GENETIC ANALYSES OF GROWTH TRAITS FOR THE SIMBRA COMPOSITE BREED

Algina Maria Johanna Smith

Thesis submitted in partial fulfilment of the requirements for the Degree

MASTER OF SCIENCE IN AGRICULTURE

(Animal Science)
Faculty of Agricultural and Forestry Sciences
Department of Animal Sciences
University of Stellenbosch
Republic of South Africa

Study leader : Professor K. Dzama

Stellenbosch March 2010

DECLARATION

I hereby declare that the work contained in this thesis is my original work and that it has not, as a whole or partially, been submitted for a degree at any other University.

Signature……………………………… Date………………………………………..

Summary

Genetic analyses of growth traits for the Simbra composite breed

Candidate	**:**	**Algina Maria Johanna Smith**
Study leader	**:**	**Professor K. Dzama**
Department	**:**	**Animal Sciences**
Faculty	**:**	**Agricultural and Forestry Sciences**
Degree	**:**	**M.Sc Agric**

The aim of this study was to evaluate the Simbra breed of cattle for certain non-genetic as well as genetic parameters influencing live weight traits in the breed. Live weight traits included birth weight (BW), weaning weight at 200 days of age (WW), yearling weight at 400 days of age (YW) and 600 day weight. The Simmental and Simbra Breeders' Society of Southern Africa availed 148751 records for analysis from the year 1987 till 2009. Due to deficiencies of various kinds in the data and the restrictions imposed for the purposes of the analysis, 56.44% of the records were discarded for BW, 76.55% for WW, 91.54% for YW and 96.32% for 600-day weight.

Non-genetic parameters affecting BW, WW, YW and 600-day weight were analysed using the General Linear Models procedure of the Statistical Analysis System (SAS, 2004) software. During this procedure sex of calf, breed composition of calf, breeder of calf, month of birth, year of birth and dam age were fitted in the models. BW, WW, YW and Mature Cow Weight (MCW) were fitted as covariates where possible. It was determined that the fixed effects of sex, dam age, breeder, year and month had a significant ($P < 0.05$) effect of BW and WW while dam age was not significant ($P > 0.05$) for YW or 600-day weight. Breed was found non significant for YW. Breeder of the calf accounted for the most variation in BW, WW, YW as well as 600-day weight with a contribution of 17.55%, 25.77%, 18.35% and 10.71% respectively. Tukey's multiple range tests were performed for testing differences between least square means. Results indicated male calves to be significantly heavier than females for all four traits measured. Breed composition differences were found significant until WW. Calves with higher Brahman percentage weighted more at birth while calves with higher Simmental percentage weighed more at weaning. Middle-aged dams were found to account for heavier calves at both BW and WW while very young dams and very old dams produced lighter calves for the two live weight traits. A number of years showed a significant difference from each other for all the traits measured as well as month of birth.

(Co) variance components and the resulting genetic parameters were estimated using single-traits and three-traits analysis by means of Restricted Maximum Likelihood procedures (Gilmour *et al.*, 2002). Appropriate models were selected by means of Log likelihood ratios tests and implemented to estimate genetic parameters for each of the traits studied. Direct additive heritabilities for BW, WW, YW and 600-day weight in the Simbra were respectively 0.56 ± 0.08, 0.67 ± 0.09, 0.70 ± 0.11 and 0.10 ± 0.03 when the most suitable animal model was fitted in single-trait analyses for each trait. Single traits analysis also included maternal additive as well as the correlation between direct additive and maternal additive for BW, WW and YW. Maternal additive heritability estimates of 0.24 ± 0.07, 0.33 ± 0.06 and 0.38 ± 0.07 was obtained for BW, WW and YW. Correlation estimates between direct additive and maternal additive were -0.75 ± 0.07, -0.93 ± 0.07 and -0.85 ± 0.08 for BW, WW and YW respectively. Furthermore, dam permanent environment was included as an additional random effect that increased the log likelihood value significantly. A value of 0.04 ± 0.05 was obtained for dam permanent environment estimate for WW. When a three traits analysis was done for the same traits, but using a significantly smaller data set, direct additive heritabilities of 0.24 ± 0.07 for BW, 0.33 ± 0.06 for WW and 0.38 ± 0.07 for YW were obtained. Genetic and environmental correlation estimates of 0.18 ± 0.16 and 0.09 ± 0.06 between BW and WW; 0.27 ± 0.16 and 0.07 ± 0.06 between BW and YW; as well as 0.52 ± 0.10 and 0.45 ± 0.05 between WW and YW were obtained during the three-trait analysis. The magnitude of the heritabilities obtained in this study indicates that the opportunity exists to make genetic progress through proper selection objectives.

Opsomming

Genetiese analises van groei eienskappe vir die Simbra komposiete ras

Kanditdaat	**:**	**Algina Maria Johanna Smith**
Studieleier	**:**	**Professor K. Dzama**
Departement	**:**	**Veekundige Wetenskappe**
Fakulteit	**:**	**Landbou en Bosbou Wetenskappe**
Graad	**:**	**M.Sc Landbou**

Die doel van hierdie studie was om die Simbra bees ras te evalueer op grond van sekere nie-genetiese so wel as genetiese parameters wat lewende gewig beïnvloed. Gereelde en akkurate opnames van lewende gewig, is ‘n goeie indikasie van groei potensiaal en is ‘n minimim vereiste vir meeste beesras telings genootskappe. Lewende gewigs eienskappe sluit in geboorte gewig (BW), speen gewig gemeet op 200 dae (WW), jaaroue gewig gemeet op 400 dae (YW) en finale gewig gemeet op 600-dag gewig. Die Simmentaler en Simbra genootskap van Suid Afrika het 148751 rekords beskikbaar gestel vir evaluasie vanaf die jaar 1987 tot 2009. Daar was egter groot tekort komings aan die gewewe data en dus is daar 56.44% van die rekords vir BW nie gebruik nie, 76.55% vir WW, 91.54% vir YW en 96.32% vir 600-dag gewig.

Nie-genetiese parameters wat die onderskeie lewende gewigte beïnvloed het, is geanaliseer deur Algemene Lineêre Modelle met behulp van die Statistiese Analitiese Sisteem (SAS, 2004) sagteware. Gedurende die analise is geslag van die kalf, ras samestelling, teler van die kalf, maand van geboorte, jaar van geboorte asook moeder ouderdom gepas in die modelle vir die onderskeie gewigte. Geboorte gewig, speen gewig, jaaroue gewig asook volwasse koei gewig is gepas in elk van die modelle as ko-variate. Volgens die resutate is daar vasgestel dat geslag van die kalf, moeder ouderdom, teler, jaar, maand en volwasse koei gewig almal ‘n betekenisvolle ($P < 0.05$) invloed gehad het op BW en WW. Die moederouderdom was nie betekenisvol ($P > 0.05$) vir YW of 600-dag gewig nie. Die ras samestelling was ook nie betekenisvol gevind vir YW. Teler van die kalf was verantwoordelik vir die meeste variasie in BW, WW, YW asook 600-dag gewig met ‘n bydrae van 17.55%, 25.77%, 18.35% en 10.71% onderskeidelik. Tukey se veelvuldige vergelykings toets is gebruik om onderskeid te tref tussen “least square means”. Resultate het aangedui dat manlike diere swaarder weeg as vroulike diere tot en met finale gewig. Ras samestelling vir BW en WW was betekenisvol verskillend vir die diere. Kalwers met ‘n hoër Brahmaan persentasie het swaarder BW opgelewer as dié met ‘n hoër Simmentaler persentasie, terwyl kalwers met ‘n hoër Simmentaler persentasie swaarder geweeg het met speen en dus ideal is vir speen kalwer produksie stelsels. Middel-jarige moeders het swaarder kalwers geproduseer met geboorte en speen as baie jong en -ou moeders. Sommige jare waarin van die kalwers gebore is, het ook betekenisvol van mekaar verskil asook die maand waarin die kalf gebore is.

