and other nutrients, body composition, body insulation and weather conditions) the nutritional needs of species of different sizes can be conveniently compared using units of “Metabolic Weight Equivalent” (MME) (viz. $M^{0.75}$) calculated according to the basal metabolic rate (Owen-Smith, 2000). It is known that body size has a great influence on animal metabolism and as a result it directly determines the feed intake and energy requirements of the animal (Owen-Smith, 2000; McDonald, *et al.*, 2002). In simple terms, the rate of metabolism varies among animals in accordance with their body weight. Owen-Smith (2000) pointed out that BMR varies among animal’s species according to their body weight raised to the power three-quarters. Therefore, the specific metabolic rate per unit body weight decreases as weight increases ($M^{0.75}/M^{1.0} = M^{-0.25}$). Owen-Smith (2000) further indicated that since the metabolic rate per unit of body liveweight decreases with increasing body size, daily food intake as a fraction of body live weight declines with increasing body size. Thus, larger animals consumed (e.g. cow -1.5-2.5%, sheep-3-4% and elephant-1-1.5%) less feed in relation to their body liveweight than small animals. A mature cow of 450 kg will consume approximately 2% (± 9 kg DMI/day) of its absolute weight whereas a young growing steer or heifer of 200 kg may consume about 4% (± 8 kg DMI/day) or more. Using the MME, the two animals will have 98 and 53 kg metabolic weights respectively and their feed intake relative to MME will be close to 9-15% per day. If these percentages ($\approx 12\%$ of MME) are used with ADG on grazing animals it is possible to

determine what is known as “Veld Feed Conversion Ratio” (VF_{CR}), hence the efficiency (Prof. T. Ungerer, Box 288, Vrede, pers, comm.). The VF_{CR} is determined as follows:

$$VF_{CR} = \frac{(12\% \times MME)}{ADG}$$

2.4 Temperament

Temperament in cattle is defined as the fear response to handling by man (Fordyce *et al.*, 1985; Petherick *et al.*, 2003). Animals with a good temperament are easy to handle during milking, mustering and vaccination. Field evidence has shown that animals with a poor temperament have slower growth rates compared to those with a good temperament and in addition tend to have a poor meat quality (Fordyce *et al.*, 1985; Fordyce *et al.*, 1988b; Voisinet *et al.*, 1997; Petherick *et al.*, 2003). Bramblett *et al.* (1963) as cited by Lanier *et al.* (2000) reported that stressful treatment during growth can have adverse effects on meat quality in lambs. Voisinet *et al.* (1997) reported that cattle breeds with aggressive temperaments have low average daily gains in feedlot compared to docile ones. In a study involving Brahman cross and Shorthorn bulls, Fordyce *et al.* (1988b) found that cattle with higher temperament scores (aggressive cattle) had more bruises, along the back and around the hips (tuber coxae) and pins (tuber ischii) areas after being transported for 740 km to abattoirs in northern Queensland. After being slaughtered cattle with higher scores had less tender meat. In a study conducted in the same area, Fordyce *et al.* (1996e) found no phenotypic or genotypic correlation between temperament scores at 18 and 24 months with liveweight or postweaning growth rate in Brahman x Shorthorn cross and Sahiwal x Shorthorn crosses.

Temperament can be improved genetically within the herd by selection and culling because of its relatively high heritability ($h^2 = 0.45$) (Bosman, 1999; Lanier *et al.*, 2000). Voisinet *et al.* (1997) reported that cattle with more Brahman breeding are more temperamental compared to those with lower or no Brahman influence. Bayer *et al.* (2004) concurred with these findings and indicated that despite being better adapted to low quality feed and tick resistant, the Brahman cannot be used in a span due to its poor



temperament. Hammond *et al.* (1998) reported similar findings in an experiment involving Brahman and Brahman x Angus crosses. According Hammond *et al.* (1998), the poor temperament in Brahman cattle is associated with a higher level of cortisol in Brahman than in Brahman x Angus cross. Voisinet *et al.* (1997) also reported that heifers are more temperamental compared to steers. Moreover, field evidence has also shown that breed with *Bos taurus* strain have a poorer temperament compared to those with a lesser strain of *Bos indicus*. Fordyce *et al.* (1996e) found that Sahiwal cattle were more temperamental compared to Brahman and that $\frac{3}{4}$ crosses had poorer temperament compared to $\frac{1}{2}$ crosses.

Studies have shown that selection for temperamental bulls carried early (i.e. after weaning) yield desirable results compared to when selection is carried later. It is believed that continuous handling interferes with the general behaviour of the bull when it is older compared to when it is still younger. Furthermore, it is suggested that an assessment of temperament at an auction should be avoided as it does not reflect the true behaviour of the animals. A study by Grandin, (1997) has shown that previous handling of the animal has an effect on the animal behaviour during particular handling procedures. According to Grandin (1997), animals that are trained and habituated to a squeeze chute may have baseline cortisol levels and be behaviourally calm, whereas extensively reared animals may have elevated cortisol levels in the same squeeze chute. The squeeze chute may perceive as neutral and non-threatening to one animal whereas to another animal, the novelty of it may trigger intense fear. Furthermore, Grandin (1997) suggested that to accurately assess an animal's reaction, a combination of behavioural and physiological measurements will provide the best overall measurement of the animal's comfort.

2.5 Muscling scores

Muscles are the most valuable part of the carcass. Muscle content greatly influences the grade which the carcass will be given at abattoirs. Animals with a higher amount of muscles usually tend obtain higher grades than those with poor muscle content (McKiernan, 2000). Muscling affects the dressing percentage and meat yield in a positive way by gaining higher prices. Dressing percentage is the weight of a carcass in relation to

the liveweight of the animal (McKiernan, 2000). Recent studies involving Hereford cattle and their crosses have shown that animals with higher muscling score do not only tend to show greater expression of musculatures, but also show healthier appearances (Koch *et al.*, 2004).

To identify muscles on a live animal or carcass a simple and cheap method termed 'muscling scoring' is used. It describes the shape of cattle independent of the fatness. Scores range from 'A' or '1' for heavily muscled to 'E' or '5' for lightly muscled (McKiernan, 2000; Sundstrom *et al.*, 2000). Muscle scores are positively correlated with meat yield (McKiernan, 2000). Muscles can be evaluated on a live animal in two ways viz. visual appraisal and through the use of a Real Time Ultrasound (RTU) scanning device. Live muscle score defines the thickness and convexity of the animal, relative to its size, discounting for subcutaneous fat and it is mainly based on a view of the hindquarters (McKiernan, 2000). RTU measures the percentage of back fat and rib eye muscle area of the animal. A moderate correlation between the rib eye muscle area (usually of the 12th and 13th rib) and shape with muscle score has been found in cattle. However, according to McKiernan (2000) the eye muscle area *per se* is not very useful as an indicator of animal or carcass muscularity because of its high correlation with the size of the animal. As an animal gets bigger its eye muscle area gets bigger but muscle score could still stay the same, increase or decrease depending on the true muscularity of the animal

A pre-requisite of accurate muscle evaluation is the accurate appraisal of fatness. Once an animal fatness is known, allowance can be made to visually and mentally ensure that fatness does not hinder the evaluation of the animal shape. The best areas to assess muscling are those that are least influenced by the fat content. Indicators of muscling in order of importance are (Koch *et al.*, 1994; McKiernan, 2000):

- ✓ thickness and roundness of the hindquarter,
- ✓ width in the twist and rump
- ✓ width across the back and loin
- ✓ thickness of the forearm



2.6 Body condition scores (BCS)

Body condition scores are subjective, visual appraisal based upon apparent external fat cover, appearance of muscle, and obvious skeletal features that are commonly used to monitor and manage the nutritional and health status of both dairy and beef cattle (Battaglia, 1998; Dechow, *et al.*, 2000). Dechow *et al.* (2000) noted that body condition scores are phenotypically associated with yield, cow health, and reproductive performance. In a study of Holstein cows, Dechow *et al.* (2000) reported that a higher BCS during the lactation period was negatively correlated to production (genetically and phenotypically) even though the relationship was less significant. A higher BCS was genetically positively correlated with a higher reproductive performance during lactation. Generally, the heritability estimate of BCS in cattle is very low. Dechow *et al.* (2000) reported 0.09 and 0.15 heritability estimates at dry-off and post partum respectively, in first lactation Holstein cows.

Body condition is scored on an integer scale of 1 to 9 (Pryce *et al.*, 2000; Koenen *et al.*, 2001; Veerkamp *et al.*, 2001) as cited by Dechow, *et al.* (2003), although some people prefer using a five point scale (Roseler *et al.*, 1997; Dechow, *et al.*, 2000), ranging from emaciated to extremely fat with each describing the amount of body reserves in the animal as shown below (Battaglia, 1998):

BCS 1-Severely emaciated: No external fat is detectable by sight or touch, over spinous processes of the backbone, edge of the loin (transverse processes), edges of hipbones, or ribs. Tail-head is quite prominent. All ribs and bones structure are easily visible and physically weak. Severe muscle loss appears at the shoulder, loin and hindquarters.

BCS 2-Poor: Similar to 1, but not as weakened. Tail-head and ribs are less prominent to eye and touch than BCS 1. Slightly more muscle is palpable over spinous processes of the spine, but nearly the same degree of muscle loss as BCS 1.

BCS 3-Thin: No palpable or visible fat on ribs, brisket or shoulder blades. Individual muscles in the hindquarter are easily visible and spinous processes are very apparent.



BCS 4-Borderline or slightly thin: only the rear ribs and hipbones are obvious to the eye.

Individual spinous processes are no longer visible, but can still be palpated. There is some fat cover over front ribs, edge of the loin, and shoulder. No visible muscle atrophy.

BCS 5-Moderate: Cow exhibits good overall appearance. Only the last two ribs are obvious to the eye. There is fat over shoulder, foreribs, and loin. Fat cover is 'springy' over ribs, and tail-head has palpable fat over on either side. No fat in brisket. Very little fat appears over hooks and pins.

BCS 6-High moderate or slightly fleshy: no individual ribs are evident. Spinous processes are not palpable except with firm palpation. Considerable fat appears around tail-head. Some fat in brisket. Obvious fat covering shoulder, loin and foreribs is visible.

BCS 7-Good or fleshy: Brisket is relatively full, tail-head and pin bones have protruding deposits of fat on them. Back appears square because of fat. Indentation is visible over spinal cord due to fat on each side.

BCS 8-Fat or obese: Neck is thick. Large indentation is over the spinal cord. Back appears square when viewed from behind. Flanks appear deep due to fat fill and brisket is distended with fat. Tail-head is lost in pones of fat.

BCS 9-Extremely fat or over obese: Description of Score 8 taken to greater extremes

2.7 Scrotum circumference (SC)

Numerous studies have shown that in addition to nutrition, bull fertility is largely affected by the size and shape of its testes. Taylor (1995), Battaglia (1998) and Bosman (1999) reported that, the shape and size of the scrotum is positively correlated to the quality and quantity of sperms, pregnancy percentage and yearling weight. In a study of bulls of the Bovelder breed, Bosman (1999) reported that bulls with SC ranging from 24 – 40 cm at two years of age produced the best quality semen with least abnormalities compared to those with a much smaller or larger SC. In addition, Bosman (1999) also reported that heifers sired by bulls with a larger than average SC, reached puberty earlier (62 days earlier) compared to those from bulls with smaller SC. Moreover, Bosman (1999) added that good scrotal circumference, size and shape are indications of an excellent hormonal

status and a high libido in the bull. On the contrary, studies by Blockey (1978), Crichton *et al.* (1987), Christie (1988) and Jacobi (1989) as cited by Taylor (1995), have all found very little relationship between SC and libido.

Scrotum circumference is highly heritable ($h^2 = 0.55$) (Bosman, 1999). Knights *et al.* (1984) and Neely *et al.* (1982) as cited by Taylor (1995) reported a heritability estimate of 0.36 and 0.44 respectively in 12 months age beef cattle. A positive correlation between scrotum circumference with the fertility of young heifers has been reported in various papers, providing an alternative selection method for increasing female fertility in a herd. A study by Mosser *et al.* (1996) reported a positive correlation between SC and age at puberty of daughter progeny, age at first breeding or rebreeding after calving of half-sib heifers in both purebred and crossbred cattle. Vargas *et al.* (1998) reported a high correlation of Brahman bulls SC with their heifer's age at puberty under subtropical conditions. Vargas *et al.* (1998) further reported a positive environmental and genetic correlation ($r_g = 0.19$) of SC with hip height in Brahman bulls.

Chewning *et al.* (1988) as cited by Brown *et al.* (1991), reported a positive relationship between body condition and SC. A positive correlation ($r = 0.15$) has also been found between SC and ADA (Taylor, 1995). Taylor (1995) reported that SC is affected by the animal's body weight and is also a function of birth weight, preweaning ($r = 0.32$ -initial body weight) and postweaning ($r = 0.39$ -final body weight) growth rate and age. Coulter & Foote (1977) as cited by Brown *et al.* (1991) reported that heavily muscled, 2-yr-old bulls had SC measurements 2 to 3 cm higher than bulls in good body condition.

Feeding has a marked effect on SC and sperm production especially after weaning. In a study on British and Continental cross breeds, Coulter *et al.* (1997) reported that feeding of a high-energy (e.g. 80% grain and 20% forage) diet can lead to larger SC, heavier weight and thicker back fat as compare to feeding of a moderate or low energy diets (e.g. 100% forage). However, bulls fed a moderate-energy diet have significantly more morphologically normal spermatozoa and a higher proportion of progressively motile spermatozoa compared to those fed a high-energy diet. It was concluded that an increased dietary energy concentration may affect scrotal or testicular thermoregulation by reducing

the amount of heat that can be radiated from the scrotal neck, thereby increasing the temperature of the testes and scrotum.

2.8 Environmental factors influencing performance

2.8.1 Adaptability

The term “adaptability” refers to the genetic and physiological changes that take place in an animal in response to internal and external stimuli (Hafez, 1968; Yousef, 1987). Physiological adaptation is, according to Hafez (1968), the capacity and process of adjustment of the animal to itself, to other living material and to the external physical environment. Genetic adaptation is the heritable characteristics that favour survival of a population in a particular environment. Animals reared under extensive grazing conditions are faced with more challenges imposed by the environment compared to pen-fed animals. Recent studies have indicated that the arid and semi arid areas are likely to experience an increase in the severity and length of droughts as well as in ambient temperatures. For this reason it is suggested that under such conditions locally adapted breeds will have a competitive advantage over the exotic breeds (Kohler-Rollefson, 2004).

The test for an animal to adapt to a particular environment begins as early as at the developmental stage of the embryo or the foetus. It is known that, upon the complete formation of the embryo, the genetic make-up of an animal gets permanently fixed. However, the expression of the hereditary make-up depends upon the environment where it will be exposed (Bonsma, 1980). For example, whilst the embryo is developing within the uterus of a pregnant cow, the environmental factors affecting the cow, being either internal or external, indirectly affect the embryo/foetus adaptability (Bonsma, 1980). A pregnant cow that is not heat tolerant stands a possibility of giving birth to a miniature calf (short and small) if the pregnancy is carried over the hot period of the year. Therefore, an adaptable animal as defined by Bonsma (1980) is the one which is in harmony with the prevailing environmental conditions at any given time.

There are a number of environmental factors that affect the adaptability of cattle under extensive grazing conditions viz. physical (e.g. rainfall, temperature, humidity, light, wind and atmospheric pressure, radiation and altitude), biological (e.g. nutrition (grazing), water and water quality, soil fertility and pH and diseases and parasitism) and human factors (i.e. breeding system and management). Each of these factors has its own degree of significance and impact on the performances of cattle reared under extensive conditions. The degree of significance is however, influenced by the specific environment. By virtue of their importance in the tropics and subtropics, temperature, nutrition and diseases and parasitism will be reviewed in detail in this paper.

2.8.1.1 Temperature

Temperature is crucial in cattle production as it determines the type of breeds that can be maintained in a particular region (Bonsma, 1980). In the tropics and subtropics the variations in daily and seasonal temperature is minimal (Williamson *et al.*, 1978). In South Africa (subtropics) the average annual isotherm (average temperature for the year) ranges between 18.3°C and 21.1°C (Bonsma, 1980). In the tropics, the average annual isotherm ranges between 22.0°C at the Tropic of Cancer and 24.0°C at the Tropic of Capricorn with the maximum temperature rising above 40.0°C (Pagot, 1992). Temperature variation within the animal body exhibits the extent to which an animal can resist adverse environmental conditions and also determines the health status of the animal. It is common knowledge that cattle are homothermous; thus, their body temperature remains fairly constant despite the changes in the external environmental temperature (Yousef, 1987; Pagot, 1992; McDonald *et al.*, 2002). The average body temperature of cattle is 39.0°C with a minimum and maximum of 37.0°C and 41.0°C respectively. Any significant deviation from these standards depicts signs of either poor adaptability or health status. Cattle that do not withstand high temperatures become hyperthermic and often have low growth rates and low fertility (Bonsma, 1980).

As has been alluded to earlier, the tropics and subtropics have high ambient temperatures and studies have shown that such an environment requires animals that are capable of



dissipating metabolic heat efficiently in order to thrive (Bonsma, 1980). The literature has shown that, when the animal body temperature rises above the normal, the thermoreceptor (sensory organ) located just underneath the skin surface, sends signals of the high heat detected to the central nervous system (e.g. hypothalamus and cerebral cortex). This is then passed to the endocrine system and musculature to react. If the endocrine system is involved in heat regulation the results are behavioural; the animal responds voluntarily (e.g. seeking shelter, drinking more water, hibernating and reducing feed intake) (McDonald *et al.*, 2002).

In the tropics, often the unadapted breeds tend to reduce their feed intake due to unfavourable temperature levels resulting in low performance compared to adaptable breeds. Research has found that temperate breeds (*Bos taurus*) relatively reduce their feed intake by 2% for every 1°C increase in average daily temperature above 25°C (McDonald *et al.*, 2002). Contrary to the general belief, Zebu cattle do not dissipate heat effectively but produce low internal heat which allows them to adapt well in the tropics (Johnston, 1981). Nonetheless, a smooth coat, thick moveable hides and vascularity of the skin have been reported as features which aid heat dissipation (Bonsma, 1980). Studies have also found that the excessive hairs of woolly-coated cattle reflect most of the energy radiation from the sunlight and consequently inhibit effective evaporative cooling on the animal (Bonsma, 1980; Pagot, 1992). Bonsma (1980) pointed out that offspring from smooth-coated Afrikaner bulls and woolly-coated Afrikaner dams, Shorthorn or Aberdeen Angus significantly differed in growth rate. Offspring that had sleek-coated skins highly outperformed their counterparts with woolly-coated skins in terms of daily weight gain, growth and thriving in hazardous subtropical environment. Results from the same study also revealed that cows that are mated in spring and carry their pregnancy over the summer give birth to miniature calves if such cows are not adapted to the hot climates of the subtropics.

Recent studies by Brito *et al.* (2004) have found that *Bos indicus* cattle has better body thermoregulatory capability than *Bos taurus* cattle, because they have a greater skin surface to body size ratio, more sweat glands, lower thermogenesis, and are usually of smaller frames. Research has shown that when *Bos indicus* bulls are exposed to high



ambient temperatures, they show a slower and less pronounced decrease in semen quality, and a faster recovery, compared to *Bos taurus* and crossbred bulls. This, according to Brito *et al.* (2004), could be attributed by small sizes (average 330.5 μm) of the testicular artery wall thickness and arterial–venous blood distance in the testicular vascular cone (TVC) of the *Bos indicus* breed than in crossbred and *Bos taurus* (average 373.7, and 609.4 μm , respectively). The morphology of the TVC plays a crucial role in heat resistance by conferring a better testicular blood supply and by facilitating heat transfer between the testicular artery and veins.

2.8.1.2 Nutrition

Feeds are crucial to the existence of cattle. The quantity and quality of what the animal eats determines its productivity (Rothouge, 2000). In addition to diseases and parasitism the rate of growth, development and the level of reproductive efficiency are all influenced by the plane of nutrition. Undernourished animals perform poorly at all levels of production. The sexual maturity of heifers and bulls, performance and fertility of bulls, the intercalving interval period and/or the ability of lactating cows to recycle, is highly influenced by the level of nutrition (Hunters *et al.*, 1992). In bulls, the nutrient requirements generally depend on age, size, growth rate and level of activities. Therefore, it is common for yearling bulls to have a higher nutritional demand compared to mature bulls due to their high growth rates (Barham *et al.*, 2001).

Rainfall in the tropics and subtropics has the greatest effect on shape and pattern of plant growth. The semi-arid areas have the shortest growing season (e.g. ± 90 -180 days) due to a short rainy season, whereas in sub-humid areas plants have a longer growth period of about 100 to 270 days (Hunters *et al.*, 1992). The seasonality of rainfall in the tropics is twofold; 1) it brings about a flush of pasture of good quality with a growth state that exceeds the animal's nutritional demands during the rainy season and 2) When it stops during the dormant season, it creates a situation where the energy intake of grazing cattle is often less than their maintenance requirements. This results in a negative energy balance that leads to a considerable reduction in herd performance. Most sub-tropical plants species are rich in polysaccharides and lignin content (Bonsma, 1980; Hunters *et*

al., 1992) due in part to a shorter rainfall and longer dormant season. Many of these plants are therefore less digestible than temperate plants. Higher lignin content reduces the activities of the rumen bacteria resulting in a longer residence of the digesta in the rumen and ultimately decreases feed intake.

2.8.1.3 Diseases and parasitism

The effect of diseases and parasitism to animal adaptability is enormous. Animals that are poorly adapted to a certain environment are more vulnerable to diseases (Bonsma, 1980). For example, low heat tolerant cattle are more susceptible to tick-borne diseases compared to those that can withstand a high ambient temperature. Hunters *et al.* (1992) & Provost *et al.* (1992) pointed out that the distribution and intensity of challenges by diseases in the tropics and subtropics is influenced by the differences in climatic conditions within these areas. For example, worm eggs survive better in humid climates than in the desert and as a result, cattle in humid areas are more prone to internal parasite infection than those in drier areas. Tick vector of East Coast Fever prefer higher and cooler areas whereas the Tsetse flies thrive better in warmer and low altitude areas. In countries such as Nigeria and Burkina Faso with altitudes of 320 and 360 m respectively, the outbreak of diseases transmitted by tsetse flies is frequent compared to countries such as Namibia, Botswana and South Africa with higher altitudes.

2.8.1.3.1 External parasites

Despite the significant number of tsetse flies, as found in most parts of the tropics (Tacher *et al.*, 1992), ticks are considered as the most important parasites in animal health (Bonsma, 1980; Provost *et al.*, 1992). The two major importance of ticks in animal production are as listed by Provost *et al.* (1992):

- 1) the economic loss caused by directly inflicting damage to cattle
- 2) their efficiency in transmitting several pathogenic, viral and bacterial diseases

Ticks can approximately remove up to 96 kg of blood from one animal in one year and cause a lot of damage to hides and skin (Bonsma, 1980). Tick bites are very painful and cause irritation to cattle. In acute cases tick bites can lead to significant loss of blood and even death (Provost *et al.*, 1992). According to Bonsma (1980), animals with thick, movable hides, well-developed panniculus muscles and a sensitive pilomotor nervous system are more tick repellent than those with woolly hair and thin hides. The resistance is due to their ability to move their hides very quickly to repel insects that may cause irritation. In addition, animals with thick hides have a fast immune system and can succumb much less to tick-borne diseases than those with thin hides (Bonsma, 1980). The most important tick-borne diseases in the tropics and subtropics are Babesiosis, Theileriosis, Anaplasmosis and Cowdriosis.

2.8.1.3.2 Internal Parasites

The effect of internal parasites in cattle is more pronounced in the hyper-humid and humid areas of the tropics because of their wet environmental conditions. Internal parasites are classified as either helminths (e.g. trematodes, cestodes and nematodes), sporozoan (i.e. unicellular parasites e.g. *amoeba*) or larvae (Pagot, 1992). Nematodes (e.g. *Ascaris*, *Filiara* and *Strongyloides* species) are smooth round worms, which live mostly in the small intestines affecting the intestines villi, causing severe haemorrhaging and anaemia. Nematode parasites inflict more disease problems compared to other internal parasites. There is a fear that they may have developed resistance against many anthelmintic drugs (Waller *et al.*, 2004). Flat worms such as trematodes and cestodes are also important and cause huge losses in cattle production in the tropics and subtropics. *Fasciola hepatica*, the common liver fluke, a trematode type of worm, is known for causing poor growth, weight loss, anaemia, and lack of stamina leading to reduction in bull fertility (Sundstrom *et al.*, 2000).

Due to the fact that they live inside the animal (e.g. GIT, glands), internal parasites are inclined to cause damage to the internal lining of the animal as indicated above. Common major defects caused by internal parasites are internal bleeding (haemorrhages) followed by anaemia and associated oedema, diarrhoea, chronic emaciations and even death.

Recent studies (Eysker *et al.*, 2000) have shown that parasitic gastroenteritis caused by nematodes has severe effects in young calves and small ruminants compared to mature cattle. In agreement with Eysker *et al.* (2000), Tyler (2004) reported that the challenge of internal parasites on animals decreases with an increase in animal age. Thus, calves are more susceptible to infection of gastrointestinal parasites (GIP) than steers or heifers, and steers and heifers are more susceptible than mature cattle.

Rainfall and temperature are the major contributors to parasitic infections. Studies have indicated that favourable rainfall and temperature conditions determine the abundance of infective larvae at different times of the year and the severity of infection within certain climatic zones (Tyler, 2004). When favourable conditions prevail, worms tend to lay as many eggs as possible. In addition, poor nutritional status and weaning stress also contribute to parasite infections (Tyler, 2004). Overstocking also increases the chances of parasite infections. Tyler (2004) noted that the exotic breeds (*Bos Taurus*) are more susceptible to worm infections than *Bos indicus* breeds. Keyyu *et al.* (2003) had similar findings in their study on GIP counts in indigenous Zebu cattle of Tanzania and in exotic breeds. It was concluded that Zebu cattle are more resistant to gastrointestinal nematodes or helminthosis in particular as they had lower worm counts comparable to crossbreeds and exotic breeds.



2.9 Breeds studied

2.9.1 Defining a breed

There is still no generally accepted definition – scientific or otherwise- of a breed (Maule, 1990; Hammack, 2003). In the 1940's a breed was defined as “a race of animals which have some distinctive qualities in common”. At the end of the twentieth century the definition of a breed changed to “a stock of animals within a species having similar appearance, usually developed by deliberate selection” (Hammack, 2003). To date, a ‘breed’ is known as a group of animals having definable and easily identifiable external characters that distinguish it visually from other similar groups within the same species (Maule, 1990; Hammack, 2003). This section will discuss in detail the origin, descriptions and performance characteristics already known for each of the breeds used in this study.

2.9.2 Indigenous breeds

2.9.2.1 Nguni

2.9.2.1.1 Breed history

The Sanga cattle are believed to have evolved from crosses between the humpless longhorn cattle and the Indian Zebu around 1600 BC in north-eastern Africa (Friend, 1978; Maule, 1990; Bergh *et al.*, 1999). They found their way into Southern Africa through the immigration of the Bantu tribes around 500 A.D. The name Nguni was derived from a tribal community (Nguni people) who then farmed with these cattle. It is claimed that originally the Sanga cattle in the Southern Africa were known as ‘Zulu’ or ‘Swasi’ cattle, a name derived from the tribes that owned them (Friend, 1978). Similar cattle in southern Mozambique and Eastern Transvaal (presently known as Mpumalanga Province) are known as ‘Landin’ and ‘Bapedi’ respectively (Friend, 1978; Maule, 1990).



2.9.2.1.2 Breed description

The variation that exists in the colours of Nguni cattle has yielded different colour descriptions by various authors. However, a recent study by Bester *et al.* (2003) has described Nguni cattle as unicoloured or multicoloured white, black, red, fawn, yellow and brown and there are 80 different colour patterns that are either uniform, spotted or pied. Their skins are well pigmented and they have a short, smooth glossy-coat. Females have lyre-shaped horns that point upward and slightly forward and weigh about 363 kg under a good feeding management (Friend, 1978). Polled animals are also common. Mature males have shorter stouter and crescent shaped horns and they weigh about 650kg. Bester *et al.* (2003) stated that although the Nguni are naturally small to medium size animals, their weights depend on the availability of feed.

2.9.2.1.3 Adaptability and performance

Maule (1990) and Bergh *et al.* (1999) stated that the Nguni cattle are adapted to the low veld areas and have good foraging ability coupled with low veld growth potential. Bester *et al.* (2003) added that Nguni have developed under a process of natural selection and highly challenging environments hence they have the genetic potential to perform better in optimal production environments. Their low maintenance requirements allow them to be very suitable for areas where rainfall is seasonal. Studies have indicated that they are selective grazers and browsers and are capable of obtaining optimal nutritional value from available vegetation, which may not necessarily be the case with the *Bos taurus* breeds (Bester *et al.*, 2003). Furthermore, Bergh *et al.* (1999) and Bester *et al.* (2003) stated that Nguni cattle have a good temperament, an important characteristic that shows their harmony with their total environment.

The resistance of Nguni cattle to ticks and tick borne diseases has been well documented even though the mechanism itself is not yet clearly understood (Spickett *et al.*, 1989; Bergh *et al.*, 1999; Bester *et al.*, 2003; Bayer *et al.*, 2004; De la Rey *et al.*, 2004). Studies have revealed that Nguni cattle are more tick resistant than Bonsmara and Hereford breeds (Spickett *et al.*, 1989). In a study on counts of engorged female ticks on naturally

infested cattle over a 2-year period in the bushveld region of RSA, Spickett *et al.* (1989) discovered that indigenous Nguni cattle harboured significantly fewer *Amblyomma hebraeum*, *Boophilus decoloratus* and *Hyalomma* species during periods of peak abundance compared to the Bonsmara and Hereford cattle. The study also showed that Nguni cattle had fewer abscesses associated with tick bites compared to the Bonsmara and Hereford breeds.

Accordingly, characteristics such as the thick skin, flexible and long tail with a well-developed switch and the vigorous movements of ears are some of the contributing characteristics that prevent the infestation or irritation of pests (Bester *et al.*, 2003). Nguni cattle are highly fertile (Bergh *et al.*, 1999), with average inter-calving rate of 420 days, and are able to withstand the high ambient temperature of Southern Africa (Table 2.9.1).

Table 2.9.1 Comparisons of the Nguni breed with the national average from 1980-1992 and 1993-1998 in the South African Beef Cattle Performance and Progeny Testing Scheme

Trait	1980-1992		1993-1998	
	Nguni	N. avg.	Nguni	N. avg.
Birth weight (kg)	28	35	26	36
Weaning weight (kg)	161	203	155	215
Age at first calving (months)	35	35	34	34
Calving percentage (%)	86.7	83.3	-	-
Inter calving period (days)	421	438	414	423
ADG (Standardized growth test) (g/d)	1141	-	1150	1653
FCR (Standardized growth test)	6.67	-	6.88	6.68
Scrotum circumference (mm)	375	-	315	347

(Bosman, 1994; Bergh *et al.*, 1999)

Table 2.9.1 shows that the Nguni breed had an above average calving percentage that was well above the national average (3.4% higher) during the 1980 – 1992 testing period. The

Nguni cattle have a long productive life span (Bergh *et al.*, 1999). Cows will produce 10 or more calves regularly (De la Rey *et al.*, 2004). The feed conversion efficiency of Nguni cattle is high and it has been recorded that calves growth may reach a rate of 0.7 kg per day until weaning time (De la Rey *et al.*, 2004). The sloping rump, small uterus and low birth weights of Nguni cattle play a vital role in easing the calving process (Bergh *et al.*, 1999; De la Rey *et al.*, 2004). Bergh *et al.* (1999) noted that Nguni heifers and steers reach their sexual maturity at a relatively early stage despite the prevailing harsh conditions. Studies have shown (Maule, 1990) that most tropical breeds reach their sexual maturity at about 36-48 months (which may seem delayed in comparison with temperate cattle) primarily due to the influence of the environment and especially poor nutrition, which may retard growth as well as the development of animals.

2.9.3 British breed

2.9.3.1 Aberdeen Angus

2.9.3.1.1 Breed history

Although there is still controversy about the exact origin of this breed, recent literature has indicated that the Angus originated from Aberdeenshire in Scotland (Dally, 1982; Porter, 1991). Today they are found in many parts of the world including China, the USA, all over Europe, Southern Africa etc. Porter (1991) stated that the Aberdeen Angus has today contributed to the development of synthetic breeds such as Brangus, Africangus, Amerifax, Barzona, Beef synthetic, Holgus, Regus and many others.

2.9.3.1.2 Breed description

Aberdeen Angus cattle are the smallest of all British breeds, polled, black with a smooth coat (Dally, 1982). The body is compact, cylindrical, well-muscled and with short legs. Currently a much taller breed is being bred in Australia, the USA and New Zealand (Porter, 1991).



2.9.3.1.3 Adaptability and performance

Studies have found that the Aberdeen Angus is an early maturing breed (Dally, 1982) and it is able to thrive in poor grazing or fatten on a low cost ration (Porter, 1991). Its popularity under extensive farming has increased its importation by many beef producing countries (60 countries) (Dally, 1982). The average daily weight gain recorded in Britain is 1.23 kg and in performance testing schemes 400 days, bulls averaged 460 kg (Porter, 1991). Aberdeen Angus bulls are extensively used in crossbreeding programs because of their dominant solid colour and polled characteristics.

2.9.4 Composites breeds

The crossing of dams of local breeds with different breeds, especially *Bos taurus* bulls to upgrade them, has been practised since the early nineteenth century. Many breeds that exist today resulted from the crossing of various breeds. Studies have shown that crossbreeding improves cow/calf efficiency when measured as energy requirement (14%) or input costs (20%) per kilogram of steer equivalent weight (Schoeman, 1999). It has been found that even though purebred animals require less energy input and lower production costs per cow than crossbred cows, crossbreds are much preferred because they outweigh the purebred cows by producing 32% more calves at 6% heavier weights. Several studies have shown that the effect of heterosis on calf performance is significant, especially on composites traits. For example, it has been found that the heterotic effect on weight of calf weaned per cow exposed, is approximately 23% in crosses among *Bos taurus* breeds and approximately 50% more for crosses between *Bos taurus* and *Bos indicus*, with at least 60% or more deriving from the maternal heterotic effect.

Initially, crossbreeding was employed for the purpose of improving draught animal power and the general body weight of an animal, however, with increasing population, technology, knowledge and changes in consumer preferences (lean meat, tenderness, milk) crossbreeding became more intensive and a necessity in beef production systems. According to Schoeman (1999), approximately 90% of breeders in Alberta, Canada and the temperate areas of the USA were already practising crossbreeding in 1991. The

United States of America has been at the forefront of developing many breeds (mostly dual purpose) that are adaptable to tropical and subtropical environments.

2.9.4.1 Beefmaster

2.9.4.1.1 Breed history

This breed was developed by a breeder known as Mr. Tom Lasater in the early 1930s in the USA (Porter, 1991; Bosman, 1994). Beefmaster is the first American composite (combination of two or more breeds) breed ever to be developed (Porter, 1991). The breeding purpose of Tom Lasater was to develop a breed that would be more productive than existing breeds in the harsh environment of Southern Texas. The cattle were strongly selected on what has become known as the Six Essential, which are the founding selection principles on which the breed was formed, namely weight, conformation, milking ability, fertility, hardiness and adaptability (Porter, 1991). Due to these selection criteria, the Beefmaster is presently considered by many as the 'Profit Breed'. The breed was developed from crossing three most productive and adaptive breeds in the semi arid areas viz. Hereford, Shorthorn and Brahman cattle. There is, however, a dearth of information regarding the exact composition of these three breeds in the Beefmaster, but it is claimed to be about a $\frac{1}{4}$ Hereford, $\frac{1}{4}$ Shorthorn and $\frac{1}{2}$ Brahman (Porter, 1991). In 1961 the Beefmaster Breeders Society was formed. In the early 1980s the breed was introduced in South Africa and in 1987 the breeder association affiliated to the South African Stud Book (Bosman, 1994).

2.9.4.1.2 Breed description

The Beefmaster varies in colour as there is no set colour pattern, but the most common colour is usually dun or red-brown (Porter, 1991). They are relatively large animals. The head is long with a medium width. Horns are also relatively long.



2.9.4.1.3 Adaptability and performance

Beefmaster cattle are highly fertile and are able to adapt well under various climatic conditions requiring minimum attention from the breeder. They are regarded as heat, drought and insect tolerant. Cows have an excellent mothering ability and are able to wean heavy calves. Bulls are moderately muscular. Newborns are usually small presenting an easy calving possibility in cows.

Table 2.9.2 The performance of Beefmaster in comparison with the national average from 1980-1992 and 1993-1998 in the South African Beef Cattle Performance and Progeny Testing Scheme

Trait	1980-1992		1993-1998	
	Beefmaster	N. avg.	Beefmaster	N. avg.
Number of females in studs	9436	-	8959	221718
Birth weight (kg)	34	35	35	36
Weaning weight (kg)	220	203	224	215
Calving percentage (%)	82.6	83.3	-	-
Inter calving period (days)	442	438	434	423
Age at first calving (months)	36	35	33	34
Final weight (kg)	466	-	478	455
ADG (g/d)	1743	-	1697	1653
FCR	6.40	-	6.59	6.68
Scrotum circumference (mm)	338	-	339	347

(Bosman, 1994; Bergh *et al.*, 1999)

Table 2.9.2 shows the performance of Beefmaster in comparison with the national average in the South African NBCPPTS during the 1980-1992 and 1993-1998 testing periods. As shown in Table 2.9.2, the breed performed well above the national average at the end of the standardised growth test during the 1993 – 1998 testing period, by gaining 23 kg more. In addition, the Beefmaster also had a higher ADG (44 g/d higher) and a fairly good FCR (6.59 versus 6.68) compared to the national average.

2.9.4.2 Simbra

2.9.4.2.1 Breed history

The Simbra breed was developed from a simple experiment that combined Simmental with Brahman on the farms of a few dedicated cattlemen in the late 1960s in the hot and humid areas in the Gulf Coast of the USA (De la Rey *et al.*, 2004). The unique characteristics of Brahman cattle i.e. heat and insect tolerance, hardiness and excellent foraging ability, as well as the ease of calving and longevity, has earned them the ability to be used in the development of other breeds such as the Simbra. The Simmental breed was added to this breed due to its docility, early sexual maturity, high fertility, high milk production, high growth rates and good carcass qualities (De la Rey *et al.*, 2004). The aim of the crossing was to combine these important characteristics of the two breeds (Bosman, 1994). Bosman (1994) noted that the South African Simbra has more Simmental component (75%) than that of the Brahman, because of consumer preference for leaner beef and more importantly to increase weaning weights.

2.9.4.2.1 Adaptability and performance

Simbra has been described as "The All Purpose American Breed" (De la Rey *et al.*, 2004). Originally developed in the hot, humid areas of the Gulf Coast, Simbra are able to thrive and reproduce in both low and high temperature environments. The breed has high growth rates, vigour, similar to Brahman, and is heat tolerant. They produce a lean high quality beef. The Simbra was developed in many areas of the world where Zebu breeding predominates as well as in other areas where its unique blend of features is desired (De la Rey *et al.*, 2004). Mature bulls have a large SC (Table 2.9.3) with a short sheath length. Cows have well-attached udders and are able to produce sufficient milk for their calves to wean heavy calves. Table 2.9.3 shows that in both testing periods, the weaning weight of the Simbra was well above the national average. Calves perform well in feedlots and grow fast. The Simbra have a relatively long productive life span compared to an average beef breed. Cows will still produce well after 10 years of age and continue to wean heavy calves (De la Rey *et al.* (2004). Bulls are also capable of mating effectively even if they



are older than ten years. Due to the Simmental component, the Simbra produces high quality carcasses at 12-15 months of age (De la Rey *et al.*, 2004).

Table 2.9.3 The performance of Simbra breed in comparison with the national average from 1980-1992 and 1993-1998 in the South African Beef Cattle Performance and Progeny Testing Scheme

Trait	1980-1992		1993-1998	
	Simbra	N. avg.	Simbra	N. avg.
Birth weight (kg)	35	35	36	36
Weaning weight (kg)	231	203	232	215
Age at first calving (months)	32	35	34	34
Inter calving period (days)	406	438	420	423
Calving percentage (%)	89.9	83.3	-	-
Final weight (Standardized growth test)	489	-	462	455
ADG (Standardized growth test) (g/d)	1904	-	1594	1653
FCR (Standardized growth test)	5.87	-	6.51	6.68
Scrotum circumference (mm)	345	-	346	347

(Bosman, 1994; Bergh *et al.*, 1999)

2.9.4.3 Bonsmara

2.9.4.3.1 Breed history

The Bosmara was developed from crosses between the indigenous Afrikaner breed and the exotic Shorthorn and Hereford. Initially, five different red British breed bulls viz. Red Aberdeen Angus, Hereford, Red Poll, Shorthorn and Sussex were crossbred with the indigenous Afrikaner cows. Later-on it was discovered that the crossbreeding between the Shorthorn and Hereford was the most successful as far as adaptation and performance is concerned and were retained in the crosses. The two breeds (Shorthorn and Hereford) were found to possess the characteristics that best suited the subtropical climates such as smooth coats, thick hides and well developed subcutaneous muscling. They were highly



fertile, better milk producers with placid temperament and considerable beef animal qualities. They were also considered as good grazers in both the sweet and sour veld and are early maturing cattle breeds. The aim was to create a breed with $\frac{5}{8}$ *Bos indicus* and $\frac{3}{8}$ *Bos taurus*. The purpose was to retain the hardiness of the *Bos indicus* breed and at the same time benefiting from the advantage of *Bos taurus* cattle (i.e. high production performance). By the time when the Bonsmara breed was developed in 1964 the final composition was $\frac{5}{8}$ Afrikaner, $\frac{3}{8}$ (Shorthorn and Hereford). The breeding program was carried out at both Mara and Messina Research Stations in South Africa. It is claimed that the Bonsmara breed is the first ever breed to have been created on the basis of objectively recorded performance data (Maule, 1990; Porter, 1991; Bosman, 1994; Bergh *at al.*, 1999). In 1964 the breeders association was founded. To date the Bonsmara cattle are found in many other semi-arid areas of the world.

2.9.4.3.2 Adaptability and performance

Bonsmara appear either as red or reddish brown with medium horns and a smaller hump. The hump is more noticeable in bulls than in cows (Maule, 1990; Porter, 1991). Bonsmaras have a good body conformation, excellent temperament and early sexual maturity. Their smooth and well-pigmented thick skin is tolerant to heat, ticks and radiation (Porter, 1991). They are fertile and produce smaller calves (± 35 kg, Table 2.9.4.3), which grow fast. They adapt well to both veld and feedlot conditions.



Table 2.9.4 Comparison of the Bonsmara breed with the national average from 1980-1992 and 1993-1998 in the South African Beef Cattle Performance and Progeny Testing Scheme

Trait	1980-1992		1993-1998	
	Bonsmara	N. avg.	Bonsmara	N. avg.
Number of females in studs	71,766	-	77268	221,718
Birth weight (kg)	35	35	36	36
Age at first calving (months)	33	35	33	34
Inter calving period (days)	427	438	416	423
Weaning weight (kg)	205	203	214	215
Calving percentage (%)	85.5	83.3	-	-
Twelve month weight (Female)	240	239	248	252
Eighteen month weight (Females)	314	312	325	328
Cow weight at calving (kg)	474	470	486	490
Cow weight at weaning (kg)	475	468	499	501
ADG (Standardized growth test) (g)	1653	-	1613	1653
FCR (Standardized growth test)	6.47	-	6.69	6.68
Scrotum circumference (mm)	344	-	346	347

(Bosman, 1994; Bergh *et al.*, 1999)

Table 2.9.4 shows that the Bonsmara had a shorter intercalving period in both testing periods compared with the national average, indicating its high fertility. The 205 days weaning weights of both males and females calves, were higher (205/203) than the national average in 1992, although it declined slightly (214/215) in 1998.

2.9.4.4 Drankensberger

2.9.4.4.1 Breed history

This formerly known ‘Vaderlanders’ and then ‘Uysbeeste’ breed is the first breed to have ever been developed in South Africa and it is now considered as an indigenous breed in

South Africa. At the time of the ‘Great Trek’ in the nineteenth century several Dutch families left the Cape Province to travel north with a large number of the Vaderlanders oxen. Along the way, most families settled around the Drakensberg mountain range presently known as the Volkrust area in the Mpumalanga Province, for farming. In 1946 the Uys breed Society was formed, a name derived from specific family members within the Dutch settlers (Porter, 1991). In the following year the breed was officially recognised by the government and was given a new name the ‘Drakensberger ‘ (Friend, 1978; Maule, 1990; Bergh *et al.*, 1999), a name derived from large number of black cattle that were found hidden in the Drakensberger mountains during the Boer War (Porter, 1991). Hence the society changed its name also to Drakensberger Cattle Breeder Society of South Africa.

2.9.4.4.2 Breed description

Drakensberger cattle are black with a loose, dark pigmented skin and sleek coat (Friend, 1978). They are regarded as large frame animals due to their long deep and broad body which probably resulted from draught work in the early eighteenth to nineteenth centuries. Feet are round and flat. Mature males weigh between 815 and 910 kg and have a small shoulder hump (Maule, 1990). Both males and females grow short white horns that grow straight out of the head with dark tips. Mature females weigh about 710 kg and they have small but well-shaped udders.

2.9.4.4.3 Adaptability and performance

The Drakensberger cattle are generally considered as a triple purpose breed due to their relatively high level of milk and meat production and the suitability for draught work. Cows usually calve at 40 months of age (Porter, 1991). Even though the breed is considered as a large frame, continuous breeding and improvement has paid-off by decreasing the birth weight to enable easy calving in cows (Table 2.9.5).

Table 2.9.5 Comparisons of the Drakensberger breed with the national average from 1993-1998 in the South African Beef Cattle Performance and Progeny Testing Scheme

Trait	1993-1998	
	Drakensberger	National average
Number of females in studs	9897	221718
Birth weight (kg)	36	36
Weaning weight (kg)	206	215
ADG (Standardized growth test) (g)	1544	1653
FCR (Standardized growth test)	6.96	6.68
Scrotum circumference (mm)	349	347
Age at first calving (months)	36	34
Inter calving period (days)	438	423

(Bosman, 1994; Bergh *et al.*, 1999)

The Drakensbergers are regarded as good foragers with a relatively good FCR. They perform well in feedlots and are able to gain significant weights in a relatively short period of time. Table 2.9.5 shows that the breed had slightly lower weaning and a yearling weight (9 and 21 kg) compared to the national average of the herd that was performance tested from 1993 – 1998. They also produce heavy and lean carcasses of high quality. Despite the relatively longer intercalving period, cows are regular breeders and produce sufficient milk for their fast growing calves (Porter, 1991).



3. Materials and methods

3.1 Introduction

Although it is often argued that a bull and cow each have a 50% chance contribution to the genetic merit of their offspring, it is common knowledge that on average, a bull has a greater impact on the overall genetic improvement of the herd compared to a cow. A cow can only produce one calf in a year, whereas on average, a bull can produce 25 calves over the same period. This substantiates the importance of a bull as compared to a cow in a beef enterprise. Several methods exist to effectively select bulls for breeding purposes. These include the use of pedigree information, breeding values and visual appearance and performance testing results. The latter has been increasingly used in recent years. With performance testing, valuable information on several traits of economic importance is collected from weaned calves (mainly male) of different breeds at testing stations or privately owned farms, and supplied to breeders to improve their herd efficiency through selection or purchasing bulls that best suit their production systems.

This study analysed performance testing data obtained from the VBC in Vrede district, RSA. The aim was to investigate the performance parameters of bulls from the six common beef breeds (viz. Aberdeen Angus, Beefmaster, Bonsmara, Drakensberger, Nguni and Simbra) performance tested on-farm. The study also investigated the variation within a breed in terms of growth performance and other production traits, and the relationship between selling price at the auctions and traits measured during the test.