(Ko) variansie faktore en opeenvolgende genetiese parameters is bepaal met behulp van enkel-eienskap analises asook meervuldige-eienskap analises deur middel van die “Restricted Maximum Likelihood” prosedure (Gilmour *et al*., 2002). Modelle is opgestel vir elk van die gewigte deur die geskikte genetiese terme toe te voeg en te toets met behulp van “Log likelihood tests” om sodoende die onderskeie genetiese parameters te bepaal. Direkte genetiese oorerflikhede bepaal deur enkel-eienskap analises vir die Simbra ras was as volg, 0.56 ± 0.08 vir BW, 0.67 ± 0.09 vir WW, 0.70 ± 0.11 vir YW en 0.10 ± 0.03 vir 600-dag gewig. Die direkte maternale genetiese oorerflikhede tydens dieselfde enkel-eienskap analise vir die onderkeie gewigte was 0.24 ± 0.07 vir BW, 0.33 ± 0.06 vir WW en 0.38 ± 0.07 vir YW. Korrelasies tussen direkt genetiese en direk maternale eienskappe was sterk negatief. ‘n Waarde van -0.75 ± 0.07 is bepaal vir BW, -0.93 ± 0.07 vir WW en -0.85 ± 0.08 vir YW. ‘n Adisionele faktor was ook ingelsuit vir WW, naamlik die permanente omgewing van die moeder, wat ‘n waarde opgelewer het van 0.04 ± 0.05. Tydens die veelvuldige-eienskap analise het die oorerflikhede merkwaardig verminder vir die betrokke gewigte en kan ook waargeneem word as die meer korrekte genetiese weergawe. Direkte genetiese oorerflikhede van 0.24 ± 0.07 vir BW, 0.33 ± 0.06 vir WW en 0.38 ± 0.07 vir YW was bepaal. Hierdie matig tot hoë parameters dui op genetiese vordering deur middel van korrekte seleksie prosedures. Genetiese- en omgewing korrelasies is ook bepaal tydens die analise en het positiewe waardes opgelewer. ‘n Genetiese korrelasie waarde van 0.18 ± 0.16 tussen BW en WW is bepaal asook ‘n waarde van 0.27 ± 0.16 tussen BW en YW en ‘n waarde van 0.52 ± 0.10 tussen WW en YW. Hierdie korrelasies dui daarop dat na-speengewigte vermeerder kan word deur te selekteer vir verhoogde WW sonder om BW dramties te vermeerder. Omgewings korrelasie waardes van 0.09 ± 0.06 tussen BW en WW, 0.07 ± 0.06 tussen BW en YW asook ‘n waarde van 0.45 ± 0.05 tussen WW en YW is gevind. Genetiese neigings is bepaal vir die onderskeie gewigte deur die gemiddelde voorspelde teelwaardes aan te teken teenoor elke jaar wat bereken was tydens die enkel-eienskap analises vir die onderskeie gewigte. Groot variasie asook negatiewe tendense vir WW en YW is ondervind van jaar tot jaar en dui daarop dat die seleksie doelwitte vir lewendige gewig nie in plek gestel is nie en is dit nodig om te her evalueer.

ACKNOWLEDGEMENTS

The author wishes to express her profound appreciation and gratitude to the following persons (individually and collectively) and institutions:

First and foremost I thank our Lord and saviour, Jesus Christ, who has enabled me to accomplish this study with the necessary courage and stamina to push through.

The Simmental and Simbra Breeders' Society of Southern Africa, in Bloemfontein for the permission to use the data.

Prof. K. Dzama, who acted as supervisor, for his valuable guidance as well as the friendly supportive discussions.

Oliver Zishiri, for his valuable tuition, constant encouragement and constructive criticism.

My parents, Mr. Jacobus and Elize Smith, for their constant encouragement, support, love and financial help.

My husband, Mr. Pieter Stofberg, for his support, love and patience.

My dearest friends that I met in Stellenbosch for always being friendly, supportive and sociable, especially Ronel Basson, who helped me with the formatting and editing of this thesis.

My horse stud (Painted Appaloosa Stud) manager, Mr. Frans Balzer, for caring for my horses as if his own, allowing me time to study.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 2

CHAPTER 3

CHAPTER 4

CHAPTER 5

CHAPTER 1

GENERAL INTRODUCTION

In beef cattle production there is no single breed that can be considered superior. Each beef breed has its advantages and limitations for certain traits, depending on production and marketing systems. A breed must be selected according to climatic conditions, production situation and market goals to be economical. It is therefore important to obtain knowledge regarding breed characteristics to choose the most suitable breed. Synthetic breeds have been shown to be the most successful in commercial production systems. This is where the Simbra has been established as the breed of choice for most production systems throughout Southern Africa. In order to be flourishing the Simbra, however, needs highly productive purebreds as foundation, possessing complementary characteristics to produce desirable offspring (Denise & Brink, 1985). The breed is composed out of two of the most popular breeds in the world namely the Simmental relating to the *Bos taurus* specie and the Brahman relating to the *Bos indicus* specie.

The ideal breed combination will depend on the specific environment as well as market goal. A higher incidence of Simmental composition will be found in less extreme environments where weaner production is the main focus. The latter is evident in the South African Simbra due to the attention on weaner calf production and consumer preference for leaner beef (Mukuahima 2008). On the other hand, in more extreme environments a higher incidence of Brahman composition will be utilized (De la Rey, *et al.,* 2004). Higher Brahman composition has been found to be appropriate for effective and integrated beef production systems in both tropical and sub-tropical environment (Amen *et al.,* 2007)

Some of the most important characteristics associated with beef production include body weight and size at different stages, milk production, age at puberty, environmental adaptability, rate and efficiency of gain, muscle expression, cut ability and marbling. Although maintaining reproductive efficiency in the herd should be of particular concern, growth potential is still increasingly important to meat output from the production system (Eler *et al*., 1995). It has been found that the majority of all the sectors in the beef cattle industry are interested in the animal's growth potential throughout its life span as well as the traits associated with it (Denise & Brink, 1985). The reason for this is that the efficiency of beef production depends on three basic elements, namely female production and reproduction as well as growth of the calf from birth to the specific slaughter weight (Meyer *et al.,* 1991; Schoeman & Jordaan, 1999). Measuring live weights at regular intervals has been found to be good indicators of growth potential. Live weights include birth weight (BW), weaning weight (WW) at 200 days of age, yearling weight (YW) at 400 days of age and 600-day weight. Live weights have been recorded for the Simbra in Southern Africa since 1987, providing the opportunity to evaluate the breed for growth potential. The breed exhibits large differences in growth potential and this variability provides the potential for genetic improvement for growth. However, more elaborate recordings, for example more traits and more animals, are required for future accurate evaluation (Pico, 2004). Genetic improvement of growth traits provides potential to improve the profitability of beef cattle farming. This is accomplished by the estimation of accurate genetic, phenotypic and environmental parameters for the breed and growth traits under investigation (Brinks *et al.,* 1964). Increased computing power as well as highly advanced software has given the ability to facilitate more detailed models and more sophisticated statistical procedures to estimate the latter (Ferreira *et al.,* 1999). These genetic parameters that are of interest include estimates for heritability (direct additive, maternal additive and permanent maternal environment), correlations (genetic, phenotypic and environmental) as well as repeatability. The latter, excluding repeatability, are computed as functions of their (co)variance components. The resemblance between genetically related animals can be used in estimating trait heritability. This is where the computation of variance components within and between family members plays a fundamental part.

1.1. Justification

Several recent studies have been published containing information on heritabilities, genetic, environmental and phenotypic correlations among various growth traits for different beef cattle breeds. However, there is a paucity of literature on genetic parameters of the Simbra breed in the major beef producing regions of the world, including South Africa. Although estimates for both the Simmental and Brahman breeds are readily available, Mohd-Yusuff & Dickerson (1991) found that the genetic variance in a composite population, like the Simbra, may differ from their parental breeds. Thus, the quest to predict new and more accurate genetic parameters for the Simbra breed is a priority to improve the breed.

1.2. Objectives

The objectives of this study were to use recorded performance data of the Simbra breed obtained from the Simmental and Simbra Breeders' Society of Southern Africa for the Simbra breed to estimate the following:

1. Non-genetic factors influencing BW, WW at 200 days of age, YW at 400 days of age and 600-day weight.

2. Genetic parameters i.e. heritabilities, additive maternal effects, dam permanent environmental effects and genetic as well as environmental correlations between BW, WW, YW and 600-day weight.

3. To obtain breeding values for BW, WW, YW and 600-day weight using different animal models and construct genetic trends over the years to assess genetic progress over time or the lack thereof for the breed.

1.3. References

Amen, T.S., Herring, A.D., Sanders, J.O. & Gill, C.A., 2007. Evaluation of reciprocal differences in *Bos indicus x Bos taurus* backcross calves produced through embryo transfer: II. Post weaning, carcass, and meat traits. *Journal of Animal Science. 85*, 373-379.

Brinks, J.S., Clark, R.T., Keiffer, N.M. & Urick, J.J., 1964. Estimates of genetic, environmental and Phenotypic parameters in range Hereford females. *Journal of Animal Science. 23*, 711-716.

De la Rey, M., De la Rey, R. &Treadwell, R., 2004. Nguni. [Online]. South African National Champion and Supreme Beef Animal (of all breeds), Bloemfontein. Available: http://www.embryoplus.com/index.html

Denise, R.S.K. & Brinks, J.S., 1985. Genetic and Environmental aspects of the growth curve parameters in beef cows. *Journal of Animal Science. 61*, 1431-1440.

Eler, J.P., Van Vleck, L.D., Ferraz, J.B.S. & Lobo, R.B., 1995. Estimation of variances due to direct and maternal effects for growth traits of Nelore Cattle. *Journal of Animal Science. 73,* 3253-3258.

Ferreira, G.B., MacNeil, M.D. & Van Vleck, L.D., 1999. Variance components and breeding values for growth traits from different statistical models. *Journal of Animal Science. 77,* 2641-2650.

Meyer, K., Hammond, K., Mackinnon, M.J. & Parnell, P.F., 1991. The use of genetic algorithms for optimising age structure in breeding population when inbreeding depresses genetic gain through effects on reproduction. *Journal of Animal Science. 68*, 449-457.

Mohd-Yusuff, M.K. & Dickerson, G.E., 1991. Genetic variation in composite and parental populations: expectation for levels of dominance and gene frequency. *Journal of Animal Science. 69*, 3983-3988.