3.2 The experimental site

The study was conducted by the Eastern Free State Veld Bull Club (VBC) on the farm “Poortjie” in the Vrede district in South Africa, (situated at 27°25’S., 29°10’E.), located at a height of 1669 m above sea level (Potgieter, 1975; The Tourism Blueprint Guide, 2001). Vrede district is well-known for its significant contribution to the agricultural industry in South Africa. It is one of the most important extensive cattle and sheep breeding areas in South Africa. Rainfall distribution in the Vrede district is variable, and above all it is seasonal, with most rain occurring in the months from December to February (Figure 3.1).

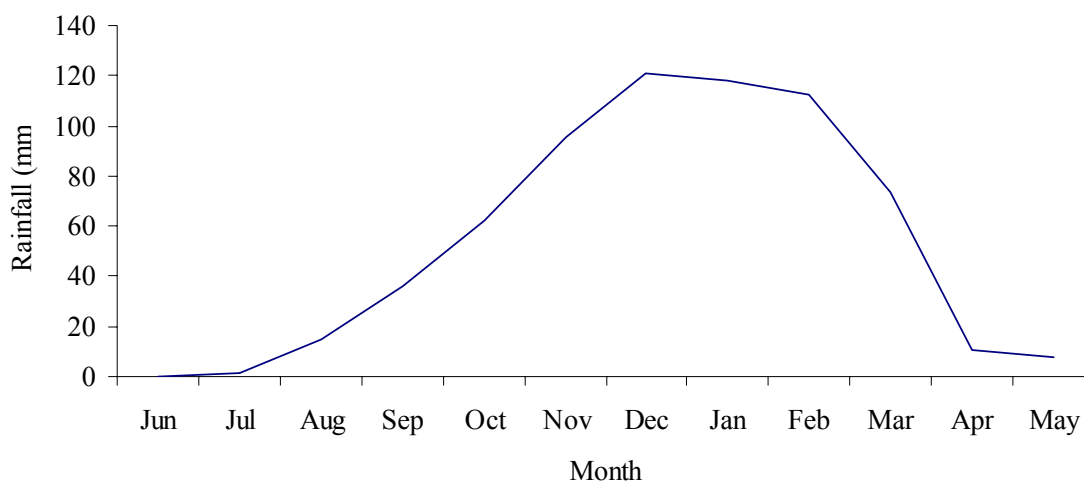


Figure 3.1 Rainfall distribution in the Vrede district during the study period from 2000-2004 (South African Weather Bureau, 2005)

Kruger (1998) stated that the variability of rainfall in dry land climates is more significant than the total or average received over a period as an indicator of the ecosystem stability. The threshold where a system is dominated more by the variability than by average conditions occurs when rainfall coefficients of variation (CV) near or exceed 30 percent. It is suggested that in areas where the CV is below 20 percent, animal populations tend to remain relatively stable creating equilibrium between herbivores and plants. The average annual rainfall received during the study period was 653.3 mm with the highest (798mm) recorded in 2000-2001 rainy season and lowest (514mm) in 2003-2004 (Table 3.1).

These rainfall figures were obtained from the neighbouring farm (viz. farm Rome). According to these rainfall figures, the CV in the area during the study period was 17.5%, suggesting an apparent balance between the animal and plants production as explain earlier.

Table 3.1 Total monthly rainfall (mm) at Rome farm from 2001-2004

Months	Year			
	2000/01	2001/02	2002/03	2003/04
June	-	-	-	-
July	-	-	6	-
August	-	-	58	-
September	35	82	27	-
October	117	79	52	-
November	189	93	20	80
December	130	110	192	53
January	94	106	118	154
February	91	160	38	161
March	69	40	120	66
April	43	-	-	-
May	30	-	-	-
Total	798	670	631	514

(South Africa Weather Bureau, 2005)

The average, maximum and minimum temperatures during the period of study were 22.7 and 7.4°C respectively. The winter seasons are relatively long in the Vrede district (Figure 3.3). The highest maximum temperature was recorded in 2003 (23.9°C) whereas the lowest minimum temperature was in 2000 and 2004 (7.3°C) (Table 3.2). Figure 3.2 on the next page shows the average monthly minimum and maximum temperatures during the study period.



Table 3. 2 Average monthly maximum and minimum temperature (°C) levels in Vrede from 2000-2004

Month	Year									
	2000		2001		2002		2003		2004	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
JAN	21.7	10.9	26.7	13.2	26.3	13.4	27.4	13.4	26.3	14.4
FEB	22.3	12.8	25.9	12.4	25.2	12.7	27.7	14.4	25	13.5
MAR	22.4	12.3	25.1	11.5	25.8	11.4	27	11.4	23	12.1
APR	20.2	7.1	21.4	9	25.1	7.5	25.5	8.9	22.4	7.4
MAY	17.7	2.4	19.6	2.9	20.9	2.5	19.9	2.3	21.5	1.9
JUN	17.8	0.5	18.5	0.6	15.9	0.3	16.6	0.3	16.7	-2
JUL	19.6	0.9	16.2	-1.2	16.7	-1.7	18.6	-1.3	15.9	-1.6
AUG	21.3	1.3	21.1	1.5	20.2	5.2	18.6	0.6	21.6	3
SEP	22.6	5.8	22.4	4.8	22.3	5.5	23.9	6.7	22.5	4.5
OCT	23.9	10.2	23.7	9.6	25.7	9	26.4	9.7	25	9.1
NOV	22.5	10.6	23.2	12.1	25.3	9.5	25.8	12.2	28.1	12.4
DEC	25.3	13.1	25.3	13.2	25.5	13.1	29.2	13.3	26.2	13.2
Average	21.4	7.3	22.4	7.5	22.9	7.4	23.9	7.7	22.9	7.3

(South Africa Weather Bureau, 2005)

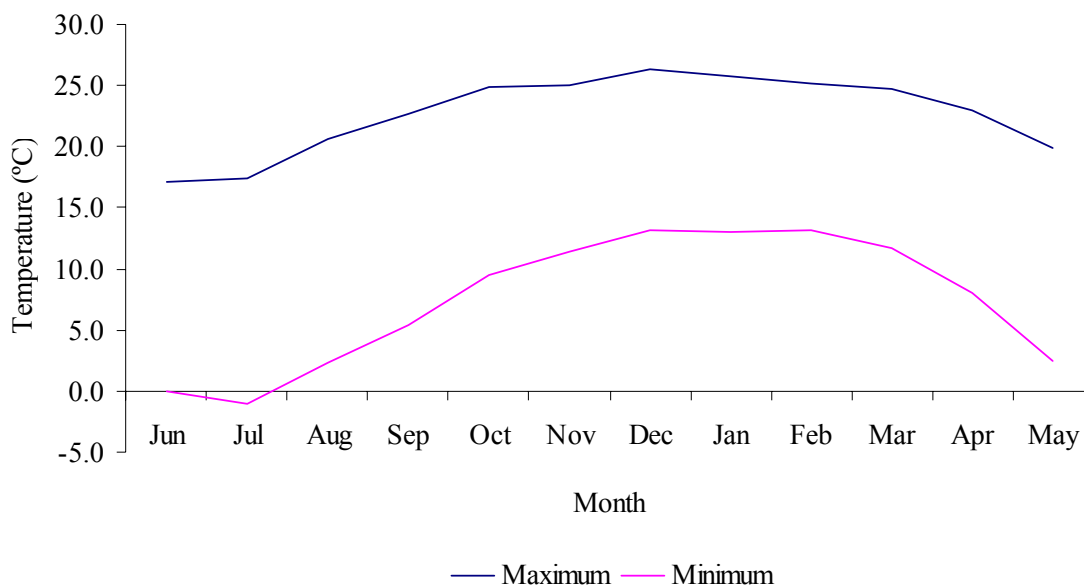


Figure 3.2 Temperature variability in the Vrede district during the study period (South Africa Weather Bureau, 2005)



The ground cover of the experimental site was dominated by grasses such as *Themeda tiandra*, *Tristachya leucothrix*, *Elionurus muticus*, *Eragrostis racemosa* and *Digitaria tricholaenoides* (Acocks, 1988). Carrying capacity of the veld during the period of study was 3-4 ha/LSU (Large stock unit). Being a grassveld, there are fewer bushes in the eastern Free State. The most common species are *Celtis africana*, *Olea europaea* subsp. *africana*, *Kiggelaria africana*, *Mersine africana*, and several *Rhus* species (Acocks, 1988).

3.3 Animals and management

Records of 444 young bulls representing six beef breeds, performance tested between 2000 and 2004 at the eastern Free State VBC, South Africa, were used for this study. Young bulls from different stud breeders in South Africa were brought to the testing centre from August, shortly after weaning. Breeds tested included 42-Aberdeen Angus, 135-Beefmaster, 97-Bonsmara, 64-Drakensberger, 50-Nguni and 56-Simbra. Bulls were selected for the test according to each breeder's own criteria and there were no minimum requirements of preweaning performance for bulls entering the test. Breeders were encouraged to nominate only bulls qualifying for entry in a national beef cattle performance testing scheme.

Choices among bulls made by breeders were by visual appraisal, which did not closely correlate with the traits that were measured during the study. Due to the fact that selection was based on individual breeder criteria (non-random), according to Brown *et al.* (1980) as cited by Chewning *et al.* (1990) and Brown *et al.* (1991), the possibility for breed samples to vary significantly was increased. Regardless of the non-random selection as indicated above, the importance of the data was generated by the fact that the bulls evaluated were the population with records that had been made available to commercial farmers at the auctions that took place at the end of the test period.

Upon their arrival, all the animals were initially restrained in a veterinary crush (chute) for detailed physical examination. Starting with the musculoskeletal system, all animals

were visually assessed and abnormalities such as straight-hocks and undershot jaws were recorded. The bulls were then released and overall structural conformation was assessed while they were moving around within the kraal. All the animals were then finally released into the camps (≈ 30 ha) for the start of the adjustment period. The age of the bulls at the start of the test period, ranged from 182 to 213 days and they completed on average 187 days (s.d. = 20.8) on-farm testing period excluding the adjustment period of 30 days (s.d. = 10.3) on average. The aim of the adjustment period was to minimise pre-testing management and environmental influences.

During the grazing period all the bulls were weighed at 21-d intervals. On the day of weighing, all animals were weighed at nine o'clock in the morning. All the animals had free access to water throughout the grazing period and no extra feed was given, except for a salt-phosphate lick and protein lick given in summer and winter respectively.

After the completion of the grazing period, bulls that showed exceptional performance were transferred to the feedlot to be prepared for the auction. The rest were culled. In addition, the purpose feedlotting was to study the growth performance of the animals in an on-farm, intensive production system. Animals were given a feedlot diet *ad libitum* for a period of 100 days while in feedlot. The placing of bulls in paddocks was at random, and therefore it did not discriminate on growth rates, feed conversion efficiency or breed differences at all.

3.4 Traits studied

The parameters monitored during the study period were:

- liveweight
- average daily gain
- Kleiber ratio
- veld feed conversion ration
- body condition score
- muscling score



- temperament score
- tick count
- scrotal circumference and
- selling price

3.4.1 Liveweight (LWT)

The LWT was obtained through weighing animals with a standard cattle scale from the start of the test period and then after every 21 days. Weighing was carried out in the mornings at 9 o'clock. The initial weight of the animal was considered as weight of the animal at the end of the adjustment period and the final weight being the weight of animal at the end of the grazing period, excluding the weight at the end of feedlotting. The weight of animals that entered the feedlot was only used to determine their ADG during feedlotting and was therefore considered separately from the weight during the grazing period. In addition, the weights during feedlotting could not be used for the analysis due to the fact that some animals did not enter the feedlot at all. All measurements were recorded in kilograms.

3.4.2 Kleiber ratio (KR)

Determining feed intake of range animals remains the biggest obstacle to beef cattle researchers. Unlike in feedlots, it is difficult to accurately measure feed intake of a grazing animal and hence it is often just predicted. According to McDonald *et al.* (2002), prediction of ruminant animals feed intake is much more complicated than that of monogastric animals because of the nature of feed consumed by ruminants. Several food variables have to be taken into account when predicting feed intake of ruminants. Nonetheless, for approximate predictions of intake, certain assumptions are used e.g. beef cattle are assumed to have a daily dry matter intake of 22 g/kg liveweight, whereas that of dairy cows is 28 and 32 g/kg in early and peak lactation, respectively. Due to these predictions, there is no universally adopted equation or formula used to determine ruminant animals feed intake. For example, on the one hand, the UK Agricultural



Research Council Technical Committee on Responses to Nutrients has constructed a series of equations for predicting the intake of grass silage for (beef and dairy cattle) fed silage and concentrates. For beef cattle the Council uses the following equations (McDonald *et al.*, 2002):

$$SDMI = CDMI + DM - AN + DOMD$$

where: SDMI = silage dry matter intake (g/kg $W^{0.75}$ per day)

CDMI = concentrate dry matter intake (g/kg $W^{0.75}$ per day)

SDM = silage dry matter content (g/kg)

AN = silage ammonia N content (g/kg total N)

DOMD = digestible organic matter in silage dry matter (g/kg)

On the other hand, the Australian Standing Committee on Agriculture has adopted a computer-based model called 'Grazfeed' to predict ruminant animals feed intake in Australia. The Committee has thus identified its own parameters, which have a possible effect on the animal, plant and environment, when predicting feed intake using the above model. For example, the animal factors include the animal's current weight in proportion to its so-called 'standard reference weight' (SRW), body condition (i.e. fatness) and stage of lactation. The food facts include herbage digestibility and any supplementary foods, whereas environmental factors are the features of the pasture that determine the structure of the sward. Adjustment is also made for the inclusion of climatic factors (McDonald *et al.*, 2002).

Max Kleiber (1961) as cited by Bergh (1994), thought otherwise, and used the $MWT^{0.75}$ to predict the feed intake of range animals. When used with ADG the $MWT^{0.75}$ gives rise to what is known to-date as 'Kleiber Ratio' (KR). KR gives an estimate of feed conversion efficiency of grazing animals. In this study, KR ratio was calculated at the end of the grazing period using the equation shown below (Arthur *et al.*, 2001b):

$$KR = \frac{ADG}{MWT^{0.75}}$$

3.4.3 Veld feed conversion ratio (VFCR)

The term feed conversion ratio (FCR) has been extensively used in beef cattle production and as a result farmers often tend to understand “animal feed efficiency” much better if this term is used (Prof. T. Ungerer, Box 288, Vrede, pers, comm.). As indicated in section A of Chapter I, accurate and reliable values of FCR are provided by an accurate measurement of feed intake. Unfortunately, it is difficult and expensive to measure feed intake in an extensive production system because animals graze on their own most of the time. To overcome this burden, a much similar term “Veld Feed Conversion Ratio” but which is only applicable to grazing animals was developed (Prof. T. Ungerer, Box 288, Vrede, pers, comm.) taking into consideration the maintenance requirements of beef cattle as discussed by Owen-Smith (2000) and McDonald *et al.* (2002). VFCR uses the animal metabolic weight or metabolic mass equivalent (MME), ADG and an estimated twelve percent to determine the feed conversion efficiency of a grazing animal. The following equation was used (Prof. T. Ungerer, Box 288, Vrede, pers, comm.):

3.4.4 Body condition score (BCS)

The BCS of each bull was visually scored at close examination just as it was leaving the veterinary crush. Scoring was done randomly in each year during the study period. All assessments were carried out by one person in all four years of the study period. A five point scale was used during the scoring process as shown below (Roseler *et al.*, 1997):

- BCS 1 – poor; no external fat is detectable by sight or touch over spinous processes of the backbone, edge of the loin, hipbones or ribs. Tail-head quite prominent. Severe muscle loss in shoulder, loin and hindquarter.
- BCS 2 – thin; no palpable or visible fat on ribs, brisket or shoulder blades. Individual muscles in the hindquarter are easily visible and spinous processes more apparent.
- BCS 3 – moderate; good overall appearance with only the 12th and 13th ribs being visible to the eye.



- BCS 4 – good; brisket is relatively full, tail-head and pin bones have protruding fat deposits on them with the back appearing square due to fatness.
- BCS 5 – extremely fat; very thick neck, larger indentation over the spinal cord. Back appear square when viewed from behind. Flanks appear too deep due to fatness. Brisket is distended with fat. Tail-head is lost in pones of fat.

3.4.5 Muscling score (MS)

Similarly to the BCS, the MS was scored visually at a close distance. Scores were given based on the convexity and the thickness of the body due to muscle and inter-muscular fat (Cumming, 2000). The main areas considered were the hindquarter, as viewed from behind (the convexity of the thighs, and the thickness through the stifle) and back, rump and loin (the thickness and convexity as well). As was the case with other scoring traits, MS was carried out by one person but only once at the end of the grazing period. A five scale scoring system (1 – 5) was used as shown below (Cumming, 2000):

- MS 1 – extremely thick through the stifle area, Muscle seams evident, ‘Butterfly’ top line, thick and bulging, forearm stands very wide.
- MS 2 – thick stifle, rounded thigh from behind view, some convexity in the hindquarter from side view, flat and wide over the top line, stands wide.
- MS 3 – flat down the thigh when viewed from behind, flat tending to angular over the top line.
- MS 4 – narrow stance, flat to convex down the thigh, thin through the stifle, sharp and angular over the top line (except when very flat)
- MS 5 – dairy type – very angular, sharp ‘tent topped’ over the top line, virtually no thickness through the stifle, concave thigh, stands with feet together.



3.4.6 Temperament score (TS)

The TS was also recorded when animals were weighed. The temperament of the bulls was observed visually and scored while the animals were in the veterinary crush. As usual, the scoring was carried out by one person throughout the study period. The scoring system used to rate the behaviour of bulls was as follows (Voisinet *et al.*, 1997);

- TS 1 – calm, no movement
- TS 2 – restless and slight shifting
- TS 3 – vigorous continuous movement and shaking of device
- TS 4 – very aggressive temperament – extreme agitation

3.4.7 Tick count (TC)

The TC was recorded randomly during the study period although the counting process was done when the animals were weighed. No classifications of tick species or sizes were made. Ticks appearing underneath the tailhead, along the twist, cod and behind the scrotum were all counted and recorded.

3.4.8 Scrotum circumference (SC)

The SC was measured at the end of the test period using a standard (60cm) scrotal measuring tape. All animals were measured while they were restrained with the veterinary crush. The scrotum of each bull was also visually assessed by manual palpation, and any obvious abnormalities such as the number of testes (1 or 2) or uniformity (e.g. length) of each testis recorded. All measurements were recorded in centimetres.



3.4.9 Selling price (SP)

Every year, at the end of the testing period an auction was held for all bulls that entered the feedlot. The SP was defined as the price paid for each individual bull sold at the auction and those that received a bid, although they were not sold. The price of each bull sold at the auction was manually recorded. The purpose was to investigate the relationship between the auction price and production traits measured during the study period.

3.5 Statistical analysis

The General Linear Model (GLM) procedure of Statistical Analysis System (SAS, 2001) was used to determine the significance between breeds, years, their interaction (breed x year) and breeders (within breed and year) for all the dependent variables. A linear and quadratic regression was fitted in the model to investigate the relationship between covariant and dependent variables. The functions used were defined as follows: linear: $Y = bx + a$, and quadratic: $Y = bx^2 + bx + a$. Of the two regressions, only the linear expression was significant in some models. Least square means (LSM) of variance and standard deviations (SD) were calculated. The mathematical model that was used is shown below:

$$Y_{kij} = \mu + B_i + S_j + BS_{ij} + TBS_{kij} + b_iA + e_{kij}$$

where

- Y_{kij} = trait of the k 'th breeder of the i 'th breed for the j 'th year
- μ = population of the appropriate trait
- B_i = effect of the i th breed
- S_j = effect of the j th year
- BS_{ij} = effect of the ij th interaction between breed and year
- TBS_{kij} = effect of the kij th breeder within breed and year
- b_iA = linear regression for a specific trait
- e_{kij} = random effects



Significance of difference (5%) between LSM was determined by Bonferoni's test (Samuels, 1989). ADG over period of four weeks in the test period was analysed with the GLM repeated measurement model (SAS, 2001). Fixed effects, which contributed significantly to variance of the different traits, are summarised in Table 3.3. Only significant effects were included in the final model fitted.

Table 3.3 The F-values for the fixed effects included in the models fitted for the various traits analyzed

Traits	Breed	Year	Breed x Year	Breeder (breeder x year)
Initial weight	125.20 ^b	ns	9.84 ^b	9.48 ^b
Final weight	91.20 ^b	4.18 ^b	ns	5.99 ^b
Average daily gain	55.28 ^b	44.46 ^b	2.72 ^a	1.82 ^a
Veld feed conversion ratio	78.23 ^b	45.52 ^b	7.28 ^b	ns
Kleiber ratio	59.75 ^b	58.76 ^b	4.15 ^b	2.57 ^b
Scrotum Circumference	12.09 ^b	4.37 ^a	2.78 ^a	2.32 ^b
Body condition score	19.23 ^b	39.41 ^b	6.60 ^b	2.98 ^b
Temperament score	7.28 ^b	ns	3.16 ^b	3.37 ^b
Tick count	16.47 ^b	39.20 ^b	2.52 ^a	2.07 ^b
Muscling score	6.01 ^b	15.85 ^b	2.88 ^a	ns
Price	ns	11.78 ^b	ns	ns

a = P < 0.05; b = P < 0.01; ns = not significant



Table 3.4 illustrates the effects of covariant (viz. ADG, SC, MS, TS, TC and BCS) on traits measured during the study period. An analysis of covariance, simple linear regression was performed to measure the association and relations between variables. Procedures were assessed at 0.05 and 0.001 critical values for the F-statistic. Once again, only variables with significant effects as covariates were included in the final model.

Table 3.4 The F-values of covariate included in the model with significant contribution

Covariate	Dependent variables										
	IWT	FWT	ADG	SC	BCS	TS	TC	MS	KR	VFCR	SP
ADG	ns	ns	0	0.004**	0	0	ns	0	0	0	9.15*
BCS	ns	19.87*	0	0	0	0	ns	0	ns	ns	ns
MS	0	11.73*	0	0	0	0	ns	0	ns	ns	2242.03*
SC	0	3.87**	9.22**	0	ns	ns	ns	ns	ns	ns	ns
TC	ns	ns	ns	ns	ns	ns	0	ns	ns	ns	ns
TS	ns	ns	ns	ns	ns	0	ns	ns	ns	ns	ns

ADG = average daily gain; SC = scrotum circumference; MS = muscling score; TS = temperament score; BCS = body condition score; IWT = initial weight; FWT = final weight; KR = Kleiber ratio; VFCR = veld feed conversion ratio; TC = tick count; SP = selling price

*P < 0.05, **P < 0.001, ns = not significant, 0 = not measured



4. Result and discussion

Part A: Performance on rangeland

4.1 Liveweight

4.1.1 Initial weight (IWT) within breed between years

Table 4.1.1 present the LSM for the effect of breed on IWT within a year. The main source of variation was breed, the interaction of breed x year, and breeder (breed x year). Aberdeen Angus bulls showed slight variations in their IWT. As shown in Table 4.1.1, Aberdeen Angus bulls performance tested in Year 3 had the lowest IWT whereas those tested in Year 4 had the highest IWT ($P < 0.05$). However, the IWT of Year 3 bulls did not differ significantly from that of Year 2 bulls which, in turn did not differ ($P > 0.05$) from that of Year 1 bulls.

Similarly, Beefmaster bulls showed less difference in their IWT. According to Table 4.2.1, the IWT of Beefmaster bulls performance tested in years 1, 2 and 3 did not differ significantly ($P < 0.05$). Differing from Aberdeen Angus bulls, the highest IWT of Beefmaster bulls was recorded in Year 3 and it was not significant from that of years 1 and 2 as mentioned above. Year 4 Beefmaster bulls showed the lowest ($P < 0.05$) IWT when compared to those tested in the previous years of the study.

The IWT of Bonsmara bulls varied from 218 to 240 kg during the study period. Similar to that of Aberdeen Angus bulls, the highest IWT of Bonsmara bulls (240 kg, ± 24.7) was recorded in Year 4 but it was not significant from that of years 1 and 2 bulls. The lowest IWT (218 kg, ± 25.75) was recorded in Year 3 and again was not significant from that of Year 1.



Table 4.1.1 Means (\pm s.d.) for the effect of breed on IWT (kg) within a year

Breed	Year			
	1	2	3	4
AN	284 ₂ ^a (\pm 24.1)	279 ₂₃ ^a (\pm 15.3)	257 ₃ ^a (\pm 16.1)	341 ₁ ^a (\pm 23.4)
BM	258 ₁ ^b (\pm 27.0)	266 ₁ ^a (\pm 31.1)	269 ₁ ^a (\pm 40.2)	240 ₂ ^c (\pm 26.2)
BO	225 ₁₃ ^c (\pm 20.7)	238 ₁ ^b (\pm 35.4)	218 ₂₃ ^c (\pm 25.8)	240 ₁ ^c (\pm 24.7)
DK	227 ₁ ^c (\pm 32.1)	247 ₁ ^{ab} (\pm 13.3)	244 ₁ ^{abc} (\pm 17.2)	230 ₁ ^c (\pm 23.3)
NG	184 ₁ ^d (\pm 13.8)	181 ₁ ^c (\pm 26.9)	182 ₁ ^d (\pm 23.0)	171 ₁ ^d (\pm 25.5)
SB	302 ₁ ^a (\pm 23.5)	278 ₁₂ ^a (\pm 36.0)	241 ₃ ^b (\pm 57.9)	275 ₂ ^b (\pm 57.4)

AN = Aberdeen Angus; BM = Beefmaster; BO = Bonsmara; DK = Drakensberger; NG = Nguni; SB = Simbra

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;

Row (1, 2, 3) and column means (a, b, c, d) with common script do not differ ($P > 0.05$)

The Drakensberger and Nguni bulls showed no significant difference in their IWT at all throughout the study period. The Drakensberger bulls had their highest IWT recorded in Year 3 (similar to Beefmaster) and lowest in Year 1. The lowest IWT in Nguni bulls was recorded in Year 4 (similar to Beefmaster) and the highest in Year 1. Simbra bulls showed more variation in their IWT compared to the other breeds. The highest IWT for the breed was recorded in Year 1 (similar to Nguni), although that did not differ ($P > 0.05$) from that of Year 2. The lowest IWT ($P < 0.05$) during the four years study period was recorded in Year 3 (similar to Bonsmara and Aberdeen Angus).

4.1.2 Final weight (FWT) within breed between years

The LSM of FWT for breeds used in this study is given in Table 4.1.2. Once again Aberdeen Angus bulls showed less variation in FWT. As was the case with the IWT, Year 4 bulls had the highest FWT ($P < 0.05$) compared to those tested in previous years. The rest were all non-significant from each other. The lowest FWT for the breed was recorded in the Year 2. Although, Year 4 bulls had the highest FWT, as mentioned above, they gained less weight (88 kg) during the grazing period when compared to Year 3 bulls, which had the lowest IWT. Year 3 bulls gained 129 kg during the same period. Years 1 and 2 gained 104 and 79 kg, respectively (Annexure A).

Table 4.1.2 Least square means (\pm s.d.) of FWT (kg) of breeds at the end of the grazing period

Breed	Year			
	1	2	3	4
Aberdeen Angus	388 ₂ ^c (\pm 31.1)	358 ₂ ^b (\pm 18.8)	386 ₂ ^b (\pm 16.8)	429 ₁ ^a (\pm 25.3)
Beefmaster	417 ₁₂ ^b (\pm 30.0)	409 ₂₃ ^a (\pm 37.4)	432 ₁ ^a (\pm 43.2)	394 ₃ ^b (\pm 39.4)
Bonsmara	369 ₁ ^c (\pm 24.6)	368 ₁ ^b (\pm 34.4)	372 ₁ ^b (\pm 28.5)	379 ₁ ^b (\pm 29.0)
Drakensberger	365 ₁ ^c (\pm 36.0)	365 ₁ ^b (\pm 20.3)	385 ₁ ^b (\pm 20.0)	373 ₁ ^b (\pm 35.7)
Nguni	305 ₁₂ ^d (\pm 18.7)	299 ₁₂ ^c (\pm 39.0)	326 ₁ ^c (\pm 29.6)	279 ₂ ^c (\pm 35.8)
Simbra	461 ₁ ^a (\pm 23.3)	449 ₁ ^a (\pm 36.1)	420 ₁ ^a (\pm 64.0)	426 ₁ ^a (\pm 72.2)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2) and column means (a, b, c) with common script do not differ ($P > 0.05$)

The variation in the FWT of Beefmaster bulls was fairly similar to that observed in their IWT. The Beefmaster bulls performance tested in Year 3 had the highest FWT, although they did not differ significantly from those tested in Year 1. The FWT of Year 1 bulls, however, did not differ significantly from that of Year 2, which in turn did not differ ($P < 0.05$) from that of Year 4, which had the lowest FWT. Unlike the Aberdeen Angus, the Beefmaster bulls with the lowest IWT did not gain the highest weight during the grazing period but it was rather those that had the highest IWT (viz. Year 3 bulls, 163 kg). Similar to the Aberdeen Angus, Year 2 Beefmaster bulls gained the lowest liveweight (143 kg) during the grazing period, hence the FWT.

Unlike the slight variation observed in the IWT, the FWT of Bonsmara bulls did not differ significantly in all four years of the study period. The lowest FWT for the breed was recorded in Year 2 and the highest in Year 4. In terms of average weight gained during the grazing period, bulls which had the lowest IWT (viz. Year 3) gained the highest weight (154 kg) as was observed with Aberdeen Angus. Moreover, as observed in Aberdeen Angus and Beefmaster, Year 2 Bonsmara bulls gained the lowest weight (130 kg) during the grazing period.

The non-significance in weight differences in the Drakensberger bulls continued to the end of the grazing period and as a result there were no significant differences in the FWT.

Nonetheless, Year 2 bulls gained the lowest weight during the grazing period, as was observed with the Aberdeen Angus, Beefmaster and Bonsmara. The highest FWT in Drakensberger bulls was recorded in Year 4 (similar to Aberdeen Angus & Bonsmara).

Unlike the IWT, there was a slight variation in FWT of Nguni bulls. The Nguni bulls' performance tested in Year 3 had the highest FWT and differed significantly from those tested in Year 4 which had the lowest FWT. Years 1 and 2 bulls were intermediate. In terms of weight gained throughout the grazing period, the bulls that were performance tested in Year 4 gained more weight (144 kg or 79%) compared to rest of the Nguni bulls used for this study. The average total liveweight gain for years 1, 2 and 4 bulls, was 121 (65%), 118 (65%), and 108 kg (63%), respectively.

The Simbra bulls gained between 151 and 179 kg during the grazing period. Their FWT did not differ significantly from each other as was the case with their IWT. The bulls that were performance tested in Year 4 gained 74% whereas those tested in Year 1 gained just above 50% of their IWT during the entire grazing period (Annexure A).

Briefly, the results show that the Aberdeen Angus and Beefmaster were the only breeds where the within breed difference in IWT and FWT was less significant whereas the Drakensberger bulls showed no differences ($P < 0.05$) at all. The variation for the other breeds (viz. Bonsmara, Simbra and Nguni) was not consistent. It is however, of interest to note that the variation observed within breeds IWT and FWT was generally minimal. On the basis of these findings, this study suggests that the pre- and postweaning environmental effects on performance tested beef bulls is therefore of little importance to within breed comparisons on traits such as liveweight. On the contrary, the effect of pre-weaning management could be the contributing factor in the low variation, particularly in IWT. It could be argued that the commencement of the testing program in August of each year might have had an effect on the decision made by the participating breeders on the time they weaned their potential bulls for performance testing. In such case, the differences in IWT within a breed may of course be lower because of the relatively synchronised weaning time. With regard to FWT, the non-significance observed within

breed could be as a result of the uniform treatment the bulls received during the grazing period/performance testing.

However, in terms of net liveweight gain, the effect of both management and environment appear to have played a crucial role in the variation observed within breeds. With the exception of Nguni and Drakensberger breed bulls, the results have shown that the bulls with lower IWT grew faster than those that had higher IWT, although they did not necessarily have the highest liveweight at the end of the test period. Despite that, this implies that there was a compensation in growth rate in bulls which had low IWT. Even though, the duration of compensatory growth is unknown for each breed at this point. This study is in total agreement with several reports e.g. by Kräusslich (1974), Dalton *et al.* (1978), Lewis *et al.* (1990), Owens *et al.* (1993), Robinson *et al.* (2001c) and Fiems *et al.* (2002) on the concept of compensatory growth. It is known that an animal given restricted feeding prior to the onset of the test period is likely to undergo a period of compensatory growth. Nonetheless, the fact the Nguni and Drakensberger bulls which had a lower IWT did not exhibit any signs of compensatory growth in this study, presents the need for further research on this phenomenon with special reference to indigenous breeds.

The most surprising finding with regard to the within breed variation in IWT and FWT in this study was that neither rainfall nor temperature showed any substantial effect on the two recorded liveweights. This is probably due to the fact that the test period for all the years commenced almost at the same period viz. in winter ending in summer. The overlapping of seasons had to occur because of the longer grazing period (187 ± 16.6) during the study. Thus, the animals were only able to finish the test in the summer season of the following year after entering the test in the winter season (August – July) of the previous year. The commencement of the test period in the winter season, when the quality of pasture is low, will minimise the effect of rainfall and temperature particularly within breed as compared to between breeds because at this point in time the determining factor will be the breed maintenance requirement and its adaptability to cold weather conditions (discussed in following section).

4.1.3 IWT and FWT between breeds within a year

In Year 1, the Aberdeen Angus and Simbra had higher IWT ($P < 0.05$) followed by Beefmaster, Drakensberger, Bonsmara and Nguni. Nguni bulls were in fact the lightest ($P < 0.05$, Table 4.1.1 & 4.1.2) in all four years during the grazing period. The Beefmasters had higher IWT ($P < 0.05$) compared to Drakensbergers and Bonsmara. The IWT between Bonsmara and Drakensberger did not differ significantly from each other. At the end of the grazing period in Year 1, the Simbra was heavier ($P < 0.05$) than Aberdeen Angus, Bonsmara, Drakensberger and Nguni. The FWT of Bonsmara, Drakensberger and Aberdeen Angus did not differ ($P > 0.05$), although that of Aberdeen Angus was numerically higher.

In Year 2, the Aberdeen Angus and Simbra had the highest IWT but did not differ ($P < 0.05$) from the Bonsmara and the Drakensberger. The Drakensberger was numerically heavier than Bonsmara, although not significantly. The FWT of Simbra and Beefmaster was higher ($P < 0.05$) compared to that of other breeds in the same year. The FWT of Bonsmara, Aberdeen Angus and Drakensberger did not differ significantly.

The Beefmaster had the highest IWT in Year 3, but it did not differ significantly from that of Aberdeen Angus and Drakensberger. The Drakensberger was heavier compared to Bonsmara and Simbra, though not significant. At the end of the grazing period, Beefmaster and Simbra (431 and 423 kg, respectively) were heavier ($P < 0.05$) compared to the other breeds. The FWT of Aberdeen Angus, Bonsmara and Drakensberger did not differ significantly.

The Aberdeen Angus had significantly higher IWT compared to other breeds in Year 4. The Simbra was second followed by Bonsmara and Beefmaster. The Drakensberger and Nguni had the lowest IWT in Year 4. At the end of the grazing period in that year, the Aberdeen Angus was again significantly ($P < 0.05$) heavier compared to the other breeds, except the Simbra. The FWT of Beefmaster, Bonsmara and Drakensberger did not differ significantly.

The results show that the Aberdeen Angus was the only breed which had a higher IWT whereas the Simbra had the highest FWT in all four years of the study period. These findings clearly denote the effect of environment on the post-weaning growth rate of cattle in an extensive production system. The consistency of Aberdeen Angus obtaining high IWT in all four years of the study period contradicts various reports which stated that calves from crossbred and or composites cattle breeds (in this case, Bonsmara, Beefmaster and Simbra) tend to outperform those from purebred cows due to the effects of breed complementarity (breed additive difference) and heterosis (non-additive) (Wood *et al.*, 1985; Skrypzeck *et al.*, 2000; Arango *et al.*, 2002d; Dadi *et al.*, 2002). Wood *et al.* (1985) reported a 7% increase in weaning weight (WW) of F₁ calves from crossbred between Hereford and Afrikaner when compared to those of purebred Hereford cattle. Dadi *et al.* (2002) reported a 5.7% increase in WW of calves from crossbreds of Charolais and Hereford sires and Bonsmara, Angus and Hereford dams compared to those from straight bred dams. The results of this study suggest that composites breeds do not always produce heavier calves at weaning as compared to straight bred, with special reference to the British breeds such as the Aberdeen Angus compared to Simbra and tropically adapted Bonsmara and Drakensbergers.

On the other hand, the consistency of Simbra in obtaining a high FWT in all four years of the study period when particularly compared to the other composite breeds used in this study indicates two things; 1) the increase in the effect of breed complementarity and heterosis in crosses involving one *Bos taurus* and *Bos indicus* as compared to a cross where two or more *Bos taurus* used to developed a composite breed (e.g. Bonsmara and Beefmaster), and 2) it emphasises the advantage of a high growth potential obtained from crosses involving large 'exotic' breed e.g. Simmental as compared to smaller breeds such as the Hereford and Shorthorn breeds. Arango *et al.* (2002d) found a significant increase in weight and height of F₁ offspring from crosses involving Brahman dams and Angus and Hereford sires compared to those from Hereford-Angus crosses. This was related to the greater effect of heterosis resulting from a cross involving *Bos taurus* x *Bos indicus* as compared a cross of *Bos taurus* x *Bos taurus*.



4.2 Average daily gain (ADG)

Liu *et al.* (1993) suggested that, ADG would be more appropriate than liveweight when evaluating the growth potential of beef bulls, particularly at test stations where the duration of the test matters. This according to Liu *et al.* (1993), is due to the effect of herd of origin on bull actual liveweight than on ADG as the test advances. Liu *et al.* (1993) found the effect of herd of origin for both periodic and cumulative ADG to decrease in as early as from the 28th to 112th day or 56th to 112th day of the test period. On that basis, Liu *et al.* (1993) recommended that an adjustment period of 56 days followed by 84 days on test would be appropriate to reduce the effect of herd of origin on ADG, hence evaluate the growth potential of beef bulls in feedlot more accurately.

Under grazing conditions, in the case of this study, the breed, year and their interactions (breed x year) were the significant sources of variation ($P < 0.05$) for ADG, whereas the effect of breeder (breed x year) was non significant. However, there was a general decrease in the ADG for all the breeds (Table 4.2.1) as tests period advances in each year. This could be attributed by the reduction in annual total rainfall as shown in Figure 3.1. on the contrary, evaluating the postweaning dataset of 19 years of feedlot testing (140 days) of beef bulls at the University of Arkansas, USA, Chewning *et al.* (1990) reported a general increase in ADG of Hereford, Angus, Charolais and Simmental, except Santa Gertrudis, as the days on test were increasing.

4.2.1 ADG within breed between years

The ADG for Aberdeen Angus bulls' performance tested in Year 3 was the highest compared to those tested in other years. This is probably due to the fact that Year 3 bulls had the lowest IWT and they had a compensatory gain even though the annual rainfall for that year was below average (Figure 3.1., Chapter III). Similarly, those tested in Year 4 had the lowest mean ADG because of their high entry liveweight and probably due to less sufficient forage as a result of a lower annual rainfall in the previous year.



Table 4.2.1 Means (\pm s.d.) for the effect of breed on ADG (g/d) during the grazing period

Breed	Year			
	1	2	3	4
Aberdeen Angus	613 ₁ ^d (\pm 142.0)	494 ₁₂ ^d (\pm 115.6)	631 ₁ ^d (\pm 83.6)	434 ₂ ^b (\pm 85.7)
Beefmaster	945 ₁ ^a (\pm 93.3)	827 ₂ ^{ab} (\pm 126.4)	793 ₂₃ ^{ab} (\pm 103.6)	754 ₃ ^a (\pm 128.0)
Bonsmara	861 ₁ ^a (\pm 109.1)	768 ₂ ^{bc} (\pm 85.3)	752 ₂₃ ^{bc} (78.7)	677 ₃ ^a (\pm 129.5)
Drakensberger	830 ₁ ^{bc} (\pm 147.0)	693 ₂ ^c (\pm 104.3)	674 ₂ ^{cd} (\pm 68.3)	712 ₂ ^a (\pm 100.4)
Nguni	745 ₁ ^{cd} (\pm 48.2)	713 ₁ ^c (\pm 125.2)	726 ₁ ^{bd} (\pm 78.5)	559 ₂ ^b (\pm 81.6)
Simbra	925 ₁ ^{ab} (\pm 102.0)	981 ₁ ^a (\pm 54.7)	886 ₁ ^a (\pm 76.6)	727 ₂ ^a (\pm 117.3)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2, 3) and column means (a, b, c, d) with common script do not differ ($P > 0.05$)

The Beefmaster bulls performance tested in Year 1 had the highest ADG ($P < 0.05$) compared to those tested in years 2, 3 and 4. Once again, it could be as a result of compensatory growth because of relatively low entry weight of the Year 1 bulls. In addition, this significance is perhaps also brought about by the fact that during that year, there was enough available forage due to the high annual rainfall received. Year 4 bulls had the lowest ADG compared to those tested in the previous years, although not significant to those tested in Year 3. The low ADG of Year 4 is difficult to explain because they had the lowest IWT ($P < 0.05$) and it would be expected to attain compensatory gain. Perhaps it could be argued that since Year 3 had the lowest total annual rainfall, the impact felt by bulls tested in Year 4 was great enough to counteract the effect of compensatory growth. Thus, because of available forage, bulls with low IWT could not even gain significantly as it would be expected. However, even though Year 4 bulls did not show compensation in growth rate, it is interesting to note that in terms of net gain during the grazing period, they had the highest percentage of 64 compared to 61, 54 and 61% of years 1, 2 and 3, respectively (Annexure A).

A much similar trend as observed in Beefmaster was also observed in Bonsmara bulls. Year 1 bulls had the highest (861 g/d, $P < 0.05$) ADG and those of Year 4 having the lowest (677 g/d). Year 1 bulls had relatively low IWT and forage material was sufficient due to the high rainfall received in that year. The most interesting finding with regards



Bonsmara bulls growth rate was that, although Year 3 bulls had the lowest IWT (218 kg) they did not show compensatory growth but again had the highest net gain of 71% compared to 64, 55 and 65% of years 1, 2 and 4, respectively. This implies that a bull with a low entry weight at test station may at times not show compensatory gain. This may possibly occurs when the quantity and quality of forage material is low. On the other hand, in terms of total gain during the grazing period it will most likely be superior to those tested in good years.

The Drakensberger bulls performance tested in Year 1 had the lowest entry weight but gained faster ($P < 0.05$) compared to those tested in other years. Year 2 did not gain much because of a high IWT combined with relatively sufficient forage available. Surprisingly, given the low entry weight and sufficient forage, Year 3 bulls had lower ADG compared to those tested in Year 4 (61 versus 62%). It could be argued that perhaps the competition for grazing was higher among the bulls tested in Year 4 compared to those of Year 3, hence the high net gain. This imply that, even though Year 3 bulls had a lower IWT, the abundance of feed did not trigger any increase in frequency of grazing in terms of feed intake to improve the total gain for the herd probably due to the higher temperatures level of that year (Table 3.2).

As regards to the Nguni bulls, it was surprising to find that the bulls with the lowest IWT did not show compensation in growth rate during the test. Year 4 bulls had the lowest entry weight, low ADG ($P < 0.05$) and also relatively low average net gain (63%). It is difficult to explain these findings. Perhaps it could be argued that, being an adaptable breed and given their low maintenance requirements, their feed intake is less influenced by the abundance or shortage of grazing material. Hence the pre-test management has little impact on the performance of the breed during the test.

As for the Simbra bulls, the highest ADG of 981 g/d was recorded in bulls that were performance tested in Year 2, although that did not differ ($P < 0.05$) from those tested in years 1 and 3 (925 and 886 g/d, respectively). The high ADG of Year 2, as just mentioned above was surprising. Logically, Year 3 bulls would be expected to gain more as a result of compensatory growth due to their low entry weight. Perhaps it could be

argued that high ambient temperatures recorded in Year 3, had an impact on the grazing behaviours of these bulls (Year 3) as compared to the low temperatures recorded in the other years (Table 3.2, Chapter III). Nonetheless, in terms of percentage growth rate for the herd, Year 3 bulls grew faster (74%) compared to those tested in other years (e.g. 53, 62 and 55% for years 1, 2 and 4, respectively).

4.2.2 ADG between breeds within a year

The Aberdeen Angus bulls had the lowest ($P < 0.05$) gains in all four years, although not significantly from the Nguni in years 1, 3 and 4 and from Drakensberger in Year 3. The Simbra on the other hand, had the highest ($P < 0.05$) mean ADG, except in Year 1 where it was less than that of Beefmaster. In general, the two breeds (Simbra and Beefmaster) gained faster compared to the other breeds. This was not surprising because composite breeds are expected to outperform the pure breeds as was mentioned earlier in this section. However, of interest to note is the performance of Bonsmara (tropically adapted composite breed) compared to the Beefmaster (exotic). The high ADG observed in Simbra bulls as compared to the Bonsmara and Beefmaster could be related to the differences in growth potential between the breeds used in the development of these composite breeds. The composite breed containing strains from the large frame sized *Bos taurus* breed (in this case, the Simmental component within the Simbra) would be expected to gain faster than those with strains from smaller frame-sized breeds (e.g. the Shorthorn and Hereford in the case of Bonsmara and Beefmaster).

The superiority of Beefmaster over the Bonsmara in terms of ADG could be in addition to the Brahman component probably due to more strains of *Bos taurus*. Even though both breeds were developed from Hereford and Shorthorn crosses as their *Bos taurus* components, the level of the admixture was not the same. The Beefmaster has more strains of the *Bos taurus* breeds (25:25) (Porter, 1991) compared to the Bonsmara (19:19) (Porter, 1991; Corbet *et al.* 2006a). The high level of the *Bos taurus* component within the Beefmaster has the possibility to boost the breed performance due to the increase in additive genetic effect for growth possessed by the *Bos taurus* breeds as well as heterosis (Schoeman, 1999). However, such performance will be subjected to the extent of

adaptability of the baseline (*Bos indicus*) component. The *Bos indicus* components were made up of the Brahman (50%) and Afrikaner (62%) for the Beefmaster and Bonsmara, respectively. As mentioned earlier, the average, maximum and minimum temperatures during the study period were 22.7 and 7.4°C, respectively. These temperature levels proved to be too low especially for Brahman bulls. As a result all Brahman bulls had to be tested at a year older than other breeds. In general, the Brahman and its crosses are known to perform poorer in cooler climates (Ragsdale *et al.*, 1957 & Gregory *et al.*, 1979 as cited by Boyles *et al.*, 1991). However, if they are given enough shelter and more careful feed bunk management e.g. in a feedlot, they can perform fairly well despite the cool environment (Boyles *et al.*, 1991). It is possible that the *Bos taurus* component was responsible for allowing the Brahman crossed breeds (viz. the Beefmaster) to adapt fairly well to the cool climates of the eastern Free State. In addition, the fact that the selection of Brahman cattle was for growth rate over years as opposed to the draught power and recently for beef production in the Afrikaner (Beffa, 2005), could also have boosted the performance of the Beefmaster compared to the Bonsmara as shown in the present study.

A study with F₂ and F₃ generation of similar breeds (Brahman cross line consisting of ½ Brahman, ¼ Hereford & ¼ Shorthorn and an Afrikaner cross line consisting of ½ Afrikaner, ¼ Hereford & ¼ Shorthorn) conducted in northern Australia by Kennedy *et al.* (1971) had similar findings to those of the present study. Kennedy *et al.* (1971) reported faster growth in Brahman-cross line compared to the Afrikaner-cross line, except shortly after weaning when the pasture condition was poor.