Mukuahima, G., 2008. The performance of beef cattle bulls in the Vrede district of Mpumalanga, South Africa. Magister Thesis, University of Pretoria, South Africa.

Pico, B.A., 2004. Estimation of genetic parameters for growth traits in South African Brahman cattle. Magister Thesis, University of the Free State, South Africa.

Schoeman, S.J. & Jordaan, G.F., 1999. Multitrait estimation of direct and maternal (co) variances for growth and efficiency traits in a multibreed beef cattle herd. *South African Journal of Animal Science. 29*, 124-136.

CHAPTER 2

LITERATURE REVIEW

The literature review offers an exploration of the Simbra breed origin as well as its previous performance record studies in order to obtain an overall view of the breed. The subject of live weight traits at different ages as an indicator of growth in composite breeds is also explored. Environmental and genetic factors influencing these traits are investigated to obtain comparable estimates. Genetic trends obtained from other composite breeds are also reviewed.

2.1. Simbra breed

During the late 1960's the Simbra(h) breed was established by a few cattlemen acting upon the idea of a breed that could thrive in the sub-tropical climate of the Gulf Coast region of the United States and still meet the demands of the industry. This led to the development of a practical cattle breed with economic advantages (De la Rey *et al.,* 2004). The American Simmental Association registered the first Simbra in 1977. The Southern Africa Simmental Society soon afterwards amended their constitution to accommodate this exceptional breed and formed the Simmental and Simbra Breeders' Society. The first South-African F1 Simbra's were registered in 1986, namely bull Nestua 851 and heifer Lichtenstein L135. The Simbra currently occupies an estimated 15% share within the group of nine synthetic breeds and is growing each year, with the highest percentage increase in females of all breeds. (Massmann, 2003)

Table 2.1. The performance of the Simbra breed in comparison to the national average in the South African beef cattle performance and progeny-testing scheme (Mukuahima 2008).

Trait	**1980-1992**		**1993-1998**	
	Simbra	**National average**	**Simbra**	**National average**
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 (Standardised growth test)	489	-	462	455
ADG (Standardised growth test) (g/d)	1904		1594	1653
FCR (Standardized growth test)	5.87	-	6.51	6.68
Scrotum circumference (mm)	345	-	346	347

The Simbra is classified as a synthetic breed, defined as a hardy, smooth-coated, well-adapted breed and characterized by heavy muscled bulls and fertile, feminine cows. It has been described as "The all purpose American breed". The breed is composed out of the two most populous beef breeds in the world, namely the Simmental and the Brahman, where the environment determines the ideal breed composition. In less challenging conditions, where weaner production is of high importance, a higher percentage Simmental is more evident while in a harsher environment a higher percentage Brahman will be included (Massmann, 2003). This must be done to obtain an optimal adaptive breed for its specific environment. A too high Brahman percentage could lead to less favourable meat characteristics, delayed age at puberty and decreased growth performance (Plasse *et al*., 2002). Crouse *et al*. (1989) have proposed a 25% Brahman inheritance to keep the favourable characteristics of both breeds. This is evident in the South African Simbra, having a higher Simmental component than that of the Brahman, due to consumer preference for leaner beef and more importantly increased weaning weights (Mukuahima 2008). The Simbra's fertility, early sexual maturity, milking ability, rapid growth, good beef characteristics and docile temperament can be attributed to the Simmental. The Brahman adds the adaptability to harsh areas due to the breed's tolerance to heat and disease including internal and external parasites. In addition to its ability to consume low quality forage, which is an important factor due to increasing feed costs, they also provide the advantage of longevity and calving ease (De la Rey *et al.,* 2004).

2.1.1. The advantage of composite breeds

The practice of combining breeds, like the Brahman and the Simmental, in order to create a "new" breed offers so much more opportunities than the conventional purebreds. Schoeman & Jordaan (1999) found that crossbreeding improves cow/calf efficiency when measured as an energy requirement (14%) or input costs (20%) per kilogram of steer equivalent weight. Lower production costs are associated with composite cows because they out perform the purebred cows by producing 32% more calves with 6% heavier weights (Mukuahima 2008). Composite superiority is mostly due to the exploitation of breed complementarities that enables incorporating climatic adaptability and performance traits into one breed (Gosey, 2006). Breed additive differences enable the breed to achieve and maintain the performance level for a variety of economically important traits that are most favourable for specified production and market situations. Furthermore it has been found that composites also provide herds of any size the opportunity to use heterosis and breed differences simultaneously to optimise additive genetic composition. Heterosis provides the opportunity to increase production performance to a maximum. It has been found that the unique feature of the Brahman breed is its excellent combining ability with European breeds, like the Simmental, resulting in generally high levels of heterosis for growth, maternal ability and reproductive performance. Heterosis values reported for Brahman-European crosses averaged more than three times that of European crosses (Koger, 1980). The retention of heterosis in composite populations is generally proportional to retention of heterozygosity (Gregory *et al.,* 1991; Gregory *et al.,* 1995a; Gosey, 2006). Heterosis observed for growth traits in large crossbreeding populations has been found to be mainly due to dominance effects (Gregory *et al.,* 1991). The latter represents the recovery of accumulated inbreeding depression within populations that have been genetically isolated from each other for many generations (Roso *et al.,* 2005). In addition to increased heterosis and exploitation of breed complementarities, the development of composites also offers the opportunity of performance consistency and the ability to produce their own replacement heifers once the breed is stabilised and established (Skrypzeck *et al.,* 2000).

2.2. Live weight traits

Performance assessment around the world for beef cattle has mainly been focusing on live weight measurement at regular intervals to evaluate growth potential. Live weight measurements usually include birth weight (BW), weaning weight (WW), yearling weight (YW) and 600-day weight. For true evaluation of these traits regular and accurate measurement is a necessity. It is important to note that gut-fill can contribute up to 10-15% of the variation associated with live weight traits (Mukuahima 2008).

BW reflects the effects of several important factors influencing the economic value of the calf during its lifespan. It is easy to obtain with reasonable accuracy (Dawson *et al.*, 1947) and displays the vigour and size of the calf at birth. Large, healthy calves have a greater capacity for milk consumption and tend to maintain lactation persistency of the dam, resulting in heavier weaning weights. BW is not only determined by its own genetic potential, but also by the maternal environment. The maternal environment mainly represents the dam's milk production and mothering ability through effects of the uterine environment and extra-chromosomal inheritance. Thus the dam's genotype affects the phenotype of her calf through a sample of her direct additive effect for growth as well as through her genotype for maternal effects on growth (Meyer, 1992).

The existence of a strong positive genetic correlation between BW and WW as well as the post weaning growth has been concurrent throughout the reported literature (see Table 2.3.) BW has accordingly been established to be a valuable prediction trait for both pre-weaning and post-weaning growth. This enhances the opportunity for growth rate selection at a very young age and thus the prospective value of the calf. From Table 2.1 the average BW for the Simbra breed is approximately 35kg.

Care should be taken when selecting for increased BW due to detrimental effects of too large calves. BW has been shown to be associated with calf growth rate dystocia, perinatal calf losses and losses of cows at calving (Holland *et al.,* 1977). Patterson *et al.* (1992) found that cows that have experienced calving difficulty had a subsequent decrease in reproductive performance as well as reduced milk production. BW has also been associated with higher mature cow weights that lead to higher maintenance costs. Thus, unlimited increase in BW selection will lead to immense economic loss (Brown & Galvez, 1969).

WW is a trait of high importance to beef producers due to the relationship of WW and dam productivity (maternal traits) and to the genetic potential of the calf's pre-weaning growth. WW is also related to other economic important traits of post-weaning growth like 400- and 600 day weight. Even though high growth rates contribute to the efficiency of most production systems, selection must not be based on these traits alone and must be brought in to perspective with other important traits like reproduction and carcass traits.

Mature cow weight has mainly been studied as pertaining to reproduction rather than for growth traits in beef cattle (Raphaka, 2008). Roberson *et al*. (1986) indicated that large cows usually produce large calves and are capable of producing more milk due to genetic maternal effects as well as genetically transmitted effects. These heavy cows also have the advantage of increased reserves that could be converted into adequate milk production throughout lactation to produce heavy weighing calves. Mature cow weight is also an important factor associated with dystocia. It has been shown by Burfening (1981) that cows having an adequate body size and -weight at the time of calving had lower incidences of calving difficulties. Koch & Clark (1955) suggested that the physiological, size and weight changes which are associated with ageing cows, might be expected to influence maternal environment and have a direct effect on BW and WW. Denise & Brink (1985) found mature weight to be highly inheritable and reported heritability estimates of 0.52 ± 0.11 and 0.57 ± 0.11. The latter indicates that improvement can be obtained through selection for this trait. It is however important to note that heavier cows are associated with larger framed cows and tends to have higher maintenance requirements that can lead to increased expenses (Schoeman, 1996). It is thus important that cows with an optimal frame size are used for the specific production situation according to feed resources, breeding systems and market end points (Dhuyvetter, 1995).