4.3 Cumulative ADG

4.3.1 Breeds cumulative ADG in Year 1

The cumulative ADG is an indication of the animal growth rate (daily body weight change) with increasing number of days on test. In the present study it was calculated as follows: (e.g. W₀–W₂₁ = [W₂₁ – W₀]/21], W₀–W₄₂ = [W₄₂ – W₀]/42] etc.). Figure 4.3.1 illustrates the cumulative ADG between breeds in Year 1. The main source of variation (P < 0.05) was the effect of breed, year, and their interaction (year x breed) whereas the

effect of breeder (year x breed) was non-significant. Regardless of the differences in the amount of weight gained, it is evident that all bulls, except the Aberdeen Angus, had adapted fairly well to the environment at the onset of the testing period as shown in their cumulative ADG within the first 21 days. During this period, the Drakensberger and Beefmaster had the highest ($P < 0.05$) cumulative ADG (524 and 517 g/d, respectively), although not significant from Bonsmara (479 g/d). The Nguni and Simbra gained 428 and 333 g/d, respectively. The slight superiority of the Drakensberger over the other breeds within the first 21 days of the test period was not surprising. Logically, a breed that is already accustomed to the particular environment would be expected to have an advantage especially early in the test period compared to those that are new to the environment. For example, unlike the other breeds, the presence of the Drakensberger cattle breed *per se* in the eastern Free State particularly in the Vrede district and the Volksrust district in Mpumalanga Province can be traced back to the 19th century at the time of the ‘Great Trek’ (Porter, 1991), and therefore it is highly likely for it to be more adapted compared to the other breeds.

On the other hand, the loss of liveweight by the Aberdeen Angus bulls (-154 g/d) during the same period was unexpected because the British or European breeds would be expected to have a stronger growth impetus in cooler environments than the tropically adapted breeds (Kenedy *et al.*, 1971; Boyle *et al.*, 1991; Fordyce *et al.*, 1996e). Prayaga *et al.* (2005) found a moderate genetic correlation between growth traits and heat tolerant traits (e.g. temperature and coat scores) in the tropics and concluded that as the ability of an animal to tolerate heat stress increases, growth increases at the genetic level. This highlights the fact that tropically adapted breeds have the advantage of outperforming the British breeds in high ambient temperature environments whereas the British breed may do so in cooler environments. However, it could also be argued that despite the cold weather (max 22.4 °C and min 11.9 °C) that prevailed during that period (between September and October of Year 1), the quality and quantity of grazing materials was inadequate to boost the growth performance of purebred *Bos taurus* breeds.

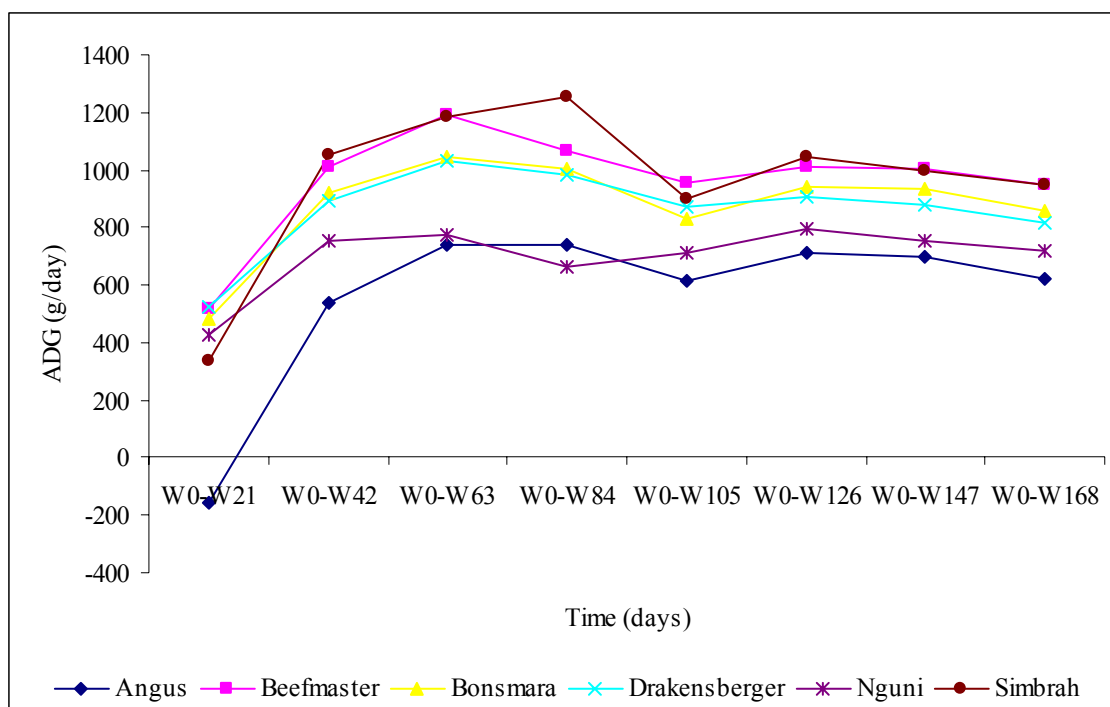


Figure 4.3.1 Cumulative ADG between breeds within a year (Year 1)

During the second period of weighing (42-day), a significant increase was observed in all breeds including the Aberdeen Angus bulls. The Beefmaster and Simbra gained more than a kilogram/day each (1009 and 1050 g/d, respectively) whereas the Bonsmara, Drakensberger and Nguni gained 919, 895 and 752 g/d, respectively with Aberdeen Angus bulls gaining just above 500 grams a day. The sharp increase in liveweight across all breeds may have been attributed to compensatory growth following the restriction of feed during the winter season. Bohman (1955), Meyer *et al.* (1965) and Horton *et al.* (1978) as cited by Lewis *et al.* (1990) stated that cattle make excellent compensatory growth on pastures following previous winter nutritional restrictions. Compensatory growth *per se* is associated with an increase in forage intake in relation to body weight during the realimentation period (Lewis *et al.*, 1990). In an extensive grazing system, forage intake is difficult to measure and it is subject to human errors. However, it is increased in animals that were restricted to a greater extent during the winter season. For that reason, it is suggested that any factor that affects forage availability and quality may alter the degree of compensatory growth in grazing animals (Lewis *et al.*, 1990). In the

present study, a record high of 117 mm of rainfall was recorded in October which as explained above, may have led to the increase in the daily gain of animals.

Furthermore, as shown in Figure 4.3.1 the Bonsmara, Drakensberger, Nguni and Beefmaster appeared to have reached the peak of their gains at day 63 whereas the Simbra ($P < 0.05$) and Aberdeen Angus continued to gain more, reaching the peak on the 84th day. This could be related to differences in rate of maturity of the breeds. There is a general consensus that smaller frame-sized cattle breeds generally tend to reach their maturity earlier (Liu *et al.*, 1993) compared to large frame sized breeds (Liu *et al.*, 1993; Vargas *et al.*, 1998). According to Liu *et al.* (1993), bulls from large breeds would likely grow physiologically older than those from smaller breeds, given the same chronological age. In addition, similar results were also reported by Laborde *et al.* (2001) between Simmental (large) and Red Angus (small) on the level of back-fat finishing (10 mm grade fat) in a feedlot. Laborde *et al.* (2001) found that the late maturing Simmental had to spend 71 days more on feed than the early maturing Red Angus to obtain the same level of back-fat thickness, while at the same time maintaining heavier slaughter weights, larger longissimus muscle area and increased lean yield. As cited by Laborde *et al.* (2001), Vanderwert *et al.* (1985) reported a similar delay of 67 days in back-fat acquisition by the Simmental bulls compared to the Hereford bulls whereas Mandell *et al.* (1998a) found a delay of 102 days in Limousin bulls compared to the Aberdeen Angus.

Moreover, Figure 4.3.1 shows that, unlike the other breed bulls, the Simbra bulls experienced a sharp ($P < 0.05$) decline in cumulative ADG after reaching the peak at day 84 of the test period. Surprisingly, the Nguni bulls gained slightly faster during the same period whilst other breeds continued to experience a gradual decline in growth rate through to the 105th day on test. Literature is of limited help to explain these findings. From day 105 onwards, all breeds picked up slightly, followed by a gradual decline at day 126 right through to the end of the grazing period. The constant increase in gains at the start of the test followed by a slight but non-significant decline towards the end of the test period as shown in this study, has been reported previously by Baker *et al.* (2002).

4.3.2 Breeds cumulative ADG in Year 2

Unlike in Year 1, bulls tested in Year 2 had a generally higher cumulative ADG, particularly in the first 22 days of the grazing period. This could be related to the differences in the allocated adjustment period between the two years. Year 2 bulls had a longer adjustment period as compared to those of Year 1. It is known that animals that undergo a longer adjustment period will likely have an advantage in terms of growth rate during the test period due to reduced stress related factors e.g. weaning and/or stress caused by introduction to newer environmental conditions (Moyo, 1996). Despite the somewhat better cumulative ADG in the first 22 days, most breeds in Year 2 appeared to have lost weight by the 43rd day, although they all picked up by the 64th day of the grazing period. The decline in weight gain by the 43rd day was most possibly caused by shortage of quality foraging materials due to the lower rainfall during the same period (Table 4.3.2). Nonetheless, of interest to note in Year 2 as compared to Year 1 was that bulls that were performance tested in Year 2 appeared to have all reached the peak by the 64th day of the grazing period. Late maturing breeds such as the Simbra were not able to extend their period of weight gain probably due to less sufficient grazing materials.

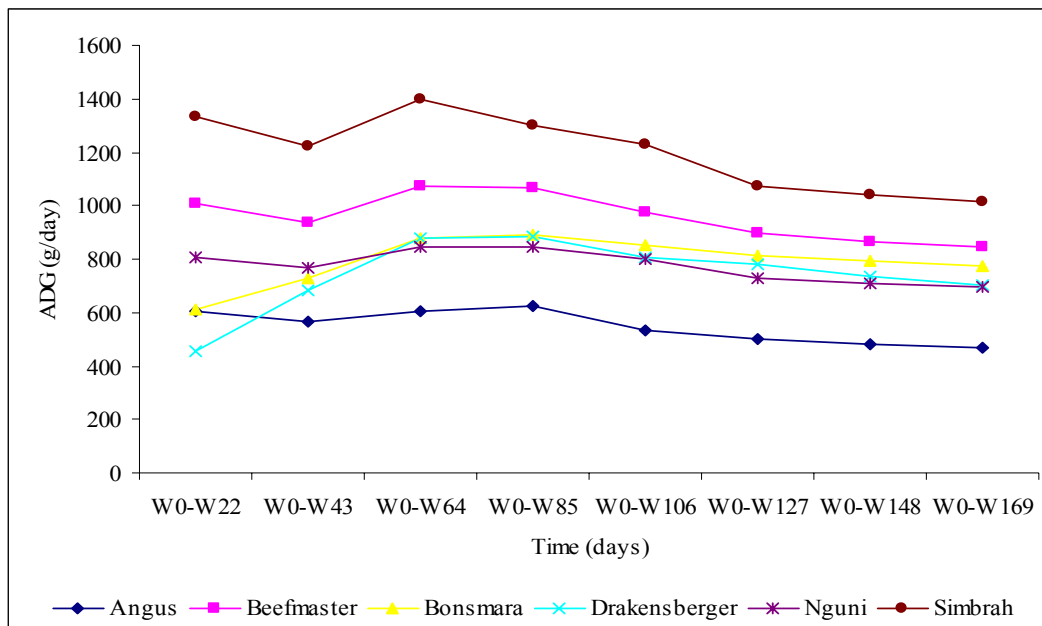


Figure 4.3.2 Cumulative ADG between breeds within a year (Year 2)

4.3.3 Breeds cumulative ADG in Year 3

The cumulative ADG continued to vary significantly between breeds in Year 3 particularly during the first period (at day 23) of the grazing period. As shown in Figure 4.3.3, the Beefmaster and Drakensberger had the lowest ($P < 0.05$) cumulative ADG (< 100 g/d) at day 23. The other breeds gained between 320 and 450 g/d during the same period. Although all the breeds had relatively lower cumulative ADG as compared to those that were tested in years 1 and 2 during the same period, the low cumulative ADG ($P < 0.05$) of both the Beefmaster and Drakensberger were unexpected. Nonetheless, of interest, was the manner in which the two breeds compensated ($P < 0.05$) from day 23 onwards. As shown in Figure 4.3.3, the two breeds appeared to have undergone a period of compensatory growth from day 23 onwards reaching the peak at day 99 combining with the other breeds. Of the two breeds the Drakensberger showed the most significant gain. In general, the bulls that were tested in Year 3 exhibited a much longer compensatory growth period (approximately 99 days) as opposed to 64 days for years 1 and 2 bulls. Compensatory growth *per se* is influenced by several factors e.g. age of animals when restrictions begin, the severity, duration, nature of under-nutrition, the re-alimentation diet and time, and breed time (Owens *et al.*, 1993) which was not measured in this study. However, it seems evident that the quality of grazing material (as discussed by Lewis *et al.*, 1990) may have had played a major role in the rapid growth rate exhibited by Year 3 bulls following a reduction in rainfall.

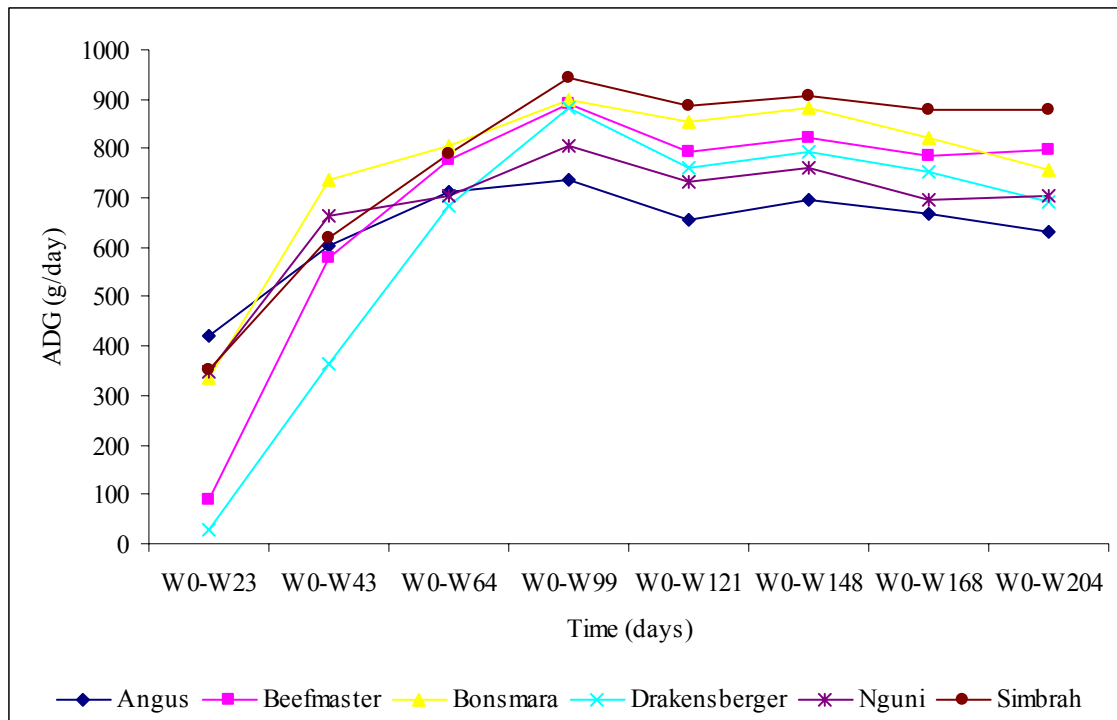


Figure 4.3.3 Cumulative ADG between breeds within a year (Year 3)

As shown in Table 3.1 (section 3), the average annual rainfall in Year 3 had dropped from 798 and 670 in years 1 and 2 respectively, to 631 in Year 3. With low rainfall, it is possible that the amount of leached nutrients had been reduced in the current year as compared to the two previous years which had a higher annual rainfall. Hence, the quality of grazing materials may have improved due to retained nutrients in the topsoil, which in turn had improved the growth rate of animals significantly. In addition, it can also be argued that, although Year 3 had a below average total rainfall (631 mm), the high rainfall received in the previous year combined with the early onset of the rainy season in Year 3 contributed to the better performance of the bulls. Holloway *et al.* (2002) under semi-arid south Texas grazing conditions reported an increase in birth and weaning weight in tropically adapted beef calves in a year when the total rainfall received was second lowest (498 mm) than those weaned in years of a higher (891 mm) or a lower rainfall. In that study it was argued that the higher than normal rainfall received in the previous year augmented the growing conditions for that year so that forage supply was greater than expected despite the low rainfall record. The effect of forage carry-over from the previous year combined with early rain during the spring growing season was also found to have supported the heavier birth and weaning weights.

4.3.4 Breeds cumulative ADG in Year 4

In Year 4 (Figure 4.3.4), all the breeds had very low gains (less than 200 g/d) during the first period of the grazing period. During the second period (at day 59), the cumulative ADG of most of the breeds declined significantly to below 100 g/day. The Aberdeen Angus and Nguni in particular, did not gain at all and appeared to have suffered the most from perhaps the effect of weaning stress and environmental factors (e.g. inadequate forage and low daily temperature levels) as they showed negative cumulative ADG's. On the other hand, the cumulative ADG of the Bonsmara increased during the same period after being in the negative during the first period of the grazing period. From day 59 onwards, all the breeds recovered well and gained significant ($P < 0.05$) weights reaching a peak at the 162nd day of the test. The Simbra and Beefmaster appeared to have dominated the other breeds during the compensation period. The Drakensberger and Bonsmara were both intermediate whereas the Nguni and Aberdeen Angus had the slowest compensation. The Aberdeen Angus had the lowest ($P < 0.05$) cumulative ADG by the end of the grazing period as observed in the previous years, even though it did not differ significantly from the Nguni.

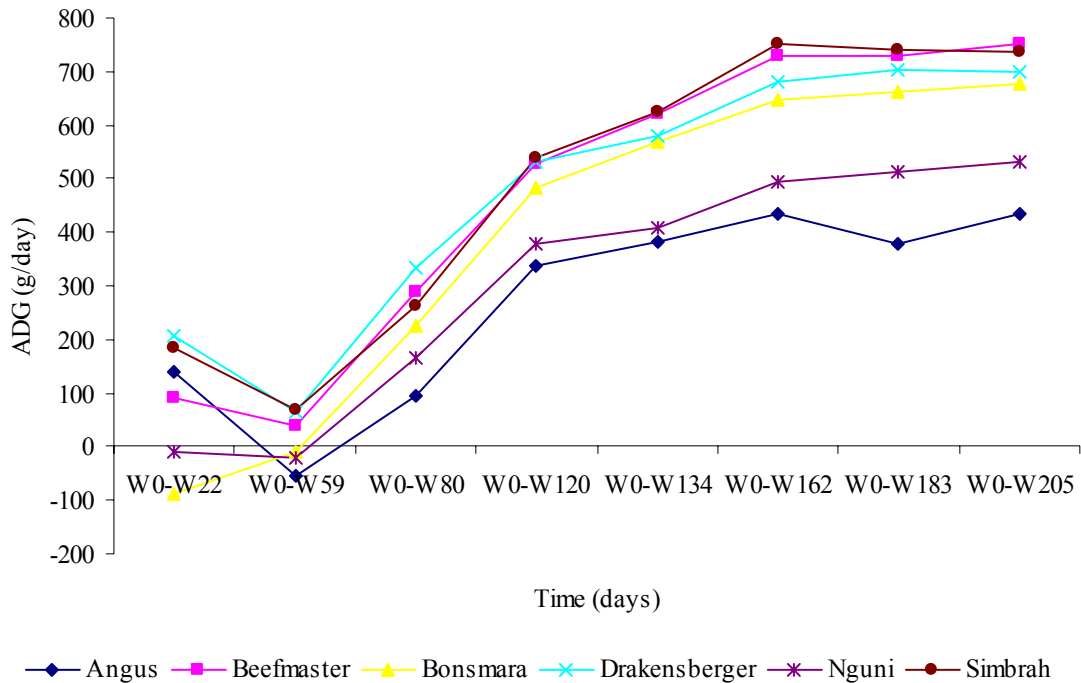


Figure 4.3.4 Cumulative ADG between breeds within a year (Year 4)

The prolonged winter season combined with the delayed onset of the rainy season (Figure 4.2.5) could be the possible causes of low cumulative ADG of animals observed early in Year 4. The effect of low daily temperature levels on pasture growth has been previously well documented (Clark *et al.*, 2003a). It is known that in winter seasons, pasture growth is limited due to the low soil temperatures level. Consequently the quality [e.g. crude protein (CP)] of forage is reduced. Although it was not tested in this study, research has shown that forage intake could be limited if diet CP falls below 6 to 8% (Aiken, 1997). Rainfall affects animal production *via* pasture production. Rainfall in Year 4 started relatively very late (in November 2003) as compared to the previous years and was generally lower, which affected the forage availability.

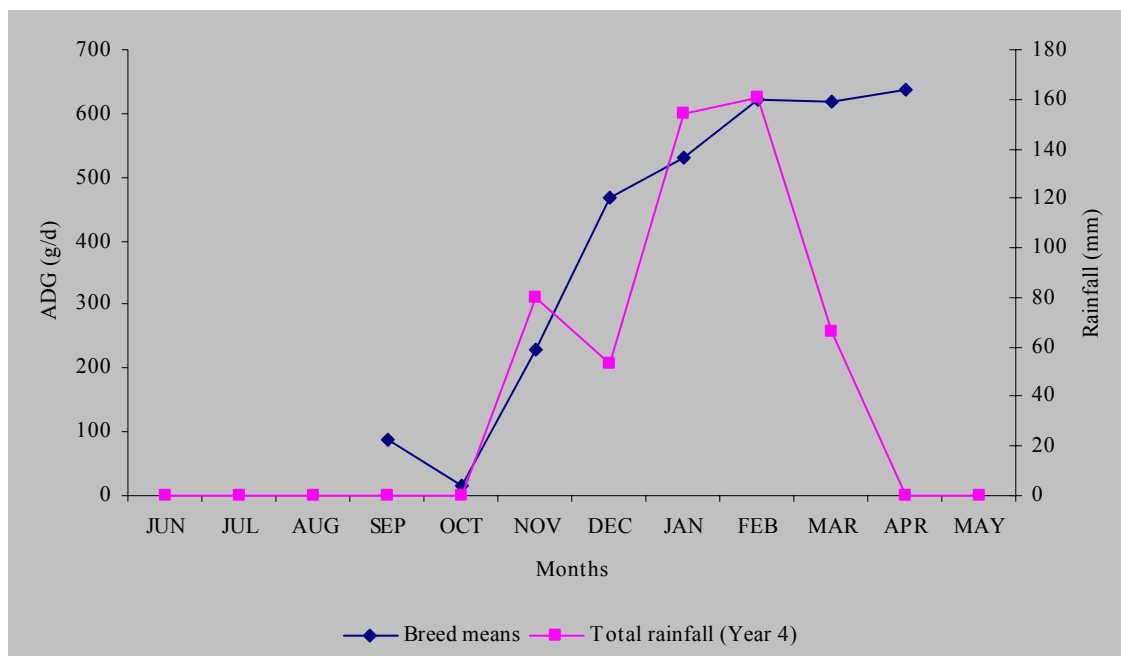


Figure 4.3.5 Relationship between breeds cumulative ADG and monthly rainfall in Year 4

Nonetheless, as shown in Figure 4.3.5 above, the cumulative ADG of all the breeds appeared to have improved ($P < 0.05$) approximately a month after the first showers of rainfall were received in November 2003, suggesting an increase in growing conditions of the vegetation. As expected, the breeds exhibited a longer period of compensatory growth due to a long period of nutritional restriction experienced in Year 4 compared to that of the previous years. Although, all the breeds appeared to have reached the peak of their gain at day 162, the Aberdeen Angus and Nguni had significantly the lowest liveweights, with Bonsmara and Drakensberger intermediate and Simbra and Beefmaster the highest ($P < 0.05$). This could be related to the breed differences in terms of maintenance requirements.



4.4 Feed conversion efficiency

4.4.1 Comparisons of the Kleiber ratio (KR) within a breed

The KR was deemed fit for evaluation of feed conversion efficiency of breeds used in this study mainly because it does not require the measurement of feed intake for each individual bull. As shown in the previous sections, KR was calculated as $ADG/MWT^{0.75}$ (ratio of ADG to metabolic body weight) (Arthur *et al.*, 2001b). A high value indicates a greater dilution of maintenance energy requirements and *vice versa* which imply that as ADG increases at the same $MWT^{0.75}$, more growth is obtained without the increase in maintenance energy cost (Tedeschi *et al.*, 2006). The results of this study have shown that the variation in KR values was due to the effect ($P < 0.05$) of the breed, year and their interactions (year x breed) as well as the breeder within breed x year interaction. In addition, the results have also shown a general decline in KR values with increasing years of study period, indicating a greater correlation with rainfall availability.