2.3. Non-genetic factors affecting growth in beef cattle

The fixed effects include all the non-genetic circumstances that influence the phenotypic value of the calf. It is of great importance to establish these non-genetic characters to facilitate genetic parameters for the breed under investigation as well as breeding values for individuals in the population. It is important to minimize environmental variation to improve the estimation of genetic parameters. Specification and potential qualification of the influence of these environmental variation (fixed effects) affecting growth traits are important in order to establish management and selection decisions (Krupa *et al.,* 2005). The main fixed effects that impact on growth traits include herd, region, sex of the calf, breed of the calf, month and year of birth, breeder of the calf, weaning age, dam age as well as cow parturition weight and previous parous state (Raphaka, 2008; Krupa *et al*., 2005).

2.3.1. Sex

It is generally recognized that the gender of an animal in most species of domestic animals has a definite influence at the different growth stages. Melka (2001) found that gender accounted for 4.3% and 3.8% of the variation associated with BW and WW respectively. It is well documented that males of most species of domestic animals grow more rapidly and reach a greater mature weight than females. (Koger & Knox, 1945; Gregory *et al*., 1950; Koch & Clark, 1955; Christian *et al.,* 1965; Dillard *et al.,* 1980; Ahunu *et al.,* 1997) In a more recent study, Villalba *et al.* (2000) found male calves to be 6.4% heavier at birth than females. This phenomenon is mainly due to the physiological effect of male endocrinology (Sushma *et al.,* 2006). It has been found that testosterone exerts a direct anabolic effect on protein synthesis in many non-reproductive organs and body tissues. This accounts mainly for the increased muscle mass associated with male calves and thus heavier body weights (Raff & Widmaier, 2004).

It is however important to calculate the contribution of the gender effect for the specific breed to formulate a proper conclusion as to how much gender contributes to the total phenotypic variance of the animal.

2.3.2. Year of birth

The year of birth has been found to significantly influence growth traits throughout the life of the calf (Sushma *et al.,* 2006). It is particularly evident in extensive grazing conditions. The contribution of year of birth can be extremely variable due to differences in climatic conditions, feeding and management as well as the genetic composition of the herd. BW was only slightly affected by year of birth. However, WW was found to be affected the most by the year of birth and showed significant variation between years. The outstanding effect of year of birth on WW is predominantly due to the quantity and quality of milk produced by the dam, which is depending on the available grazing for that specific year. It has been found by Holloway *et al*. (1985) that dams that were allowed to have high quality nutrients showed a 23% increase in fatness, 0.90 kg/day increase in milk production and weaned a 20.1kg heavier calf. Other authors (Christian *et al*., 1965; Koch, 1972) also reported a significant association between milk production of beef cows and gain of calves. Yearling weight as well as final weight varied considerably between years due to the availability of feed and the carry over effect from pre-weaning growth (Shelby *et al.,* 1955). It has been shown that year of birth can also significantly influence other important traits like, average daily gain (ADG), feed efficiency, shrinkage, slaughter grade, dressing percentage, carcass grade, colour of eye muscle, area of eye muscle and fat thickness.

2.3.3. Month of birth

It was shown that month of birth had a significant effect on calf weight measured at different stages. (Plasse *et al.,* 1995; Ahunu *et al.,* 1997; Villalba *et al.,* 2000; Sushma *et al*., 2006; Raphaka, 2008) Similar to the year of birth effect, the plane of maternal nutrition in general reflects the effect of month of birth on calf weight. This is due to the fact that calves born from dams that were in a higher body condition score during their late pregnancy phase, on good grazing, produced calves with a heavier birth weight. These dams will also have better quantity and quality milk to feed their young properly than those dams in poor condition. The dams on restricted planes of nutrition prior to calving produced lighter calves due to a decreased fetal growth rate (Villalba *et al.,* 2000). Maternal performance of beef cows has been found to be accountable for 40% of the variance in weaning weights (Robinson *et al.,* 1978). Drewry *et al.*, (1959) found significant correlations of 0.43 and 0.29 respectively between birth weight of the calf and milk production of the dam during the first and third months of lactation. The effect of month of birth was found to be significant up to 18-months weight (Plasse *et al*., 1995).

2.3.4. Breed composition

Numerous authors have found breed composition to account for the large amount of variation associated with live weight traits within cattle. Due to the fact that the *Bos indicus* is well known for its survival and effective production in harsh conditions, the higher incidence of Brahman will be obtained in the breed composition when farmed in tropical or sub-tropical conditions where resources are limited. In less challenging environments where resources are easily available, the higher the *Bos taurus* (Simmental) component will contribute to the breed composition. The latter will add to higher WW and is thus ideal for weaner production systems. (Massmann, 2003; Pico, 2004)

2.3.5. Breeder

Sushma *et al*., (2006) found that calves bred by different breeders differed significantly from each other due to environmental conditions as well as human choice variation. Day to day decisions made by the breeder mostly relating to management practises, selection objectives as well as the choice of breeding animals accounts for the majority of the variation associated with growth traits. (Krupa *et al.,* 2005)

2.3.6. Dam age

It was reported by numerous authors that BW and WW as well as YW increased along with increasing age of dam until the age of 5-7 years. Lower BW, WW and YW were obtained for dams younger than two years old as well as dams older than 8 years (Krupa *et al.,* 2005). It has been found by Burfening (1981) that younger dams had a higher percentage of calving difficulties than older dams. This is probably due to the fact that the older dams are physically more mature with a larger body size, while younger dams are physically impaired by their immature body size. Elzo *et al*. (1987) reported that this trend is a reflection of the greater ability of mature cows to provide the foetus with the necessary nutrients and environmental conditions for its development. Changes in weight, size and physiological function, which are associated with ageing, presumably influence this environment and consequently have a direct effect on BW and WW. Very young dams that are not physically or biologically mature enough, the consumed nutrients are not only used for maintenance, lactation and gestation, but also towards their own growth (Rumph & Van Vleck, 2004). Christian *et al.* (1965) found that calves from mature cows were heavier at birth, received more milk from their dams, consumed more feed and were heavier at weaning than the calves of 2-year-old dams. Interestingly enough Robinson *et al.* (1978) found that milk yield estimates increased noticeably in middle-aged cows up till an age of 8 years with a remarkable decrease for cows older than 8 years. Christian *et al.* (1965) also found that the amount of butterfat and non-fat solids produced by the dam is even more important that the milk volume produced. This is due to the fact that the young calf's consumption is limited by its abomasal capacity and is in need of a higher energy source at this stage.

2.4. Genetic parameters

The estimation of genetic parameters is an integral part of animal breeding since they estimate gene transmission from one generation to the next. These parameters also make it possible to select for superior breeding individuals to improve future populations (Bourdon, 2000). Thus for sound breed programs these parameters is of the essence and necessary to asses ongoing programs. The computation of genetic parameters will provide a better understanding of the genetic mechanisms involved in the breed under investigation. Genetic parameters that are of interest include heritability (direct additive, maternal additive and permanent maternal environment), correlation estimates (genetic, phenotypic and environmental) as well as repeatability. The latter are computed as functions of their (co) variance components. The resemblance between genetically related animals can be used in the estimation of trait heritability. This is where the computation of variance components within and between family members plays a fundamental part (Van der Werf, 2006).

With a sufficient dataset we assume a mixed model that relates to the observations. The mixed model is composed out of fixed effects and random effects. The fixed effects determine the level (expected means) of observations and the random effects establish the variance. The genetic variability occurring in a population is depicted by the variance components. It is necessary to estimate variance when we are interested in a new trait or breed that has no genetic parameters available in literature. (Co) variance components are unique to the population in which they were estimated and may change over years (Pico, 2004). Based on particular biological rules we assume that (co) variances as well as the ratio between them does not change rapidly over time. However with selection and management practices this is not always the result. This is especially evident in situations with high selection intensities, short generation intervals or a high degree of inbreeding. The latter can also be associated with traits determined by only a few genes. Another important factor is the circumstances under which measurements are collected that can vary. The more uniform the measuring conditions are, the more the environmental variance decreases and consequently the heritability increases. Mohd-Yusuff & Dickerson (1991) found that the genetic variance in a composite population, similar to the Simbra, might be more or less than that of the parental breeds.

It is therefore imperative that a constant need for regular (co) variance component estimation exists in order to update genetic parameters as accurately as possible to improve the traits under selection.

There are various methods that can be used to estimate (co) variance components. Although the best method is not obvious, it can be based on un-biasedness or in practice estimating the variance accuracy. For the latter it would be for minimal variance, which is usually the preferred method. It is important to note that unbiased methods do not correct for selection in animal breeding data because of least square equations utilization. Selection is an integral part of most animal data, making it thus impossible to eliminate. Maximum Likelihood (ML)-estimators maximizes the likelihood of the parameters, but tends to be biased although they have smaller variances than unbiased estimators. ML methods also do not consider the loss of degrees of freedom (DF) when correcting for fixed effects. Restricted ML (REML) on the other hand maximizes likelihood of parameters after correcting for fixed effects and does take the loss of DF in to account. Due to the fact that REML also accounts for selection, it has been made the method of choice for most animal breeding applications. A example of a program for parameter estimation is the ASREML package (Gilmour *et al*., 2002).

The heritability of growth traits (thus weight at different ages) at any stage during the calf's life will differ from medium (0.2-0.4) to high (> 0.4). Such traits are easy to improve through selection and will lead to increased performance in future generations (Bourdon, 2000). A summary of heritabilities and weight correlations at different stages of the calf's life can be seen in Table 2.2 and Table 2.3.

Table 2.2. Literature estimates for genetic parameters (h^2_a, h^2_m and r_{am}) for BW, WW, YW and 600-day weight in beef cattle.

Breed	**Country**	**h^2_a**	**h^2_m**	**r_{am}**	**Reference**
		Birth weight (BW)			
Angus	Australia	0.34	0.10	0.27	Meyer (1994)
Angus	New Zealand	0.31	0.09	0.26	Waldron *et al*. (1993)
Belmont red	Australia	0.57	0.18	-0.25	Burrow (2001)
Bonsmara	South-Africa	0.32	0.13	-	Maiwashe *et al*. (2002)
Boran	Ethiopia	0.24	0.08	-0.55	Haile-Mariam & Kassa-Mersha (1995)
Brahman	Venezuela	0.31	0.09	0.16	Martinez & Galindez (2006)
Composite	Botswana	0.55	0.09	0.20	Raphaka (2008)
De los Valles	Australia	0.32	0.13	-	Gutierrez *et al*. (1997)
Hereford	Australia	0.38	0.14	0.05	Meyer (1992)
Hereford	New Zealand	0.23	0.14	0.30	Waldron *et al*. (1993)
Hereford	USA	0.72			Shelby *et al.* (1955)
Multibreed population	Canada	0.51	0.09	0.17	Tosh *et al*. (1999)
Multibreed pop.	South Africa	0.72	0.14	-0.40	Skrypzeck *et al.* (2000)
Multibreed pop.	Ethiopia	0.14	0.07	0.47	Demeke *et al*. (2003)
Nelore	Brazil	0.22	0.12	-0.72	Eler *et al*. (1995)
Ndama and West African	Ghana	0.45	-	-	Ahunu *et al*. (1997)

Shorthorn					
Romosinuano	Colombia	0.25	0.06	-0.37	Sarmiento & Garcia (2007)
Simmental	Canada	0.34	0.20	-0.22	Trus & Wilton (1988)
Simmental	USA	0.46	-	-	Bennet *et al,* (1996)
Synthetic breeds	South Africa	0.66	0.22	-0.32	Schoeman *et al*. (2000)
Tswana	Botswana	0.31	0.11	0.33	Raphaka (2008)
Weaning weight (WW) measured at 200-days of age					
Angus	Australia	0.19	0.18	0.20	Meyer (1994)
Angus	New Zealand	0.12	0.28	0.04	Waldron *et al*. (1993)
Belmot red	Australia	0.17	0.34	-0.19	Burrow (2001)
Bonsmara	South Africa	0.25	0.18	-	Maiwashe *et al*. (2002)
Brahman	Venezuela	0.17	0.11	0.12	Martinez & Galindez (2006)
Composite	Botswana	0.17	0.15	0.88	Raphaka (2008)
De los Valles	Australia	0.60	0.30	-0.73	Gutierrez *et al*. (1997)
Hereford	New Zealand	0.14	0.41	-0.40	Waldron *et al*. (1993)
Hereford	USA	0.23			Shelby *et al.* (1955)
Hereford x Brazilian Nellore	Brazil	0.21	0.37	-0.53	De los Reyes *et al*. (2006)
Kenyan Boran	Kenya	0.61 to 0.64	0.25 to 0.27	-0.84 to -0.80	Wasike *et al.* (2003)
Multibreed pop.	Canada	0.33	0.13	-0.11	Tosh *et al*. (1999)
Multibreed pop.	South Africa	0.53	0.21	-0.65	Skrypzeck *et al.* (2000)
Multibreed pop.	Ethiopia	0.07	0.03	0.07	Demeke *et al*. (2003)
Ndama and West African Shorthorn	Ghana	0.38	0.32	-0.29	Ahunu *et al*. (1997)
Nelore	Brazil	0.13	0.13	-0.32	Eler *et al*. (1995)
Romosinuano	Colombia	0.34	0.19	-0.34	Sarmiento & Garcia (2007)
Simmental	USA	0.24	-	-	Bennett & Gregory (1996)
Synthetic	South Africa	0.53	0.36	-0.53	Schoeman *et al*. (2000)

breeds					
Tswana	Botswana	0.20	0.15	0.69	Raphaka (2008)
Zebu Crosses	Australia	0.59	0.49	-0.74	Meyer (1994)
Yearling weight (YW) measured at 400-days of age					
N/A	United Kingdom	0.26	-	-	Bishop (1992)
Hereford	Australia	0.16	0.11	-0.48	Meyer (1992)
Angus	Australia	0.33	0.04	-0.49	Meyer (1992)
Zebu cross	Australia	0.25	0.14	-0.39	Meyer (1992)
Bokoloji	Zamfara	0.07	-	-	Shehu *et al.* (2008)
Hereford	USA	0.47	0.09	-0.07	Dodenhoff, *et al. (*1998)
Multibreed pop.	Ethiopia	0.12	0.01	-	Demeke *et al*. (2003)
Simmental	USA	0.41	-	-	Bennett & Gregory (1996)
600-day weight					
Hereford	USA	0.47			Swiger *et al.* (1961)
Hereford	USA	0.84			Shelby *et al.* (1955)
Hereford	Australia	0.22	0.03	-0.20	Meyer (1992)
Zebu cross	Australia	0.20	0.01	1.00	Meyer (1992)

h^2_a, heritability of direct additive effects; h^2_m, heritability of maternal effects; r_{am}, genetic covariance between direct and maternal genetic effects.

Knowledge about correlation estimates (genetic, phenotypic and environmental) is important to know how selection for one trait will influence another correlated trait that could be correlated (Zishiri, 2009; Pico, 2004). Favourable as well as unfavourable correlation responses have been reported for growth traits. Adverse correlations could render improvement in a specific trait and lead to economic loss. For instance the strong positive correlation reported in literature between BW and WW. If WW is increased dramatically through selection, BW will increase and will result in dystocia. (Holland *et al.,* 1977)

Table 2.3. Literature estimates for genetic correlations ($\mathbf{r_a}$) and environmental correlation ($\mathbf{r_e}$) estimates for beef cattle breeds.

Breed	**Country**	**Model**	r_a	r_e	**Reference**
Birth weight and Weaning weight					
Angus	Canada	BAM	0.76	0.38	Meyer (1994)
Zebu cross	Australia	BAM	0.79	0.78	Meyer (1994)
Nellore	Brazil	MAM	0.23	0.14	Eler *et al.* (1995)

Brahman	South Africa	BAM	0.62	0.09	Pico (2004)
Birth weight and Yearling weight					
Angus	Canada	BAM	0.70	0.48	Meyer (1994)
Zebu cross	Australia	BAM	0.79	-	Meyer (1994)
Nellore	Brazil	MAM	0.16	0.12	Eler *et al.* (1995)
Brahman	South Africa	BAM	0.47	0.12	Pico (2004)
Weaning weight and Yearling weight					
Angus	Canada	BAM	0.95	0.60	Meyer (1994)
Zebu cross	Australia	BAM	0.79	0.78	Meyer (1994)
Nellore	Brazil	MAM	0.74	0.64	Eler *et al.* (1995)
Brahman	South Africa	BAM	0.88	0.47	Pico (2004)

BAM, bivariate animal model; MAM, multivariate animal model.

Taking all of the above factors in consideration it is thus possible to construct different models that incorporate both non-genetic factors as well as genetic factors to calculate appropriate genetic parameters for the breed under investigation for the different live weight traits under investigation. The obtained results can then be compared to results obtained in previous studies for the same species in order to facilitate conclusions, set breeding objectives and future goals.

2.5. References

Ahunu, B.K., Arthur, P.F. & Kissiedu, H.W.A., 1997. Genetic and phenotypic parameters for birth and weaning weights of purebred and crossbred Ndama and West African Shorthorn cattle. *Livestock Production Science. 51*, 165-171.

Bennett, G.L. & Gregory, K.E., 1996. Genetic (co)variances among birth weight, 200-day weight, and post-weaning gain in composites and parental breeds of beef cattle. *Journal of Animal Science. 74*, 2598-2611.

Bishop, S.C., 1992. Phenotypic and genetic variation in body weight, food intake and energy utilization in Hereford cattle. I. Performance test results. *Livestock Production Science. 30*, 1-18.

Bourdon, R.M., 2000. The genetic model for quantitative traits. IN: *Understanding Animal Breeding. 2nd Edition.* Ed. K. Linsner & M. Carnis. Charles E. Stewart, Jr. Prentive-Hall, Inc. P.110-120.

Brown, J.C. & Galvez, M., 1969. Maternal and other effects on birth weight of beef calves. *Journal of Animal Science. 28*, 162-167.

Burfening, P.J., Kress, D.D. & Friedrich, L.R., 1981. Calving Ease and growth rate of Simmental-sired calves. III. *Journal of Animal Science. 53*, 1210-1216.

Burrow, H.M., 2001. Variances and co variances between productive and adaptive traits and temperament in a composite breed of tropical beef cattle. *Livestock Production Science. 70*, 213-233.

Christian, L.L., Hauser, E.R. & Chapman, A.B., 1965. Association of pre-weaning and post-weaning traits with weaning weight in cattle. *Journal of Animal Science. 24*, 652-259.