As for the Aberdeen Angus bulls, the variations of KR values were generally lower, averaging at 6.1 for the entire study period. The highest value (7.3 KR, $P < 0.05$) was recorded in Year 3 whereas the lowest (4.6 KR, $P < 0.05$) was in Year 4 (Table 4.4.1). The lower value observed in Year 4 was expected because of slow growth rates exhibited by the breed due to the influence of environmental (e.g. delayed rainfall and prolonged winter season) factors as explained earlier. On the other hand, the high KR value observed in Year 3 was not surprising either, although the rainfall recorded in that year was below average. As mentioned earlier, animals in Year 3 exhibited a better growth rate due to 1) forage carry-over due to high rainfall received in the first two years and 2) early commencement of rainy season in Year 3.



Table 4.4.1 Least square means (\pm s.d.) for the effect of breed on Kleiber ratio within a year

Breed	Year			
	1	2	3	4
Aberdeen Angus	7.0 ₁ ^b (\pm 1.4)	5.712 ₁₂ ^c (\pm 1.3)	7.3 ₁ ^c (\pm 0.9)	4.6 ₂ ^b (\pm 0.8)
Beefmaster	10.3 ₁ ^a (\pm 0.9)	9.3 ₂ ^{ab} (\pm 1.2)	8.4 ₃ ^b (\pm 1.0)	8.5 ₃ ^a (\pm 1.1)
Bonsmara	10.2 ₁ ^a (\pm 1.1)	9.3 ₁₂ ^{ab} (\pm 1.2)	9.0 ₂ ^{ab} (\pm 0.8)	7.9 ₃ ^a (\pm 1.3)
Drakensberger	9.8 ₁ ^a (\pm 1.6)	8.4 ₂ ^b (\pm 1.0)	8.0 ₂ ^{bc} (\pm 0.7)	8.2 ₂ ^a (\pm 0.8)
Nguni	9.9 ₁ ^a (\pm 0.5)	9.7 ₁ ^a (\pm 1.2)	9.2 ₁ ^{ab} (\pm 0.8)	7.8 ₂ ^a (\pm 0.8)
Simbra	9.5 ₁ ^a (\pm 0.9)	10.4 ₁ ^a (\pm 0.8)	9.6 ₁ ^a (\pm 0.9)	7.9 ₂ ^a (\pm 0.9)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2, 3) and column means (a, b, c) with common script do not differ ($P > 0.05$)

The variation of KR values for the Beefmaster bulls was significant. Year 1 bulls had a higher ($P < 0.05$) value compared to those tested in subsequent years. This was true ($P < 0.05$) for Year 2 but not for Year 3 bulls. This could be due to year effect (e.g. variability in total rainfall recorded and temperature) and partially due the effect of breeder (year x breed interaction). The fact that not all breeders for a specific breed (e.g. Beefmaster in this case) had their bulls tested each year during the study period, presents the likelihood of a high variation within a breed due to the differences in management practises of breeders.

The Bonsmara bulls tested in Year 4 were significantly ($P < 0.05$) the least efficient in terms of the KR compared to those tested in the previous years. This was expected due to the poor grazing in that year as a result of low annual rainfall. However, despite the low KR values, Year 4 bulls had the highest FWT, which suggests to a lesser extent a lower correlation between feed conversion efficiency with FWT (at approximately a year old). Those tested in Year 1 had the highest KR value compared to those of years 1 and 2, although not significantly to those of Year 2.

The Drakensberger bulls did not differ much in terms of KR values, except for those tested in Year 1, which had the highest ($P < 0.05$) values. The KR values for bulls tested in years 2 to 4 did not differ ($P > 0.05$). The high KR value in Year 1 could be linked

partially to the high rainfall received in that year and most importantly to the low IWT of those bulls compared to those tested in years 2 to 4. It appeared that because of low IWT, these bulls were able to obtain a high KR due to the effect of compensatory growth ($P < 0.05$) experienced early during the grazing period of that year. Similarly to the Drakensberger, there were no significant differences between the KR values of Nguni bulls, apart from that of Year 4 bulls which was the lowest ($P < 0.05$). A similar trend was observed in Simbra bulls.

4.4.2 Comparisons of KR values between breeds

In Year 1 the Beefmaster had the highest KR value compared to the rest of the breeds, although it was not significant from the Bonsmara, Drakensberger, Nguni and Simbra. In contrast, the Aberdeen Angus had the lowest ($P < 0.05$) KR value during the same year. In Year 2, the Simbra was the more efficient feed converter, although not significant from the Nguni, Bonsmara and Beefmaster. The Aberdeen Angus had the lowest ($P < 0.05$) KR value in that year. Contrary to years 1 and 2, Year 3 Aberdeen Angus bulls had a slightly higher KR value, although it was still significantly lower compared to that of Beefmaster, Bonsmara, Nguni and Simbra. The Simbra was the most efficient in Year 3, although not significant from Nguni and Bonsmara. In general, the averages of KR values in Year 4 were lower compared to those of previous years for all the breeds. This could be due to the low annual rainfall and the delayed onset of the rainy season. Of interest to note was that the Drakensberger was among the highest ranked breeds in terms of KR in Year 4. Together with the Beefmaster, the breed had numerically the highest KR values, although not significant from the Simbra, Nguni and Bonsmara. The Aberdeen Angus maintained the bottom position ($P < 0.05$) in the final year as in previous years of the grazing period.

The results had shown that there was a reduction in the herd KR with increasing numbers of years during the study period. It is however, clear that feed conversion efficiency measured in terms of KR, is highly affected by the amount of grazing material available. This implies that in years of good rainfall, animals tend to convert feed more efficiently compared to dry years in terms of KR. Moreover, it was also found that the Aberdeen

Angus appeared to have been severely affected by the poor rainfall as its level of efficiency dropped by 34% in a dry year. The Bonsmara and Nguni were intermediate (22 and 23%, respectively), whereas the Beefmaster, Drakensberger and Simbra were least affected (17, 16 and 16%, respectively).

4.4.3 Comparisons of the veld feed conversion ratio (VFCR) within a breed

The term feed conversion ratio (feed eaten per weight gained; FCR) has been extensively used in beef cattle production and as a result farmers often tend to understand “animal feed conversion efficiency” much better if this term is used (Prof. T. Ungerer, Box 288, Vrede, pers, comm.). Animals that have a low FCR are considered efficient users of feed. The difficulty of obtaining reliable values of FCR in grazing animals, however, led to the recommendation of the VFCR for range animals (Prof. T. Ungerer, Box 288, Vrede, pers, comm.). Similar to the KR, the VFCR does not require the direct measurement of feed intake (FI) of the animals. In this study, VFCR was calculated as $(12\% \times \text{MME}) / \text{ADG}$.

The main source of variation ($P < 0.05$) in VFCR was the effect of year, breed and their interaction (breed x year). The effect of breeder (breed x year) was non-significant. Breed means for VFCR are presented in Table 4.4.2. Generally, the Aberdeen Angus had a high mean VFCR, which indicates that the breed was relatively less efficient during the grazing period. The lowest ($P < 0.05$) VFCR recorded for the breed was in Year 3 whereas the highest ($P < 0.05$) was in Year 4. This could be related to quantity and quality of grazing in both years as explained in previous sections and also to the effect of environmental stress factors (e.g. drought). The poor performance of Year 4 animals in particular is probably due to the prolonged dry season experienced in that year, which could have inflicted severe stress on the animals grazing performance. Similarly, the performance of Year 3 animals was expected because of the good distribution of rainfall in that year. Moreover, as mentioned earlier on, the fact that Aberdeen Angus bulls had shown a higher vulnerability to the dry season (low rainfall years), further substantiates that for a breed of poorer adaptability to the prevailing environmental conditions, such as those of the Vrede district, a low VFCR is likely to be obtained.



Table 4.4.2 Least square means (\pm S.D.) for breeds veld feed conversion ratio

Breed	Year			
	1	2	3	4
Aberdeen Angus	17.7 ₃ ^b (\pm 3.9)	22.2 ₂ ^a (\pm 5.6)	16.7 ₃ ^a (\pm 1.9)	27.0 ₁ ^a (\pm 5.4)
Beefmaster	11.8 ₂ ^a (\pm 1.1)	13.1 ₁₂ ^b (\pm 1.8)	14.4 ₁ ^{ab} (\pm 1.9)	14.4 ₁ ^b (\pm 2.0)
Bonsmara	11.9 ₂ ^a (\pm 1.4)	13.2 ₂ ^b (\pm 1.7)	13.6 ₂ ^b (\pm 1.3)	15.6 ₁ ^b (\pm 2.4)
Drakensberger	12.6 ₂ ^a (\pm 3.9)	14.5 ₁₂ ^b (\pm 1.9)	15.2 ₁ ^{ab} (\pm 1.4)	14.8 ₁₂ ^b (\pm 1.4)
Nguni	12.2 ₂ ^a (\pm 0.5)	12.6 ₂ ^b (\pm 1.6)	13.1 ₂ ^b (\pm 1.1)	15.6 ₁ ^b (\pm 1.7)
Simbra	12.7 ₂ ^a (\pm 1.2)	11.6 ₂ ^c (\pm 0.9)	12.7 ₂ ^b (\pm 1.3)	15.4 ₁ ^b (\pm 1.7)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2, 3) and column means (a, b, c) with common script do not differ ($P > 0.05$)

As for the Beefmaster, the highest mean VFCR was recorded in years 3 and 4 and lowest in Year 1. Year 2 bulls were better than years 3 and 4 bulls in terms of VFCR, although not significant. These performances were unexpected. However, the results demonstrate that although there is a relatively low difference within the Beefmaster bulls, their performance in terms of VFCR is closely linked to the total annual rainfall.

Year 4 Bonsmara bulls were least efficient ($P < 0.05$) compared to those of previous years in that they had the highest VFCR. There was no significant difference in VFCR of other Bonsmara bulls tested in years 1 to 3. The performance of Year 4 bulls was not surprising as explained earlier with the Aberdeen Angus. On the contrary, the performance of years 1 to 3 bulls was of interest. These performance results confirmed that within the Bonsmara breed, the variation in terms of VFCR is minimal and can only be pronounced in severe dry seasons.

As for the Drakensberger bulls, the variation in VFCR values was mostly non-significant. Year 3 bulls had the poorest VFCR compared to those tested in other years but did not differ ($P > 0.05$) from those of years 2 and 4. Similarly, although Year 1 bulls were the most efficient in terms of VFCR they did not differ significantly from those tested in years 2 and 4. In addition to the explanation given in 4.3.1, the performance shown by Year 1 bulls in terms of VFCR could be as a result of high ADG as observed in that year.



Previous studies have shown that there is a negative correlation between ADG and FCR ($r_p = -0.64$) (Nkrumah *et al.*, 2004). It is therefore possible to obtain a similar relationship when VF_{CR} is used. The poor VF_{CR} exhibited by Year 3 bulls was difficult to explain.

The VF_{CR} for Nguni bulls was as follows, 12.2, 12.6 and 13.1 in years 1, 2 and 3, respectively and hence there were no significant differences. As expected, Year 4 bulls had the highest but poorest (15.6; $P < 0.05$) VF_{CR}, as observed with the Aberdeen Angus and Bonsmara. In addition to the explanation given earlier for the Aberdeen Angus and Bonsmara, the performance of Year 4 Nguni bulls was obvious because; 1) they had a very low ($P < 0.05$) entry weight compared to those of years 1 to 3 bulls, 2) could not be able to compensate due to insufficient forage during the grazing period and 3) prolonged unfavourable weather conditions for the breed (cold weather). Although, the Zebu breed of which the Nguni is an ecotype has a long history of natural selection (Maule, 1990; Bergh *et al.*, 1999; Bester *et al.*, 2003), the selection was restricted to tropical climates. Therefore, it would be logical to expect the Nguni to perform below average during a prolonged winter season and if there is also insufficient forage for grazing. The Simbra bulls showed a similar performance to that exhibited by Nguni bulls. Year 2 bulls were numerically the most efficient in terms of VF_{CR} compared to those tested in other years. Year 4 bulls, on the other hand, had the poorest ($P < 0.05$) VF_{CR} compared to those tested in previous years during the study period.

4.4.4 Comparisons of the VF_{CR} between breeds

In Year 1, the Aberdeen Angus had the poorest VF_{CR} ($P < 0.05$) compared to other breeds, whereas the Beefmaster and Bonsmara had a better ratio. In Year 2, the Aberdeen Angus once again had the poorest ($P < 0.05$) VF_{CR} compared to other breeds. The Simbra was the most efficient in that year, although not significant from the Beefmaster, Bonsmara, Drakensberger and Nguni. During the third year the efficiency of feed conversion for the Aberdeen Angus was still lower, although not significantly from the Drakensberger and Beefmaster. The Simbra and Nguni were numerically the most efficient in that year. In Year 4, as observed with the KR values, the general average of breeds VF_{CR} was lower. The Aberdeen Angus was significantly ($P < 0.05$) the least

efficient compared to other breeds, whereas the Beefmaster and Drakensberger were numerically the most efficient feed converters.

The results have shown that the Aberdeen Angus was the least efficient whereas despite the insignificance the composites and the Nguni were more efficient feed converters during the grazing period. The Bonsmara and Drakensberger were both intermediate. This implies that the Aberdeen Angus and relatively the Bonsmara and Drakensberger consumed more forage per kilogram gained than the composites and Nguni. These results were not surprising. The composite breeds *per se* are expected to perform better than the purebred simply because of the nature of their breed composition (Wood *et al.*, 1985; Skrypzeck *et al.*, 2000; Arango *et al.*, 2002d; Dadi *et al.*, 2002). As regards the performance of the Nguni breed in terms of feed efficiency, it was also expected due to the nature of the breed characteristics. The Nguni breed is known for its small frame body-size and as a result it has a low feed intake and/or a low maintenance requirement compared to the large frame size exotic breeds (Moyo, 1996). The fact that, breeds such as Sanga and other Zebu type cattle have originated from environments where natural selection was on rangeland (Moyo, 1996), gives the Nguni breed the upper hand in terms of feed efficiency compared to the other breeds used in this study.

These results also indicate that ranking of breeds in order of feed conversion efficiency using VFCE does not differ ($P > 0.05$) from that when KR is used. This could be due to the fact that both expressions [viz. $KR = ADG/M^{0.75}$; $VFCE = (12\% \times MME)/ADG$] use the average daily gain and the metabolic body weight to determine the efficiency of feed utilisation.



4.5 Body condition score (BCS)

4.5.1 BCS within a breed

The recording of BCS was only started in Year 2 at the farm where the bulls were tested and therefore the Year 1 bulls were not included in the analysis for this trait. The BCS was the average of the scores from three observations within a year using a 5-point scale (1= thinnest and 5 = fattest) (Roseler *et al.*, 1997). The least square means and standard deviation for BCS within and between breeds during the three year period are given in Table 4.5.1. The year, breed, breeder (breed x year) and the interaction of year x breed had a significant ($P < 0.05$) effect on body condition scores in this study. In addition, this study also found that the FWT [as covariates] had a significant ($P < 0.05$) contribution to the variation observed in BCS (Table 3.3).

Table 4.5.1 Least square means (\pm S.D.) of BCS of breeds during the grazing period

Breeds	Year		
	2	3	4
Aberdeen Angus	2.6 ₂ ^c (± 0.27)	2.5 ₂ ^c (± 0.15)	3.0 ₁ ^a (± 0.19)
Beefmaster	3.1 ₁ ^b (± 0.23)	3.1 ₁ ^a (± 0.24)	3.0 ₁ ^a (± 0.17)
Bonsmara	3.1 ₁ ^b (± 0.17)	2.9 ₂ ^b (± 0.26)	3.1 ₁ ^a (± 0.22)
Drakensberger	3.1 ₁ ^b (± 0.25)	2.7 ₂ ^{bc} (± 0.19)	3.1 ₁ ^a (± 0.22)
Nguni	3.1 ₁ ^b (± 0.27)	3.0 ₂ ^{ab} (± 0.25)	3.1 ₁₂ ^a (± 0.20)
Simbra	3.6 ₁ ^a (± 0.20)	2.9 ₂ ^b (± 0.28)	3.1 ₂ ^a (± 0.35)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2) and column means (a, b, c, d) with common script do not differ ($P > 0.05$)

Figure 4.5.1 illustrates that the Aberdeen Angus bulls tested in Year 4 had a greater BCS ($P < 0.05$) compared to those tested in years 2 and 3. Although this was unexpected because of a lower total annual rainfall received in Year 4, the discrepancy could be related to the high FWT attained by Year 4 bulls compared to the averages of the others.

The averages of BCS for Beefmaster were the same for all the years and did not differ ($P > 0.05$) between each other. Year 3 Bonsmara had a lower BCS ($P < 0.05$) compared to years 2 and 4. This was somewhat unusual particularly when compared to Year 4, due to the differences in the total and distribution of rainfall between the two years. In Year 4, much of the rainfall fell over a period of 5 months (November to March) compared to 9 months (July to March) in Year 3. Such irregularities in these data could be attributed to 1) the subjective nature of BCS measurement and 2) the recording of BCS during the study period. Although the total observations for BCS in all three years were carried out three times, they were not done at a common time in each year. Similar to the Bonsmara, Year 2 Drakensberger had the lowest ($P < 0.05$) BCS compared to years 2 and 3. On the other hand, years 2 and 4 had the same BCS and no differences were found between them.

The BCS of years 2 ($P < 0.05$) and 4 of Nguni bulls were the same as that observed in Bonsmara and Beefmaster and were higher than those of Year 3. As for the Simbra, year 2 bulls had the highest BCS compared to years 3 and 4. On the other hand, years 3 and 4 did not differ ($P > 0.05$) between them. It is likely that the high FWT and rainfall in Year 1 as indicated earlier attributed to the variation observed in Simbra bulls.

4.5.2 BCS between breeds within a year

In Year 2, the Simbra had a higher BCS ($P < 0.05$) compared to the other breeds. On the contrary, the Aberdeen Angus had the lowest BCS ($P < 0.05$). All the other breeds had the same BCS (3.1) in Year 2 and there were no significant differences found between them. In Year 3, the Beefmaster had a significant BCS [highest] compared to the other breeds, except the Nguni. The Aberdeen Angus again had the lowest BCS, although in Year 3 it did not differ ($P > 0.05$) from the Drakensberger. The BCS in the final year of the study period did not differ ($P > 0.05$) between all six breeds tested. The fact that BCS *per se* is mostly associated with the cow reproductive performance and milk yield, direct comparisons of these results with those published in the literature is therefore narrowed. It has been proven in various studies that, for example, in dairy herds calving BCS is tightly related to milk yield [(Frood *et al.* (1978), Garnsworthy *et al.* (1987), and Domecq

et al. (1997) as cited by Ezamo *et al.* (2005)]. In beef cows, however, the pre- and postpartum diets rather than BCS have been linked with milk yield and calf birth weight [(Lowman *et al.* (1979) and Houghton *et al.* (1990) as cited by Ezamo *et al.* (2005)]. Nonetheless, the BCS of bulls particularly prior to the mating season has received ample attention in the literature. Over- or under-feeding has been reported to influence the reproductive performance of bulls. It is known that feeding a high energy diet impairs spermatogenesis, structural soundness, libido and overall reproductive performance of the bull compared to moderate energy diets (Morrow *et al.*, 1981, Coulter *et al.*, 1997). In an experiment on Ethiopian Horro rams by Gizaw & Thwaites (1997), it was found that, although mating had an adverse effect on BCS, liveweight and SC, the increase in mating liveweight and SC (from 30 to 40 kg and 27 to 31 cm, respectively) does not have a significant effect on the sexual activity.

4.6 Muscling scores (MS)

4.6.1 Muscling score within a breed within a year

Table 4.6.1 illustrates the breed means of MS during the grazing period. The year and breed were the main sources of variation in MS whereas none of the interactions had a significant effect. However, the FWT also had a significant influence on MS (Table 3.3). This is probably due to the fact that MS was only scored once at the end of the grazing period. As for the Aberdeen Angus, Year 4 bulls were more muscular ($P < 0.05$) compared to those tested in years 1 to 3, most probably due to their high FWT as shown in previous sections. Similarly, Year 2 bulls had a lower MS compared to the others as a result of their lower FWT. The influence of FWT on MS as shown in these results was not surprising since it is highly likely for animals with heavier weight to exhibit higher levels of muscularity. Analysis of covariance also indicated the presence of the effect of FWT on MS ($P < 0.05$) (11.73 kg FWT per increase in MS; Table 3.4). This agrees with the work of Robinson *et al.* (1993). In an experiment on estimation genetic and environmental (co)variances for weight, ultrasound measurements were taken from Angus, Hereford, and Polled Hereford cattle by Robinson *et al.* (1993) and it was reported that the environmental correlations between MS or fat depths and weight were highly moderate ($r_e = 30$). The argument from Robinson *et al.* (1993) was that; if an

animal is given environmental conditions to increase its fatness or muscularity it will also put on weight.

Similarly to the Aberdeen Angus, the Beefmaster bulls with the higher FWT (Year 3) had more muscles compared to those with lower FWT. However, this was not true for the herd with the lowest MS. Year 2 bulls had a lower MS ($P < 0.05$) compared to Year 4 despite the high FWT attained (400 versus 394 kg). It is difficult to explain these differences but perhaps it could be due to the incomplete relationship that exist between the two traits, both environmentally ($r_e = 30$) and genetically ($r_g = 0.07$ to 0.12) (Robinson *et al.*, 1993). Therefore, it is likely that selection for a high MS based on a higher FWT (that is at approximately 12 months of age in normal terms) may not necessarily produce the desired results. Year 4 Bonsmara bulls were significantly more muscular compared to those tested in other years, except Year 3. Year 1 bulls, on the other hand, were less muscular, although they did not differ significantly ($P > 0.05$) from Year 2. Of interest, is that Year 4 bulls tended to dominate the others in terms of MS despite having a lower ADG, lower FCE and also emerging from a year when rainfall was at its lowest.

Table 4.6.1 Least square means (\pm s.d.) for average muscling scores within a year

Breed	Year			
	1	2	3	4
Aberdeen Angus	3.2 ₂ ^{ab} (± 0.48)	2.9 ₂ ^b (± 0.52)	3.2 ₂ ^c (± 0.30)	3.8 ₁ ^a (± 0.22)
Beefmaster	3.4 ₁₂ ^a (± 0.41)	3.3 ₂ ^a (± 0.38)	3.9 ₁ ^a (± 0.42)	3.6 ₁ ^{ab} (± 0.27)
Bonsmara	3.1 ₂ ^a (± 0.35)	3.2 ₂ ^a (± 0.29)	3.4 ₁₂ ^{bc} (± 0.52)	3.7 ₁ ^{ab} (± 0.25)
Drakensberger	3.2 ₁ ^{ab} (± 0.52)	3.3 ₁ ^a (± 0.34)	3.2 ₁ ^c (± 0.26)	3.4 ₁ ^{ab} (± 0.30)
Nguni	3.0 ₂ ^{ab} (± 0.65)	3.2 ₂ ^a (± 0.38)	3.6 ₁ ^{abc} (± 0.27)	3.3 ₂ ^b (± 0.394)
Simbra	3.5 ₁ ^{ab} (± 0.35)	3.5 ₁ ^a (± 0.32)	3.7 ₁ ^{ab} (± 0.39)	3.8 ₁ ^a (± 0.37)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2) and column means (a, b, c) with common script do not differ ($P > 0.05$)

Unlike the other breeds previously discussed, there were no differences in terms of MS within the Drakensberger bulls in all four years of the study period. Nor was there a difference in Simbra bulls. This could again be linked to their FWT which did not differ

($P > 0.05$) between all four years (Table 4.1.2). The Nguni bulls tested in Year 3 were muscular ($P < 0.05$) compared to years 1, 2 and 4. No significant differences were found between years 1, 2 and 4. The high muscularity observed in Year 3, could still be as a result of their higher FWT as observed in other breeds. Although, the relationship between FWT and MS may not be complete as discussed previously, these results have clearly demonstrated that growth rate, FCE, environmental factors such as rainfall and temperature do not have a direct effect on muscling scores an animal will have.

4.6.2 Muscling score between breeds within a year

In Year 1, the Simbra was more muscular compared to the other breeds, although it was not significant. The Bonsmara on the other hand was less muscular. As indicated previously, the breed had a significant effect on MS. Therefore, the high MS found in Simbra and Beefmaster as shown in Table 4.6.1 could perhaps be argued that it was due to the breed differences in terms of body frame and weight. However, this can not be generalised because the differences were not consistent as shown by the results in Year 2. In Year 3, the Simbra and Beefmaster were again more muscular ($P < 0.05$) compared to the other breeds. However, the Simbra did not differ from the Bonsmara and Nguni. The Aberdeen Angus had fewer muscles ($P < 0.05$) compared to the other breeds in the same year although it did not differ significantly from the Bonsmara, Nguni and Drakensberger. In the final year, the Simbra and Aberdeen Angus had the same and highest MS compare to the other breeds. The discrepancy was, however, not significant ($P > 0.05$) particularly from the Beefmaster, Bonsmara and Drakensberger. The Nguni had the lowest MS in the same year.

4.7 Average tick count (ATC)

4.7.1 Tick count within breed within a year

The least squares means of ATC for within and between breed during the grazing period are presented in Table 4.7.1. The breed and year effect were significant on ATC. In addition, a significant difference was also found within breed in terms of ATC. Year 4

Aberdeen Angus bulls had the highest ATC ($P < 0.05$) compared to those tested in years 1 and 3. Year 2 had more ticks compared to those of years 1 and 3 but lower than Year 4. The difference was, however, non-significant.

As for the Beefmaster bulls, the ATC increased every year ($P < 0.05$). Thus, Beefmaster bulls tested in Year 1 had significantly ($P < 0.05$) lower number of ticks compared to Year 2, and Year 2 had lower ticks than Year 3 and so on. The difference between years 2, 3 and 4 was, however, non-significant. Ticks numbers in Bonsmara followed slightly the same trend as in Beefmasters. The ATC for this breed was 8.7, 12.7 (± 5.0), 12.7 (± 3.7) and 14.3 in years 1, 2, 3, and 4, respectively. A significant difference was found between Year 1 compared to years 3 and 4.

Table 4.7.1 Least square means (\pm s.d.) for average tick count

Breed	Year			
	1	2	3	4
Aberdeen Angus	9.0 ₂ ^{ab} (± 3.2)	13.4 ₁₂ ^a (± 5.6)	10.0 ₂ ^c (± 2.7)	15.1 ₁ ^a (± 3.2)
Beefmaster	10.4 ₂ ^a (± 3.1)	13.8 ₁ ^a (± 4.3)	15.2 ₁ ^a (± 3.6)	15.6 ₁ ^a (± 2.8)
Bonsmara	8.7 ₂ ^{ab} (± 3.8)	12.7 ₁₂ ^a (± 5.0)	12.7 ₁ ^{ab} (± 3.7)	14.3 ₁ ^{ab} (± 3.4)
Drakensberger	7.3 ₂ ^b (± 3.0)	15.1 ₁ ^a (± 2.9)	15.0 ₁ ^a (± 4.8)	16.3 ₁ ^a (± 4.2)
Nguni	5.5 ₂ ^b (± 1.2)	6.8 ₂ ^b (± 3.3)	10.4 ₁ ^{bc} (± 3.3)	10.7 ₁ ^b (± 3.1)
Simbra	12.4 ₁ ^a (± 5.1)	12.8 ₁ ^a (± 3.9)	12.3 ₁ ^{ac} (± 3.5)	14.9 ₁ ^a (± 2.3)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2) and column means (a, b, c) with common script do not differ ($P > 0.05$)

The variation of ATC within the Drakensberger bulls was non-significant, except for Year 1 which had the lowest ($P < 0.05$) number of ticks compared to those tested in other years (Table 4.4.1). An ATC of 7.3 was recorded in Year 1, which then increased ($P < 0.05$) to 15.1 in the following year. The ATC for years 3 and 4 was 15 and 16.3, respectively.

The overall number of ticks in the Nguni bulls was lower compared to that of other breeds. Year 1 bulls had an ATC of 5.5 followed by an increase to 6.8 in the following

year. In Year 3, the ATC increased by just 43% and again by 57% in Year 4. There were no significant differences between years 1 and 2 and also between years 3 and 4. The ATC within the Simbras did not differ ($P > 0.05$). Year 4 had more ticks (14.9) compared to years 1 to 3.

4.7.2 Tick count between breeds within a year

In Year 1, the Nguni and Drakensberger had the lowest ATC with Aberdeen Angus and Bonsmara intermediate and Beefmaster and Simbra the highest. The Aberdeen Angus and Bonsmara had more ticks compared to the Drakensberger and Nguni and lower ATC compared to the Beefmaster and Simbra in that year. Generally, the ATC increased each year and hence Year 4 bulls harboured more ticks ($P < 0.05$) compared to those tested in previous years. Most of the increase was particularly observed from Year 2 onwards for all the breeds. It could be argued that the decrease in average rainfall may have had a role, although it was not directly tested in this study. It could be that the reduction in rainfall may have led to the disappearance of other intermediate hosts of ticks (i.e. squirrels, mice, hares) in the area and possibly cattle (bulls) were the only available hosts. However, despite the increase, the Nguni demonstrated their genetic capability to resist ticks and as a result harboured a lower ($P < 0.05$) number of ticks compared to the other breeds. The other breeds did not differ ($P > 0.05$).

In the third year, the Aberdeen Angus and Nguni had a lower ATC, whereas the Simbra and Bonsmara were intermediate and Beefmaster and Drakensberger harboured more ticks ($P < 0.05$). In Year 4, the Nguni and Bonsmara had lower ATC compared to the other breeds. However, the ATC of the Bonsmara did not differ significantly ($P < 0.05$) compared to that of the other breeds. The Drakensberger had more ticks in that year, followed by the Beefmaster, Aberdeen Angus and Simbra.

These results confirmed that the Nguni is more resistant to ticks when compared to the *Bos taurus* and/or composite breeds as previously reported by various investigators (Spickett *et al.*, 1989; Bergh *et al.*, 1999; Bester *et al.*, 2003; Bayer *et al.*, 2004; De la Rey *et al.*, 2004). In an experiment on counts of engorged female ticks on naturally

infested cattle over a 2-year period in the bushveld region of South Africa, Spickett *et al.* (1989) reported a significant resistant to ticks by the Nguni cattle compared to the Bonsmaras and Hereford. In that study, it was found that the Nguni harboured fewer *Amblyomma hebraeum*, *Boophilus decoloratus* and *Hyalomma* species during periods of peak abundance compared to the other breeds.

Other studies, have suggested that characteristics such as 1) the thick skin, 2) long tail with a well-developed switch and 3) vigorous movements of ears as some of the characteristics in Nguni cattle that prevent the infestation of ticks and other external parasites (Bester *et al.*, 2003). Another explanation as discussed by Moyo (1996) is that the Nguni breed has evolved from a long process of natural selection under harsh environmental conditions which as a result may have boosted its natural resistance to tick infestation. Conversely, the poor resistance of Simbra and Beefmaster underline the need of crossbreeding these breeds with the indigenous breeds to improve resistance and at the same time benefit from their performance in other production traits such as those shown in this study.

4.8 Temperament scores (TS)

4.8.1 Comparisons of temperament scores within a breed

The LSM for the effect of breed on TS are presented in Table 4.8.1. As expected, the year did not have a significant effect on TS. In addition to the breed, the interactions [year x breed, breeder (year x breed)] were the main source of variation in TS. The inclusion of other traits measured in this study in the model as covariates did not show significant effects on the variation of TS (Table 3.4), suggesting that TS can be independently selected within a herd without compromising other traits. Literature is of limited help to make a direct comparison under grazing condition. However, these findings differ from studies that were conducted in a feedlot. Voisinet *et al.* (1997) found that cattle with low temperament tend to have low weight gain in a feedlot. Drugociu *et al.* (1977) as cited by Lanier *et al.* (2000) also reported that dairy cows with calm temperaments had increased milk production. Petherick *et al.* (2003) also found that poor temperament animals in

feedlot performs less (have low ADG and FI) compared to those with a good temperament.

Similarly to BCS, the TS were the average of scores recorded during the grazing period. As explained in the experimental procedures, a four point scale (1 = calm and 4 = very aggressive) (Voisinet *et al.*, 1997, Lanier *et al.*, 2000) scoring system was used. Within the Aberdeen Angus, Year 3 bulls were more aggressive ($P < 0.05$) compared to those tested in other years, except Year 1. Year 4 bulls were less temperamental, although not significant to years 1 and 2. The variation of TS within breed has been previously reported (Grandin, 1997). It is known that temperament is relatively highly heritable ($h^2 = 0.45$) (Bosman, 1999, Lanier *et al.*, 2000) and with continuous selection it can be improved within a herd. It was previously mentioned in the present study that there was no consistency among the breeders who brought the animals for testing. For that reason it is likely that for example; a breeder who brought animals for testing in years 2 and 4 were those who had TS improved in the herd.

Within the Beefmaster, the variation of TS was non-significant in all four years. This was also true with the Nguni and Drakensberger. The absence of significant variations in TS within these three breeds, suggests that selection for calmer cattle within these breeds could be of secondary importance. In addition, this further illustrates that within such breeds it is easy to over-select for one trait (e.g. temperament). Over-selection for TS has been negatively associated with economically important traits such as maternal ability (Grandin, 1997). The Bonsmara tested in Year 1 were more aggressive ($P < 0.05$) compared to those tested in other years although not significant to years 2 and 4. Year 3 was less temperamental but not significant to years 2 and 4 as well. As for the Simbra, Year 3 bulls were more temperamental compared to those of other years, particularly Year 1 ($P < 0.05$). In addition to the explanation given previously with the Aberdeen Angus, the differences observed within the Bonsmara and Simbra could be associated with the fact that the degree of heritability of temperament is specific to a breed (Grandin, 1997). Therefore, the variations of TS within the breed may vary according to the degree of heritability. Grandin (1997) reported that temperament is more heritable in breeds with lesser amount of Brahman strain compared to those with a more Brahman component.



Table 4.8.1 Effect of breed on temperament score within a year (least square means (\pm s.d.) according to the model)

Breed	Year			
	1	2	3	4
Aberdeen Angus	1.5 ₁₂ ^{bc} (\pm 0.4)	1.2 ₂ ^b (\pm 0.1)	1.8 ₁ ^{ab} (\pm 0.2)	1.0 ₂ ^b (\pm 0.1)
Beefmaster	2.0 ₁ ^a (\pm 0.5)	1.8 ₁ ^a (\pm 0.5)	1.8 ₁ ^a (\pm 0.4)	1.6 ₁ ^a (\pm 0.5)
Bonsmara	1.8 ₁ ^{ab} (\pm 0.7)	1.5 ₁₂ ^{ab} (\pm 0.3)	1.4 ₂ ^b (\pm 0.3)	1.6 ₁₂ ^a (\pm 0.4)
Drakensberger	1.7 ₁ ^{ab} (\pm 0.3)	1.6 ₁ ^{ab} (\pm 0.4)	1.5 ₁ ^{ab} (\pm 0.4)	1.7 ₁ ^a (\pm 0.6)
Nguni	1.4 ₁ ^{bc} (\pm 0.3)	1.6 ₁ ^{ab} (\pm 0.4)	1.7 ₁ ^{ab} (\pm 0.4)	1.7 ₁ ^a (\pm 0.6)
Simbra	1.2 ₂ ^c (\pm 0.1)	1.4 ₁₂ ^{ab} (\pm 0.3)	1.7 ₁ ^{ab} (\pm 0.5)	1.4 ₁₂ ^{ab} (\pm 0.3)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2) and column means (a, b, c) with common script do not differ ($P > 0.05$)

4.8.1 Comparisons of temperament scores between breeds

The Simbra, Nguni and Aberdeen Angus had lower TS compared to the Beefmaster, Bonsmara and Drakensberger in Year 1. The Beefmaster was more temperamental ($P < 0.05$) compared to other breeds. However, it did not differ ($P > 0.05$) from the Bonsmara and Drakensberger. In Year 2, the Beefmaster was again more aggressive ($P < 0.05$) compared to the other breeds, although not significant from the Bonsmara, Drakensberger, Nguni, and Simbra. The Aberdeen Angus had the lowest TS. In Year 3, the Aberdeen Angus and Beefmaster had the same and highest TS compared to the other breeds, but yet not significant. The Beefmaster was however, significant from the Bonsmara which had the lowest TS. In the final year of the study period, the Aberdeen Angus had the lowest TS ($P < 0.05$), although significant from the Simbra. There were no significant differences between the other breeds in terms of TS. Temperament differences between breeds have also been reported by Stricklin *et al.* (1980) and Tulloh (1961) as cited by Grandin (1997). The literature indicates that genetics also affects animal response to stress. Studies have shown that Brahman crossed cattle have higher cortisol levels while restrained in a squeeze chute compared to English crosses (Zavy *et al.*, 1992). In the present study the Aberdeen Angus (European origin) and Simbra (a composite) were less temperamental compared to other breeds which included a *Bos indicus* and composite breed. Similar findings were previously reported (Zavy *et al.*,



1992; Voisinet *et al.*, 1997; Hammond *et al.*, 1998). In central Florida, Hammond *et al.* (1998) reported a higher increase in temperamental scores in Brahman cattle than in Angus or Brahman x Angus crosses. It was concluded that the increase in temperament ratings in Brahman cattle was as a result of a high cortisol (a steroid synthesized and secreted by cells of the adrenal cortex in reaction to stress inducing factors e.g. physical, emotional or psychological and hypoglycaemia) (Okeudo *et al.*, 2005) concentration level in their blood. In feedlot testing, Voisinet *et al.* (1997) reported an increase in the disposition in cattle with a high Brahman strain ($\geq 25\%$) in the blood compared to those with little influence of Brahman. This study further supports reports by Bester *et al.* (2003) which stated that Nguni cattle are docile. In the present report the Nguni bulls had less temperamental ratings compared to both the Aberdeen Angus and Simbra, though not significantly.

4.9 Scrotum circumference (SC)

4.9.1 The variability of SC within a breed

Sire selection in beef cattle is an efficient method to achieve genetic progress because of the high selection intensity that can be applied on the male side. Among all measures of fertility in beef cattle, the SC presents several advantages. It is easy and inexpensive to measure and has moderate heritability (Martinez-Velázquez *et al.*, 2003). Its effect on female fertility has been studied in depth. Some old literature has indicated that there is a substantial correlation between a bull SC and its breeding capability and age at first breeding or rebreeding of half-sib heifers after calving (Taylor, 1995; Mosser, 1996; Battaglia, 1998; Vargas *et al.*, 1998; Bosman, 1999). Recent studies, on the contrary, have found no significant genetic correlation between SC and female reproductive traits e.g. age at puberty, first calving, pregnancy status, calving status and weaning status for first-parity cows (Martinez-Velázquez *et al.*, 2003). In the present study, SC was studied for the purpose of determining the variation in sizes within and between breeds in different years.

Breed means for SC are presented in Table 4.9.1. The variations in SC were due to the effect of breed and breeder (breed x year) and as a result the within breed variation was



minimal. However, when ADG was included in the model as covariate the linear relationship between the two traits was highly significant (Table 3.4). According to Table 3.4, for every increase in ADG the SC increased by 0.04mm. All the Aberdeen Angus bulls performance tested during the study period did not differ ($P < 0.05$) in terms of the size of the SC. Similar results were found within the Bonsmara and Nguni. As for the Bonsmara, Year 1 bulls had the smallest SC on average whereas Year 2 had the largest.

As for the Beefmaster, the SC varied from 32.6 to 34.8 cm in years 1 and 2, respectively. Year 2 bulls had the largest ($P < 0.05$) SC compared to their counterpart in other years, except for those of Year 3. These slight differences are probably due to the influence of breeder, in terms of selection for this trait. Another possible explanation could be due to the effect of the number of Beefmaster bulls tested. Out of the 444 bulls tested during the four year period as indicated in earlier sections, the Beefmaster bulls were the most represented (30%) compared to the other breeds. With this total, it would be logical to expect a greater variation within the breed compared to the other breeds which were not fully represented.

The sizes of the SC within the Drakensberger, varied ($P < 0.05$) from 31.7 to 35.3 cm. Year 3 bulls had the largest SC, differing significantly from years 1 (had the lowest SC; $P < 0.05$) and 4. Year 2 had a relatively larger SC compared to years 1 and 4, although not significantly. With regard to the Simbra, the variation of SC sizes was very small with only the Year 3 bulls having the smallest SC ($P < 0.05$) compared to those tested in other years. Literature is of little help to explain the slight variation found within the two breeds. Perhaps it could be due to the effect of breeder (breeder x year), as indicated earlier. Changes in grazing condition during the years showed little impact on the sizes of SC. The study however, found that SC was significantly ($P < 0.001$) influenced by FWT and ADG (Table 3.4). According to Table 3.4 on page 50, the inclusion of FWT and ADG as covariates in the model shows that SC increased by 3.87 and 9.22 cm respectively.

Coulter *et al.* (1997) & Baker *et al.* (2002) found that feeding of a high energy diet has a significant effect on SC. Baker *et al.* (2002) also reported that creep feeding followed by

forage-base feeding on-test have a significant effect on SC. The interesting finding was that among the purebred that were tested in this study [the Aberdeen Angus and Nguni in this case], there were no significant differences between these bulls during the four year period. Although, this may need more research to confirm, these finding suggests that the improvement of herd fertility based on a bull SC within the purebred may not always produce the desirable results. The SC of composites breeds, except the Bonsmara, was significant.

Table 4.9.1 Means (\pm s.d.) of breeds scrotum circumference at the end of the grazing period

Breed	Year			
	1	2	3	4
Aberdeen Angus	34.5 ₁ ^a (\pm 2.3)	34.5 ₁ ^a (\pm 1.1)	34.0 ₁ ^{ac} (\pm 2.2)	34.6 ₁ ^a (\pm 2.4)
Beefmaster	32.6 ₂ ^{ab} (\pm 1.9)	34.8 ₁ ^a (\pm 2.6)	33.5 ₁₂ ^{ab} (\pm 2.0)	33.1 ₂ ^{ab} (\pm 2.7)
Bonsmara	32.4 ₁ ^{ab} (\pm 1.2)	33.8 ₁ ^a (\pm 2.5)	33.5 ₁ ^{ac} (\pm 1.6)	33.7 ₁ ^a (\pm 2.8)
Drakensberger	31.7 ₂ ^b (\pm 1.9)	34.3 ₁₂ ^a (\pm 2.2)	35.3 ₁ ^a (\pm 2.4)	32.0 ₂ ^{ab} (\pm 1.7)
Nguni	30.6 ₁ ^b (\pm 0.9)	30.9 ₁ ^b (\pm 1.5)	31.3 ₁ ^b (\pm 2.5)	31.1 ₁ ^b (\pm 3.0)
Simbra	34.9 ₁ ^a (\pm 1.5)	35.4 ₁ ^a (\pm 2.9)	32.0 ₂ ^{bc} (\pm 3.6)	34.5 ₁ ^a (\pm 3.9)

Year 1 = 2000 – 2001; Year 2 = 2001 – 2002; Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;
Row (1, 2) and column means (a, b, c) with common script do not differ ($P > 0.05$)

4.9.2 The variation of SC between breeds within a year

In Year 1, the Simbra had numerically the largest SC compared to the other breeds, though not significantly from the Aberdeen Angus, Beefmaster and Bonsmara. The Nguni had the smallest SC in that year. In Year 2, Nguni again had the smallest ($P < 0.05$) SC compared to other breeds. The Simbra also again had the largest SC, although it did not differ ($P > 0.05$) from the Aberdeen Angus, Beefmaster, Bonsmara and Drakensberger. At the end of the grazing period in Year 3, the Nguni recorded the smallest SC again, though not significantly from the Simbra and Beefmaster. The Drakensberger had the largest SC in that year, though not significantly from the Aberdeen Angus, Beefmaster and Bonsmara. In the final year of the study, the Aberdeen

Angus had significantly the largest SC compared to the Nguni, except for the other breeds.

The above results suggest that there is a substantial difference between *Bos taurus* and *Bos indicus* in terms of SC, with the former tending to have a larger SC. Several investigators (Brown *et al.*, 1991; Taylor, 1995; Baker *et al.*, 2002) have indicated that SC is directly affected by body weight and body condition. McGowan *et al.* (2002a) reported a more significant correlation between liveweight and SC in Brahman bulls than in Belmont Red in northern Australia. In the present study, lower weight breeds (Nguni, Bonsmara and Drakensberger) had smaller SC compared to heavier breeds. Of these breeds, the Nguni had significantly smaller SC, a reflection of its lower body weight. Similar results were also previously reported by Brito *et al.* (2004).

4.9.3 SC as a percentage of body weight

By definition, ‘SC’ refers to the actual size of the enclosing boundary of the scrotum. The advantage of selecting for a larger SC has been already mentioned and it will not be repeated here. The purpose of this section was to study the variation in breeds SC as a percentage of body weight. Logically, larger body weight breeds would be expected to have a larger SC considering the correlation between body weight and SC as discussed by Brown *et al.* (1991), Taylor, (1995) and Baker *et al.* (2002).

On the contrary, the findings of this study have produced inconsistent results (Figure 4.9.2). The lower body weight Nguni bulls had significantly ($P < 0.05$) the highest percentage (10.19%) of SC per kilogram liveweight compared to the other breeds. The Simbra, a larger body weight breed, had the lowest ($P < 0.05$) percentage of SC/liveweight. The Aberdeen Angus and Beefmaster had a percentage of 8.61 and 8.25 SC, respectively. In addition, the Aberdeen Angus did not differ ($P > 0.05$) from Bonsmara and Drakensberger with SC values of 9.02 and 8.94%, respectively.

Table 4.9.2 Effect of breed on scrotum circumference as a percentage of body weight between breeds



Breed	SC as percentage (%)
Aberdeen Angus	8.61 ^{bc} (± 0.8)
Beefmaster	8.25 ^{cd} (± 0.9)
Bonsmara	9.02 ^b (± 0.8)
Drakensberger	8.94 ^b (± 0.7)
Nguni	10.19 ^a (± 1.1)
Simbra	7.96 ^d (± 0.7)

Column (a, b, c, d) means with common script do not differ significantly ($P > 0.05$)

These results suggest that SC increases in its actual size as the weight of the bull increases. However, in terms of percentage of body weight, the SC tends to decrease with increasing liveweight.



Part B: Performance in feedlot

4.10 Analysis of ADG

As indicated in the experimental methodology, the data set for the bulls ADG in a feedlot was of a smaller size due to 1) the data was collected over a short period of time (viz. years 3 and 4) and 2) not all bulls for each breed tested during the grazing period were finished-off in the feedlot. Consequently, the variability in terms of within and/or between breeds ADG could be limited due to the smaller sample analysed for each breed. Corbet *et al.* (2006a) found large standard errors in estimation of genetic correlations between growth and fertility traits and attributed it to the smaller size sample analysed. A larger standard error is that it is associated with low accuracy of estimation. Altarriba *et al.* (2005) pointed out that the accuracy of estimation of heritability and genetic correlations of meat and carcass quality traits in *Bos indicus* and *Bos taurus* is reduced when sample size analysed is small. In the present study, larger standard deviations were found between the ADGs of bulls during the feedlot stage (Table 4.10.1), suggesting that improvement could have been made if a larger sample was analysed.

The interest in these data is, however, generated by the fact the animals were intensively fed (as part of finishing before auctioning) instead of grazing. Nonetheless, there were no significant differences within each breed in terms of ADG in a feedlot in both years. In addition to the smaller sample size, the non-significant differences observed within breeds were anticipated. Logically, it is possible to expect animals to perform equally if they were exposed to a similar environment prior to the feedlot. Petherick *et al.* (2003) found animals that were pre-exposed to aspects of feedlot to have higher ADG from days 1 – 27, compared to those not exposed. According to Petherick *et al.* (2003), the superiority of pre-exposed animals over the non-exposed was likely due to the fact that the digestive tracts of the pre-exposed animals were more adapted to concentrates and were more able to cope with feedlot ration and make more efficient use of it.