Crouse, J.D., Cundiff, R.M., Koch, M.R., Koohmaraie, M. & Seiderman, S.C., 1989. Comparisons of *Bos indicus* and *Bos tarus* inheritance for carcass beef characteristics and meat palatability. *Journal of Animal Science. 67*, 2661-2668.

Dawson, W.M., Philips, R.W. & Black W.H., 1947. Birth weight as criterion of selection in beef cattle. *Journal of Animal Science. 6*: 247-257.

De la Rey, M., De la Rey, R. & Treadwell, R., 2004. Nguni. [Online]. South African National Champion and Supreme Beef Animal (of all breeds), Bloemfontein. Available: *http://www.embryoplus.com/index.html*

De los Reyes, A., Elzo, M.A., Fries, L.A., Roso, V.M. & Carvalheiro, R., 2006. Non-genetic, additive and non-additive genetic effects for animal model analyses of weaning weights in a Nellore x Hereford mutibreed population in Brazil. *8th World Congress on Genetics Applied to Livestock Production.*

Demeke, S., Neser, F.W.C. & Schoeman, S.J., 2003. Variance components and genetic parameters for early growth traits in a mixed population of purebred *Bos indicus* and crossbred cattle. *South African Journal of Animal Science. 84*, 11-21.

Denise, R.S.K. & Brinks, J.S., 1985. Genetic and Environmental aspects of the growth curve parameters in beef cows. *Journal of Animal Science. 61*, 1431-1440.

Dillard, E.U., Rodriguez, O. & Robinson, O.W., 1980. Estimation of additive and non additive direct and maternal genetic effects from crossbreeding beef cattle. *Journal of Animal Science. 50*, 653-663.

Dodenhoff, J., Van Vleck, L.D., Kachman, S.D. and Koch, R.M., 1998. Parameter estimates for direct, maternal, and grand maternal genetic effects for birth weight and weaning weight in Hereford cattle. *Journal of Animal Science. 76*, 2521-2527.

Dhuyvetter, J., 1995. Beef cattle frame scores. Available at: www.ag.ndsu.edu/pubs/ansci/beef/as1091w.htm

Drewry, K.J., Brown, C.J. & Honea, R.S., 1959. Relationships among factors associated with mothering ability in beef cattle. *Journal of Animal Science. 18*, 938-946.

Eler, J.P., Van Vleck, L.D. & Ferraz, J.B., 1995. Estimation of variances due to direct and maternal effects for growth traits of Nelore cattle. *Journal of Animal Science. 73*, 3253-3258.

Elzo, M.A., Quaas, R.L. & Pollak, E.J., 1987. Effects of age of dam on weight traits in the Simmental population. *Journal of Animal Science. 64*, 992-1001.

Gosey, J., 2006. Crossbreeding with composites. *Beef. Minneapolis. 42,* 22.

Gregory, K.E., Blunn, C.T. & Marvel, L.B., 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. *Journal of Animal Science. 9*, 338-346.

Gregory, K.E., Cundiff, L.V. & Kock, R.M., 1991. Breed effects heterosis in advanced generations of composite populations for birth weight, birth date, dystocia and survival as traits of dam in beef cattle. *Journal of Animal Science. 69*, 3574-3589.

Gregory, K.E., Cundiff, L.V. & Kock, R.M., 1995a. Genetic and phenotypic (co) variances for growth and carcass traits of purebred and composite populations of beef cattle. *Journal of Animal Science. 73*, 1920-1926.

Gutierrez, J.P., Canon, J. & Goyache, F., 1997. Estimation of direct and maternal genetic parameters for pre-weaning traits in the Australian de los Valles beef cattle breed through animal and sire models. *Journal of Animal Breeding and Genetics. 114,* 261-266.

Haile-Mariam, M. & Kassa-Mersha, H., 1995. Estimates of direct and maternal (co)variance components of growth traits in Boran cattle. *Journal of Animal Breeding and Genetics. 112*, 43-52.

Holland, B.J.M., Mullaney, P.D. & Hopkins, I.R., 1977. Breed and environmental factors affecting birth weight in Victorian beef cattle. *Journal of Animal Science. 17*, 5-9.

Holloway, J.W., Butts, W.T., J.R., McCurley, E.E., Beaver,H.L., Peeler,H.L. & Backus, W.L., 1985. Breed x nutritional environment interactions for beef female weight and fatness: Milk production and calf growth. *Journal of Animal Science. 61*, 1354-1363.

Koch, R.M. & Clark, R.T., 1955. Influence of sex, season of birth and age of dam on economic traits in range beef cattle. *Journal of Animal Science. 14*, 386-397.

Koch, R.M., 1972. The role of maternal effects in animal breeding: VI. Maternal effects in beef cattle. *Journal of Animal Science. 35*, 1316-1323.

Koger, M. & Knox, J.H., 1945. The effect of sex on weaning weight of range valves. *Journal of Animal Science. 4*, 15-19.

Koger, M., 1980. Effective crossbreeding systems utilizing zebu cattle. *Journal of Animal Science. 50*, 1215-1220.

Krupa, E, Oravcova, M, Polak, P, Huba, J. & Krupova, Z., 2005. Factors affecting growth traits of beef cattle breeds raised in Slovakia. *Czech Journal of Animal Science*. *50*, 14-21.

Maiwashe, A.N., Bradfield, M.J., Theron, H.E. & van Wyk, J.B., 2002. Genetic parameter estimates for body measurements and growth traits in South African Bonsmara cattle. *Livestock Production Science. 75,* 293-300.

Martinez, G. & Galindez, R., 2006. Genetic and environmental trends for birth and weaning weights in registered Brahman cattle. *In: Proc. 8th World. Congr. Genet. Appl. Livest. Prod. Belo Horizonte, Brazil.*

Massmann, C.P., 2003. History of the Simbra. The Simbra cattle breeders' society of Southern Africa. Available at: *http://www.simbra.org/ENGLISH/Index.htm*

Melka, H.D., 2001. Genetic parameter estimates for weaning traits in a multi-breed beef cattle population. Magister Thesis, University of Stellenbosch, South Africa.

Meyer, K., 1992. Variance components due to direct and maternal effects for growth traits of Australian beef cattle. *Livestock Production Science. 31*, 179-204.

Meyer, K., 1994. Estimates of direct and maternal correlations among growth traits in Australian beef cattle. *Livestock Production Science. 38*, 91-105.

Mohd-Yusuff, M.K. & Dickerson, G.E., 1991. Genetic variation in composite and parental populations: expectation for levels of dominance and gene frequency. *Journal of Animal Science. 69*, 3983-3988.

Mukuahima, G., 2008. The performance of beef cattle bulls in the Vrede district of Mpumalanga, South Africa. Magister Thesis, University of Pretoria, South Africa.

Patterson, H.D. & Thompson, R., 1971. Recovery of inter-block information when block sizes are unequal. *Biometrika. 58*, 545-554.

Patterson, D.J., Perry, R.C., Kiracofe, G.H., Bellows, R.A., Staigmiller, R.B. & Corah, LR., 1992. Management considerations in heifer development and puberty. *Journal of Animal Science. 70,* 4018-4035.

Pico, B.A., 2004. Estimation of genetic parameters for growth traits in South African Brahman cattle. Magister Thesis, University of the Free State, South Africa.

Plasse, D., Fossi, H., Hoogensteijn, R., Verde, O., Rodriguez, R., Rodriguez, M.C. & Bastidas, P., 1995. Growth of F_1 *Bos taurus* x *Bos indicus* vs *Bos indicus* beef cattle in Venezuela. I. Weights at birth, weaning and 18 months. *Journal of Animal Breeding and Genetics. 112,* 117-132.

Plasse, D., Verde, O., Fossi, H., Romero, R., Hoogesteijn, R., Bastidas, R. & Bastardo, J., 2002. (Co)variance components, genetic parametrs and annual trends for calf weights in a pedigree Brahman herd under selection for three decades. *Journal of Animal Breeding and Genetics. 119*, 141-153.

Raff, H., Strang, K.T. & Widmaier, E.P., 2004. Blood and hemostasis. IN Human physiology: The mechanisms of body function 9th Edition. Ed. M. Watnick. McGraw-Hill Companies Inc. New York, USA.

Roberson, R.L., Sanders, J.O. & Cartwright, T.C., 1986. Direct and maternal genetic effects on pre-weaning characters of Brahman, Hereford and Brahman-Hereford crossbred cattle. *Journal of Animal Science. 63*, 438-446.

Robinson, O.W., Yusuff, M.K.M. & Dillard, E.U., 1978. Milk production in Hereford cows. I. Means and correlation. *Journal of Animal Science. 47*, 131-136.

Roso, V.M., Schenkel, F.S., Miller, S.P. & Wilton, J.W., 2005. Additive, dominance and epistatic loss effects on pre-weaning weight gain of crossbred beef cattle from different *Bos tarus* breeds. *Journal of Animal Science. 83*, 1780-1787.

Rumph, J.M. & Van Vleck, L.D., 2004. Age-of-dam adjustment factors for birth and weaning weight records: A review. *Genetic and Molecular Research. 3,* 1-17.

Raphaka, K., 2008. Estimation of genetic and non-genetic parameters for growth traits in two beef cattle breeds in Botswana. Magister Thesis, University of Stellenbosch, South Africa.