Table 4.10.1 Effect of breed x year on ADG (g/day) during the finishing period

Breed	n	Year	
		3	4
Aberdeen Angus	23	1422.56 ₁ ^a (±302.9)	1300.00 ₁ ^{ab} (±255.0)
Beefmaster	80	1035.61 ₁ ^{ab} (±161.1)	1148.93 ₁ ^{ab} (±260.1)
Bonsmara	51	1167.02 ₁ ^{ab} (±230.6)	1119.17 ₁ ^{ab} (±365.3)
Drakensberger	16	1054.80 ₁ ^{ab} (±232.4)	1096.67 ₁ ^{ab} (±293.9)
Nguni	23	875.13 ₁ ^b (±91.5)	916.67 ₁ ^b (±236.2)
Simbra	27	1056.72 ₁ ^{ab} (±284.4)	1345.78 ₁ ^a (±281.3)

Year 3 = 2002 – 2003; Year 4 = 2003 – 2004;

Row (1) and column means (a, b) with common script do not differ ($P > 0.05$)

In terms of ADG variation between breeds, the Nguni had the lowest growth performance ($P < 0.05$) in both years. More specific, in Year 3 the Aberdeen Angus had the highest ADG compared to the other breeds, although it did not differ ($P > 0.05$) significantly from the Beefmaster, Bonsmara, Drakensberger and Simbra. In Year 4, the Simbra had the highest ADG compared to the other breeds. However, as with the Aberdeen Angus in the Year 3, the Simbra did not differ ($P > 0.05$) from the other breeds in Year 4, except from the Nguni.

The slow growth performance of the Nguni (*Bos indicus*) breed shown in the present study when compared to the other breeds (*Bos taurus* and composites) has been previously reported in the literature (Meissner, 1993; Moyo, 1996; Lunstra *et al.*, 2003). In a study on productivity of indigenous and exotic beef breeds, Moyo (1996) reported a slow growth rate in Tuli bulls (*Bos indicus*) in comparison with the *Bos taurus* breeds (Hereford, Simmental and Charolais) in feedlot testing in Zimbabwe. The standardised growth test in Phase C of the National Beef Cattle Performance and Progeny Testing Scheme (NBCPPTS) in South Africa also showed similar results. As shown in Table 2.9.1 on page 26, the 1993 – 1998 results showed that the Nguni breed had an ADG of 1150 g/d, which was greatly below that of the average of the herd tested during that period (Bergh *et al.*, 1999; Bosman, 1999). It is known that the superiority of indigenous breeds over the exotic tends to surface in adverse environmental conditions (Moyo,

1996). The low ADG observed in the Nguni breed could also be associated with breed low maintenance requirements, low feed intake and low mature body weight when compared to *Bos taurus* (Moyo, 1996; Bester *et al.*, 2003).

4.11 Analysis of selling price (SP)

The effect of breed, year, the interaction between breed and year, and breeder within breed and year were all non significant in the variation observed in the SP. However, when ADG and MS were included in the model as covariates, their effect yielded significant regression coefficient (9.15 and 2242.3; $P < 0.05$) on SP (Table 3.4, page 50). Thus, with increasing ADG and/or MS the SP increased. Fourie *et al.* (2000) found an apparent increase in SP of Dorper rams at auctions with the increase in auction weight, coat type, KR, SC and FWT index. The least square means for breed effect on SP is depicted in Table 4.11.1. The Beefmaster and Nguni were the only breeds in which the variation of SP was significant. As shown in Table 4.11.1, Year 1 Beefmaster bulls fetched the lowest SP ($P < 0.05$) compared to years 2, 3 and 4. Year 4 bulls obtained the highest SP ($P < 0.05$) than years 1 and 3, except for Year 2. Similarly, Year 1 Nguni bulls obtained the lowest SP ($P < 0.05$) compared to Year 4 which fetched the highest SP ($P < 0.05$). In general, the SP of Beefmaster and Nguni bulls increased almost every year in this study. For example; the SP for Beefmaster increased from R5, 677.00 in Year 1 to as high as R14, 470.00 in Year 4, indicating an increase of 39.2%. Corresponding SP values for Nguni were R6, 725.00 and R15, 814.00 (42.5% increase). Although the literature is of limited help in explaining these variations, the increase in price value in Year 4 could be associated with the increase in MS in that year as stated previously (Table 3.4, page 50). The relative high emphasis on MS as compared to other traits measured could imply that the act of bull buying was more on appearance than the general performance of the bull. The inclusion of MS in the model as covariate also showed significant effect on SP. The linear regression coefficient of MS on SP was 2242.03 ($P < 0.05$). This suggests that for every increase in muscling score there was an increase of R2242.03 in buying price of bulls. Farmers in northern Australia were reported to exhibit similar behaviours (Bortolussi *et al.*, 2005b). Bortolussi *et al.* (2005b) found a negative correlation between the use of Breed Plan and the traditional bull selection criteria (conformation and colour)



in northern Australia. According to Bortolussi *et al.* (2005b), farmers in northern Australia tended to put more emphasis on the conformation/ appearance of the bull during bull buying than on its genetic potential to improve the herd performance.

Table 4.11 1 Least square means (\pm s.d.) for the effect of breed x year on selling price [in South African rand (R)]

Breed	Year			
	2000-2001	2001-2002	2002-2003	2003-2004
Aberdeen Angus	9103 ₁ ^a (\pm 1348.7)	14258 ₁ ^a (\pm 0)	12124 ₁ ^a (\pm 2000.0)	11842 ₁ ^a (\pm 1483.2)
Beefmaster	5677 ₃ ^a (\pm 2862.2)	12426 ₁₂ ^a (\pm 4751.3)	9334 ₂ ^a (\pm 2117.0)	14470 ₁ ^a (\pm 14313.9)
Bonsmara	7519 ₁ ^a (\pm 1391.1)	11336 ₁ ^a (\pm 3014.8)	10551 ₁ ^a (\pm 2916.6)	9919 ₁ ^a (\pm 3235.7)
Drakensberger	7967 ₁ ^a (\pm 2387.5)	10756 ₁ ^a (\pm 1204.2)	7156 ₁ ^a (\pm 500.0)	9555 ₁ ^a (\pm 3535.5)
Nguni	6725 ₂ ^a (\pm 353.6)	9920 ₁₂ ^a (\pm 1940.8)	7457 ₂ ^a (\pm 1241.6)	15814 ₁ ^a (\pm 4026.8)
Simbra	6319 ₁ ^a (\pm 2267.8)	8719 ₁ ^a (\pm 1747.5)	7118 ₁ ^a (\pm 1361.1)	8651 ₁ ^a (\pm 2043.3)

Row (1, 2, 3) and column means (a) with common script do not differ ($P > 0.05$)

The overall findings between breeds in terms of SP were that the Aberdeen Angus appeared to have fetched the highest price despite the poor performance in growth traits (e.g. ADG, KR and VFCR) during the grazing period. In contrast, the Simbra obtained the lowest SP despite its better performance in growth traits during the grazing and partly the finishing period compared to the other breeds tested. Once again, it is difficult to explain these variations but it could perhaps be argued that buyers had other specific interests such as the genetic merit, demand for a specific breed, coat colour etc, which were not directly measured in this study. Although it was not consistent, the average SP increased each year. Possibly, each year there were more farmers at the auctions, which as a result increased the initial bidding price.

When compared to rainfall (not statistical), the SP seemed variable. Figure 4.11.1 illustrates the relationship between the average rainfall received during the study period and SP. It is obvious to expect an increase in SP in years of good rainfall, assuming an increase in production output, hence the buying power, when climatic conditions are favourable. However, since the auctions were conducted just before the onset of the rainy

season (September – October) of each year, the graphic demonstration (Fig. 4.11.1) of the two variables would be contrasting. Thus, the impact of high rainfall would be seen in the following year.

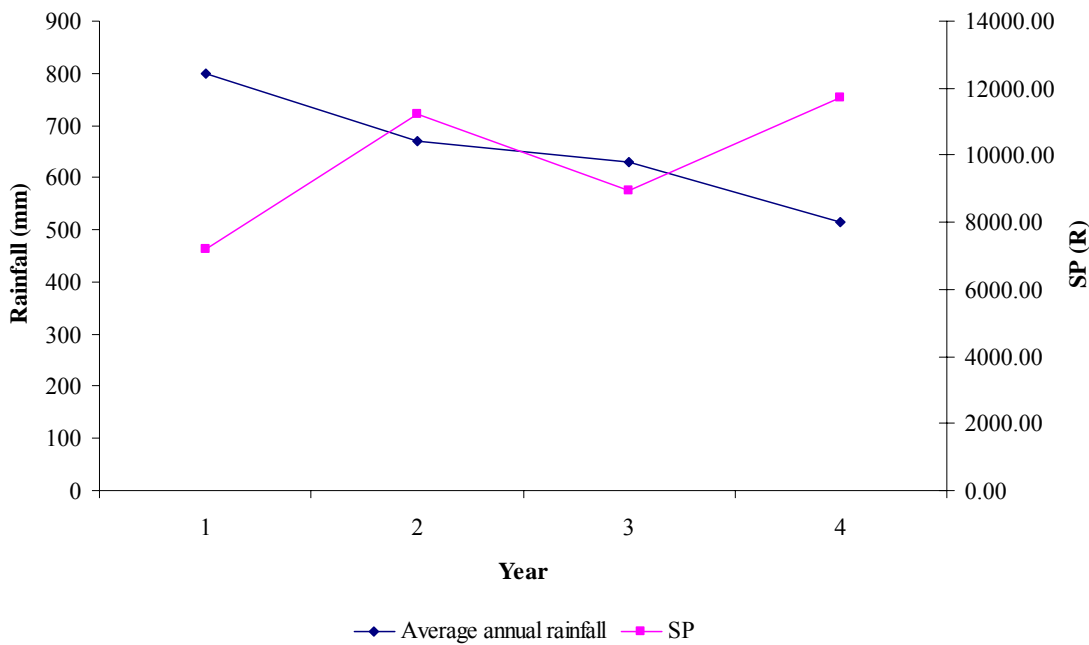


Figure 4.11. 1 Relationship between average annual rainfall and SP (2000-2004)

As shown in Fig 4.11.1, the effect of high rainfall received in Year 1 was seen in Year 2. Similarly, the low rainfall received in Year 2 appeared to have had an influence on SP in Year 3. The drastic increase in SP in Year 4 whilst rainfall decreased in the previous year may reflect the buyer’s personal desires (e.g. muscularity) more than the effect of climatic conditions. It may also reflect an increase in producers (commercial and communal) desires to buy on-farm performance tested bulls. This may well be argued that the extension messages that encourage farmers to buy performance tested bulls might have reached many potential buyers.

4.12 Effect of external factors on SP

4.12.1 Maize price

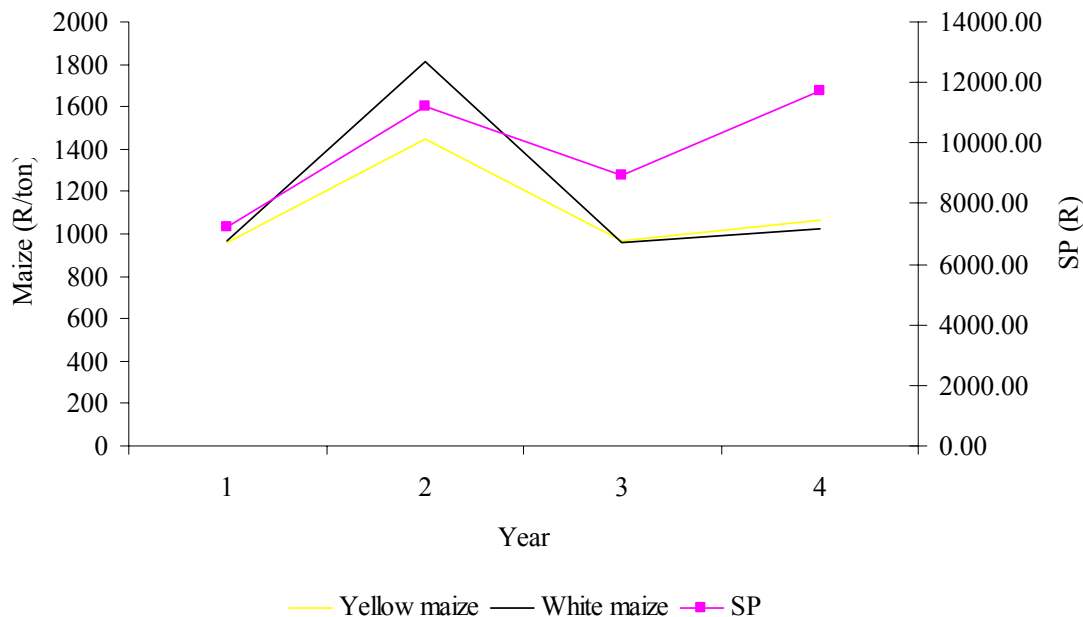


Figure 4.12.1 Relation between maize prices in RSA and SP of 2000 – 2004

Maize is the most important grain crop in South Africa, being both the major feed grain and the staple food for the majority of the South African population (DoA, 2003). Because of the high proportion of energy required to ensure good feedlot performance, the cost of carbohydrate, which is usually included in most feedlot rations in the form of maize, hominy chop or one of the other grains, in relation to the beef price, is a significant factor deciding profitability of a feedlot enterprise. This is usually expressed by the ratio beef: maize price, which experience has shown to be more than 13:1 (DoA, 2003) for feedlotting to be profitable. Feedlotters can make substantial profits when the beef to feed cost price ratio is favourable (DoA, 2003). Thus, the relationship between the producer maize price and SP is as would be expected, influenced by the price of weaners (Fig. 4.12.1). It would also be obvious to see an increase in the bidding price for bulls if weaners price increase and maize price decline.

It is clear from Figure 4.12.1 that there was a correlation between the producer price of maize (NAMPO, 2005) and the SP of bulls at auctions. Cognisance should be taken of

the fact that maize price is influenced by various market forces such as demand and supply, R/US\$ exchange rate and weather conditions (DoA, 2003). Thus, even in bad years in terms of rainfall received, maize price may be variable. The increase in SP following a massive decrease in producer’s price of maize in years 3 and 4 clearly demonstrate the advantage taken by beef producers following a tumble in the maize industry.

4.12.2 Weaners price

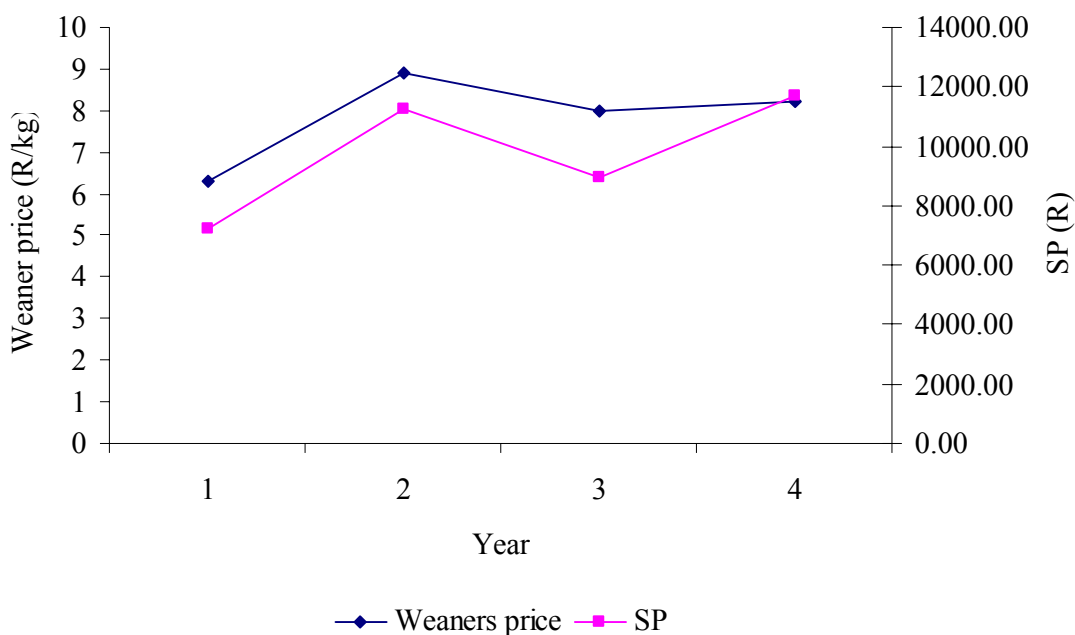


Figure 4.12.2 Relation between the average sale price of weaners and SP of 2000 – 2004

According to the DoA (2003) report, the feedlot industry produces approximately 70 to 80% of beef in the formal sector in the RSA. At any point in time, it is estimated that this sub-sector has a standing capacity of 420,000 head of cattle of which most if not all are weaners. Animals normally enter the feedlot system at a mass of between 200 and 220 kg and are expected to gain 100kg more over a period of 100 days (DoA, 2003). This equates to an expected gain of a kilogram/day for each animal. The selling price of an animal from feedlot is as in the case of maize prices, influenced by various market forces including the purchase price of the animal into the feedlot, transportation cost and most importantly the price of feed. The price paid for feedlot cattle or their initial value



(cost/kg), is a critical factor affecting the profitability of a feedlot enterprise (DoA, 2003). The profit or loss made by feedlotters has an ultimate impact on beef producers, in that it dictates the buying power of producers. Figure 4.12.2 demonstrates this close relationship. The fact that SP was slightly lower than the feedlot purchase price (SAFA, 2005) of weaners throughout the study period, except in Year 4, demonstrates the strong dependence of beef producers on feedlots. It also suggests that most of the buyers at these auctions were practising the weaners production system instead of ox/steers production system.



5.1 CONCLUSION

Generally, the main purpose of any form of performance testing is to predict the performance of future progeny's (Dalton *et al.*, 1978). This study analysed data set on growth performance and other productivity traits of beef cattle bulls that were tested on-farm. The purpose was to quantify objectively the performance parameters of each breed in order to provide criteria by which farmers would select bulls that would produce offspring that would perform in the given environment. Because of the existence of genotype x environment interactions for numerous traits as expressed in various production systems (Harris *et al.* 1994), more emphasis in this study was placed on the quantification of the within-breed variability instead of the between-breeds comparison. Nonetheless, the results also presented the relative variations as observed between breeds. The rationale was due to the fact that all the breeds used in the study are commonly found in the region where the study was conducted. Significant differences were found both between and within breeds in a number of productivity traits measured in this study.

Aberdeen Angus bulls showed a significant difference for all traits analysed except for SC and SP. Beefmasters did not differ in BCS and TS only. Bonsmaras differed in all traits analysed except for FWT, SC and SP. Unlike the other breeds, the Drakensberger had more traits that they showed no significant differences viz. IWT, FWT, MS, TS and SP. The Nguni showed significant difference in all traits analysed except for IWT, TS and SC. Finally, the Simbra also did not differ significantly in five of the eleven traits measured during the study viz. FWT, MS, TC, SC and SP. The general conclusion with regard to between breed variations is that the Simbra and Beefmaster showed better performance [in terms of ADG, BCS, MS, KR and VFCR] compared to the other breeds. In terms of tick resistance, the Nguni showed a high resistance and could be deemed the most suitable breed for areas where tick borne disease is a problem.

The combination of crossbreeding and within breed selection is important for long term improvement of the herd performance in terms of growth and adaptive traits, temperament, reproductive traits, body condition score and muscling score in most



production systems. The significant differences found within-breed in this study further emphasise the need to include the within-breed component of variation in selection criteria in a breed plan. With the exception of the SP and ADG in feedlot, the results showed that the Simbra and Drakensbger had less variability as compared to the other breeds, suggesting an increase in selection intensity within the two breeds in the region. On the contrary, the greater variability found in Aberdeen Angus, Nguni, Bonsmara and Beefmaster, however, guarantees that the improvement programmes can still be achieved.

The lower variability of SC in all breeds, except for the Beefmaster and Drakenberger, signify greater selection for this trait, which may suggest a common increase in the general herd fertility in the region. The absence of a significant correlation between the FCE traits (KR and VCFR) and growth traits (ADG and liveweight) as shown in this study suggest that there is a potential to select animals for improved efficiency based on KR or VFCR without compromising their growth rate. In terms of the duration of the test period, the study found that it may not be necessary to extend the test period to 205 days as there was no significant increase in growth rate as from the 168th day onwards..

Moreover, the results also showed that none of the breeds differed in terms of ADG during the finishing period or in a feedlot. This clearly demonstrated that, given a favourable environment, each bull will have an equal opportunity to perform at its optimum genetic potential. This implies that in a production environment where feed resource is not the limiting factor, higher production efficiency may well be accomplished from each of the bulls tested. Despite the insufficient data, the absence of significant influence from traits measured during the grazing period on ADG in a feedlot further suggests that there is no need to continue testing the bulls for an additional 100 days in a feedlot. If these days are cut-off it would result in considerably saving costs of running an additional performance test. In addition, the close association found between SP with MS and ADG during the grazing period as opposed to ADG in the feedlot further substantiate the lack of interest the buyers had in feedlot performance tests results. The analysis of covariance also indicated a close association between other variables (i.e. FWT & SC, FWT & MS, FWT & BCS, and SC & ADG) and yielded a significant regression coefficient.

5.2 CRITICAL REVIEW AND RECOMMENDATIONS

A research project such as this one which seems to have an immediate impact on the decision making process of farmers, is worthy of critical analysis so as to recommend possible improvements for future similar projects. According to the findings in this study there is a significant variability within and between breeds in terms of productivity traits such as those measured during the study. These findings are of greater importance, bearing in mind that the beef industry uses genetic variation within and between breeds as a measure of output to effect productivity. In brief the study suggested that, regardless of a type of breed or its origin, there is still room (both within breed and between breeds) for improvement of herd performance through a selection process.

While these results may be true and statistically reliable, caution should be exercised in generalising these results. The absence of specific test entry requirements (i.e. exact age and weaning weight index of each bull) for bulls entering the test already increased the degree of variation even within a breed. It may, therefore be wise to consider a population or herd-specific variation component, because through successful selection the genetic composition of the population of the herd may change over time. In addition, cognisance should be taken of the fact that the bulls tested during this study represent a sub-set of the South African cattle population for each breed, and this selection has not been accounted for in breed comparison. Although the RSA is in the subtropical region, the weather conditions in the Vrede district are quite different from many other parts of South Africa because sometimes winter rain and cold conditions and mild summers exist. This may have repercussions on the use of these results in other parts of the RSA or in the sub-tropical region at large.

The FWT as a measure of growth rate at test stations showed a great association with SC, BCS and MS in this study. However, caution again has to be exercised when selecting for high FWT because it could have a detrimental effect on birth weight, which could lead to dystocia. The analysis done in this study showed that animals with larger SC have lower SC as a percentage of body weight. It would be prudent if a follow-up study on the performance of such bulls in the field is carried out to investigate their fertility status (e.g.



sperm production and quality, sperm mobility and survival rate and libido) and as well as the performance of their female progeny. Although it was found that ADG in feedlot did not have any influence on SP, hence the recommended discontinuation of the finishing period, it would be necessary to consider the effect of auction weight on SP before such a decision is implemented. Finally, the strength of the Veld bull Club is that apart from indirectly assisting breeders to improve their herd through selection of their best bulls for testing, it also provides the opportunity for them to market their bulls' and have their status known.

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ANNEXURE A

Weight gained during the grazing period for each breed

Breed	Aberdeen Angus			
Year	IWT	FWT	LWT gained (kg)	Percentage growth (%)
1	284	388	104	37
2	279	358	79	28
3	257	386	129	50
4	341	429	88	26

Breed	Beefmaster			
Year	IWT	FWT	LWT gained (kg)	Percentage growth (%)
1	258	417	159	62
2	266	409	143	54
3	269	432	163	61
4	240	394	154	64

Breed	Bonsmara			
Year	IWT	FWT	LWT gained (kg)	Percentage growth (%)
1	225	369	144	64
2	238	368	130	55
3	218	372	154	71
4	230	379	149	65

Breed	Drakensberger			
Year	IWT	FWT	LWT gained (kg)	Percentage growth (%)
1	227	365	138	61
2	247	365	118	48
3	244	385	141	58
4	230	373	143	62

Breed	Nguni			
Year	IWT	FWT	LWT gained (kg)	Percentage growth (%)
1	184	305	121	66
2	181	299	118	65
3	182	326	144	79
4	171	279	108	63



Breed	Simbra			
Year	IWT	FWT	LWT gained (kg)	Percentage growth (%)
1	302	461	159	53
2	278	449	171	62
3	241	420	179	74
4	275	426	151	55