Sarmiento, R.M. & Garcia, J.P., 2007. Estimation of genetic parameters and variance components for growth traits in Romosinuano cattle in the Colombian humid tropics. *Genetic Molecular. Research. 6*, 482-491.

Skrypzeck, H., Schoeman, S.J., Jordaan, G.F. & Neser, F.W.C., 2000. Pre-weaning growth traits of the Hereford breed in a multi breed composite beef cattle population. *South Africa Journal of Animal Science. 30*, 220-229.

Schoeman, S.J., 1996. Characterization of beef cattle breeds by virtue of their performances in the National Beef Cattle Performance and Progeny testing Scheme. *South African Journal of Animal Science. 26*, 15-19.

Schoeman, S.J., & Jordaan, G.F., 1999. Multitrait estimation of direct and maternal (co) variances for growth and efficiency traits in a multibreed beef cattle herd. *South African Journal of Animal Science. 29,* 124-136.

Schoeman, S.J., Jordaan, G.F. & Skrypzeck, H., 2000. The influence of proportion of Simmental breeding in a multi breed synthetic beef cattle population on pre-weaning growth traits. *South African Journal of Animal Science. 30,* 98-109.

Shelby C.A., Clark., R.T. & Woodward, R.R., 1955. The heritability of some economic characteristics of beef cattle. *Journal of Animal Science. 14*, 372-385.

Shehu, D.M., Oni, O.O., Olorunju, S.A.S. & Adeyinka, I.A., 2008. Genetic and phenotypic parameters for body weight of Sokoto Gudali (Bkoloji) cattle. *International Journal of Applied Sciences. 2*, 64-67.

Sushma, G., Ramesh Gupta, B., Vinoo, G.V., Reddy, N. & Reddy ,S., 2006. Influence of genetic and non-genetic factors of body weights and body measurements of Ongole cattle. *Indian Journal of Animal Science. 75,* 228-235.

Swiger., L.A., 1961. Genetic and environmental influences on gain of beef cattle during various periods of life. *Journal of Animal Science. 20*, 183-188.

Tosh, J.J., Kemp, R.A. & Ward, D.R., 1999. Estimates of direct and maternal genetic parameters for weight traits and back fat thickness in a multi breed population of beef cattle. *Canadian Journal of Animal Science. 79*, 433-439.

Trus, D. & W, J.W., 1988. Genetic parameters for maternal traits in beef cattle. *Canadian Journal of Animal Science. 68*, 119-128.

Van der Werf, J., 2006. Estimation of genetic parameters. University of New England. Armidale, NSW Australia. P. 110.

Villalba, D., Casasus, I., Sanz, A., Estany, J. & Revilla, R., 2000. Pre-weaning growth curves in Brown Swiss and Pirenaica calves with emphasis on individual variability. *Journal of Animal Science. 78*, 1132-1140.

Waldron, D.F., Morris, C.A., Baker, R.L. & Johnson, D.L. 1993. Maternal effects for growth traits in beef cattle. *Livestock Production Science. 34*, 57-70.

Zishiri, O.T., 2009. Genetic analyses of South African terminal sire sheep breeds. Magister Thesis, University of Stellenbosch, South Africa.

CHAPTER 3

NON-GENETIC FACTORS INFLUENCING GROWTH TRAITS IN SIMBRA CATTLE

3.1. Abstract

The effect of different fixed effects on birth weight (BW), weaning weight at 200 days (WW), yearling weight at 400 days (YW) and 600-day weight were analysed using the General Linear Models procedure of the Statistical Analysis System. During this procedure sex of calf, genotype of calf, breeders of calf, month of birth, year of birth and age of dam were fitted in the models analysed because of their significant ($P < 0.05$) influence on variation in the respective weights. BW, WW, YW and Mature cow weight (MCW) where fitted as covariates where appropriate. It was determined that the fixed effects of sex, dam age, breeder, year, month and MCW had significant ($P < 0.05$) effects of BW and WW while dam age was not significant ($P > 0.05$) for YW or 600-day weight. Breed was found not significant for YW. Gender of the calf accounted for most of the variation (2.25%) associated with BW. Breeder of the calf accounted for the most variation in WW, YW as well as 600-day weight with contributions of 25.77%, 18.35% and 10.71% respectively. Tukey's multiple range tests were performed for testing differences between least square means. Results indicated that male calves were significantly heavier than females for all four traits measured. Breed composition differences were significant ($P < 0.05$) up till weaning weight. Calves with a higher Brahman percentage weighted more at birth while calves with higher Simmental percentage weighted more at weaning. Middle-aged dams were found to account for heavier calves at both BW and WW while very young and very old dams produces lighter calves for the two live weight traits. Some years showed a significant difference from each other for all the traits measured as well as month of birth. It is thus evident that certain non-genetic factors play an important part in the respective live weight traits and should be considered during the formulation of breeding objectives.

Keywords: birth weight, weaning weight, yearling weight, 600-day weight, dam age, sex, breed

3.2. Introduction

An animal's phenotype is dependant largely on factors other than genotype. The latter can be seen from the following equation:

$$P = G + E$$

Where P = phenotype
G = genotype
E = environment

The greater proportioned E, the less P will be as an indication of G and thus the smaller heritability (h^2) will be for that trait. A smaller h^2 means that the environmental influence will be more and less progress will be made through selection and management should receive more attention. However if enough genetic variation exists for exploitation between individuals for the respective trait genetic improvement is inevitable. The following main factors have been found in literature to effect growth weight in cattle: Herd, region, year, month of calving, calving number, gender of calf, breed composition of calf, muscularity of calf, weaning age, dam's body conformation, condition and age.

Pribyl *et al*. (2000) has found that these environmental factors, especially management practices, to be accountable for the large variability in beef growth traits. Heritabilities are normally smaller than 0.5 and indicate the importance of the environmental proportion. To improve the performance of the Simbra breed, it is essential to determine these factors that act as environmental variation as well as their contribution to the animal's phenotype. The objective of this study was therefore to gain information on the environmental factors that influence birth weight (BW), weaning weight at 200 days (WW), yearling weight at 400 days (YW) and 600-day weight while determining the value of each character in the Simbra breed.

3.3. Materials and Methods

3.3.1. Records

The Simmental and Simbra Breeders Society of South Africa availed a total of 148751 performance records for the Simbra breed. The available records ranged from the year 1987 to 2009. Calves were born all year round in different parts of South Africa. The animals were composed out of Brahman and Simmental with differing percentages of each parental breed. The information contained in the data set included pedigree information, birth date, birth weight, breeder, breed type, intercalving period, birth weight, weaning weight (200-dayweight), yearling weight (400-day weight), 600-day weight and mature cow weight. Most of the calves have birth weight records, whereas a smaller number have weaning weights, yearling weights and 600-day weights available.

Although this was a rather large and complex data set, there were some important traits lacking from the obtained data. For instance the date of weighing that was not documented for either one of the weight traits and made it impossible to calculate other important traits like average daily gain. The animals were also not assigned to contemporary groups with the prevalence of some single sires and dams with few progeny. Some sires and dams also had no performance records recorded. There was also the incidence of traits that were measured but not documented correctly. The latter was evident for the number of calvings as well as birth status. However, it was possible to calculate a dam-age for most of the dams in the remainder of the dataset.

The unedited data was opened in GenStat version 7.2.0.220. Summary statistics and one-way frequencies were done to get an overall view of the data. Animals were considered Simbra if they were of the following composition: 50% Simmental and 50% Brahman (SI50%BB50%), 25% Simmental and 75% Brahman (SI25%BB75%), 75% Simmental and 25% Brahman (SI75%BB25%).

Records of animals with unknown identity and unknown pedigree, with the exclusion of base animals, as well as false weight traits for all of the weights measured were discarded. The remainder of the data was then transferred to Microsoft Excel in order to obtain a proper set of data that could be transferred to the Statistical Analysis System (SAS, 2009). Dam age was calculated and grouped together according to observed trends in BW and WW. Animals with a dam age equal to one were removed and the animals with a dam age of more than 9 were pooled together, leaving eight classes of dam-age. The uni-variate procedure in SAS was then utilized to determine the ranges of all four-weight traits. After calculating the means and standard deviations, 95% confidence intervals were constructed. Only calves with weight records within the 95% confidence interval for that specific weight were then retained in the analysis. When treated in this manner, birth weight ranged from 25-45kg, weaning weight from 133-332kg, yearling weight from 171-448kg and 600-day weight from 234-547kg.

The total number of records and means for all the traits available for analysis after editing are presented in Table 3.1. Because of deficiencies of various kinds in the data and the restrictions imposed for the purposes of the analysis, 56.44% of the records were discarded for modelling birth weight, 76.55% for modelling weaning weight, 91.54% for modelling yearling weight and 96.32% for modelling 600-day weight.

Table 3.1. Description of data set after editing for calf BW, WW, YW and 600-day weight.

Trait	Number of records	Minimum	Maximum	Mean	Standard deviation
Birth weight (kg)	64794	25	45	35	4.2
Weaning weight (kg)	34880	133	332	233	43.0
Yearling weight (kg)	12585	171	448	303	57.2
600-day weight (kg)	5477	234	547	384	65.1

3.3.2. Statistical Analysis

Data were analyzed using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS, 2004) to study the influence of factors affecting the different growth traits. The models fitted included the fixed effects of sex of the calf (2 levels), genotype of the calf (3 levels), breeder of the calf (265 levels), month of birth (12 levels), year of birth (23 levels) and age of dam (8 levels).

BW, WW, YW and Mature Cow Weight (MCW) were fitted as linear covariates where appropriate. All fixed effects and their interactions that had no influence ($P > 0.05$) on BW, WW, YW and 600-day weight were excluded from the final analyses according to a step down procedure. Least square means and standard errors were calculated. Tukey's multiple range tests were performed for testing differences between least square means.

The following models were fitted:

Birth weight

$$\mathbf{Y_{ijklmn} = \mu + S_i + G_j + M_k + Y_l + D_m + B_n + e_{ijklmn}}$$

Where: Y_{ijklmn} = Birth weight (kg)

μ = population mean

S_i = fixed effect of the i^{th} sex (i = 1, 2) male / female

G_j = fixed effect of the j^{th} genotype (j = 1, 2, 3) SI50%BB50%, SI25%BB75%, SI75%BB25%

M_k = fixed effect of the k^{th} month of birth (k = 12) January, February…..December

Y_l = fixed effect of the l^{th} year of birth (l = 23) 87, 89….09

D_m = fixed effect of the m^{th} age of dam (m = 8)

B_n = fixed effect of the n^{th} breeder (n = 265)

e_{ijklmn} = random error

Weaning weight

$$\mathbf{Y_{ijklmn} = \mu + S_i + G_j + M_k + Y_l + D_m + B_n + b_0\,(MCW)_{ijklmn} + b_1\,(BW)_{ijklmn} + e_{ijklmn}}$$

Where: Y_{ijklmn} = Weaning weight

μ = population mean

S_i = fixed effect of the i^{th} sex (i = 1, 2) male / female

G_j = fixed effect of the j^{th} genotype (j = 1, 2, 3) SI50%BB50%, SI25%BB75%, SI75%, BB25%

M_k = fixed effect of the k^{th} month of birth (k = 12) January, February…..December

Y_l = fixed effect of the lth year of birth (l = 23) 87, 89….09

D_m = fixed effect of the mth age of dam (m = 8)

B_n = fixed effect of the nth breeder (n = 265)

MCW_{ijklmn} = mature cow weight fitted as a linear covariate

b_0, b_1 = linear regression coefficients of Y_{ijklmn} on mature cow weight (MCW) and birth weight (BW).

e_{ijklmn} = random error

Yearling weight

$$\mathbf{Y_{ijkl} = \mu + S_i + M_j + Y_k + B_l + b_0\,(MCW)_{ijkl} + b_1\,(BW)_{ijkl} + b_2\,(WW)_{ijkl} + e_{ijkl}}$$

Where: Y_{ijkl} = Yearling weight

μ = population mean

S_i = fixed effect of the ith sex (i = 1, 2) male / female

M_j = fixed effect of the jth month of birth (j = 12) January, February…..December

Y_k = fixed effect of the kth year of birth (k = 23) 87, 89….09

B_l = fixed effect of the lth breeder (l = 265)

MCW_{ijkl} = mature cow weight fitted as a linear covariate

b_0, b_1, b_2 = linear regression coefficients of Y_{ijkl} on birth weight (BW) and weaning weight (WW).

e_{ijkl} = random error

600-day weight

$$\mathbf{Y_{ijklm} = \mu + S_i + G_j + M_k + Y_l + B_m + b_0\,(MCW)_{ijklm} + b_1\,(BW)_{ijklm} + b_2\,(WW)_{ijklm} + b_3\,(YW)_{ijklm} + e_{ijklm}}$$

Where: Y_{ijklm} = Yearling weight

μ = population mean

S_i = fixed effect of the i^{th} sex (i = 1, 2) male / female

G_j = fixed effect of the j^{th} genotype (j = 1, 2, 3) SI50%BB50%, SI25%BB75%, SI75%, BB25%

M_k = fixed effect of the k^{th} month of birth (k = 12) January, February…..December

Y_l = fixed effect of the l^{th} year of birth (l = 23) 87, 89….09

B_m = fixed effect of the n^{th} breeder (n = 265)

$MCW_{\mathbf{ijklm}}$ = mature cow weight fitted as a linear covariate

$b_{0,}$ $b_{1,}$ $b_{2,}$ $b_{3,}$ = linear regression coefficients of Y_{ijklm} on birth weight (BW), weaning weight (WW) and yearling weight (YW).

e_{ijklm} = random error

3.4. Results and Discussion

The contribution of each fixed effect (FE%) on every particular growth trait was depicted by expressing the sum of squares for such an effect as a percentage of the total corrected sum of squares (TCSS) (Leighton *et al*., 1982; Raphaka, 2008). The contribution of each fixed effect for that particular growth trait can be seen in Tables 3.2, 3.3, 3.4, 3.5. The least squares means for these growth traits are represented in Table 3.6. The R-square value obtained from the model fitted for each trait measured gives us a good idea of the variation within the data associated with each fixed effect component. The R-square values for the models fitted for BW, WW, YW and 600-day weight were 0.23, 0.39, 0.54 and 0.65 respectively. This indicates that the fixed effects fitted for the respective models are explaining 23%, 39%, 54% and 65% of the variation. The R-square value obtained in this study for BW is consistent with the findings of Raphaka (2008) and that of Nephawe (1998), but not with that of Melka (2001) who found an R-square value of 0.44. This indicates that the fixed effects fitted for the respective models are explaining 23%, 39%, 54% and 65% of the variation. The remainder of the variation is due to other factors (random effects as well as other fixed effects) not included.

Table 3.2. Type III sum of squares (SS), Mean squares (MS), significance level and proportional contribution of fixed effects (FE %) to the overall variance for BW.

Source of variation	DF	Type III SS	MS	F Value	FE (%)
Dam age	7	14594.25	2084.89***	153.29	1.71
Month	11	1607.07	146.10***	10.74	0.19
Year	22	2056.87	93.49***	9.87	0.24
Sex	1	19296.46	19296.46***	1418.74	2.25
Breed	2	404.63	202.32***	14.87	0.04
Breeder	264	150196.93	568.92***	41.83	17.55
Corrected total sum of squares	48953	855905.71			
Error mean square	48645		13.60		
R-square			0.23		
Coefficient of variation (CV%)			10.49		

*P< 0.05

**P< 0.01

***P< 0.001

Table 3.3. Type III sum of squares (SS); Mean squares (MS), significance level and proportional contribution of fixed effects (FE %) to the overall variance for WW.

Source of variation	DF	Type II SS	MS	F Value	FE (%)
Mature cow weight	1	148969.89	148969.89***	130.68	0.29
Dam age	7	618546.23	88363.75***	77.51	1.20
Month	11	2459975.39	223634.13***	196.18	4.76
Year	21	789796.71	37609.37***	32.99	1.53
Sex	1	1043465.95	1043465.95***	915.35	2.02
Breed	2	8767.48	4383.74*	3.85	0.02
Breeder	168	13308324.88	79216.22***	69.49	25.77
Birth weight	1	484345.08	484345.08***	424.88	0.94
Corrected total Sum of Squares	27893	51652321.24			
Error mean square	27681		1139.97		
R-square			0.39		
Coefficient of variation (CV%)			14.55		

*P< 0.05

**P< 0.01

***P< 0.001

Table 3.4. Type III sum of squares (SS); Mean squares (MS), significance level and proportional contribution of fixed effects (FE %) to the overall variance for YW.

Source of variation	**DF**	**Type II SS**	**MS**	**F Value**	**FE (%)**
Mature cow weight	1	15304.69	15304.69	10.12	0.04
Month	11	379122.40	34465.67***	22.78	0.92
Year	20	512928.29	25646.41***	16.95	1.25
Sex	1	2950370.21	2950370.21***	1949.99	7.17
Breeder	127	7557512.06	59507.97***	39.33	18.35
Birth weight	1	148956.25	148956.25***	98.45	0.36
Weaning weight	1	3981761.93	3981761.93***	2631.67	9.67
Corrected total Sum of Squares	12584	41175258.39			
Error mean square	12422		1513.02		
R-square			0.54		
Coefficient of variation (CV%)			12.85		

*P< 0.05
**P< 0.01
***P< 0.001

Table 3.5. Type III sum of squares (SS); Mean squares (MS), significance level and proportional contribution of fixed effects (FE %) to the overall variance for 600-day weight.

Source of variation	**DF**	**Type II SS**	**MS**	**F-value**	**FE (%)**
Mature cow weight	1	61799.35	61799.35	40.85	0.27
Month	11	431426.25	39220.57***	25.93	1.86
Year	18	255990.65	14221.70***	9.40	1.10
Sex	1	813433.15	813433.15***	537.74	3.50
Breed	2	12358.32	6179.16*	4.08	0.05
Breeder	87	2487958.82	28597.23***	18.91	10.71
Birth weight	1	21134.62	21134.62**	13.97	0.09
Weaning weight	1	229241.02	229241.02***	151.55	0.99
Yearling weight	1	1704751.45	1704751.45***	1126.98	7.34
Corrected total Sum of Squares	5476	23233791.16			
Error mean square	5353		1512.68		
R-square			0.65		
Coefficient of variation (CV%)			10.13		

*P< 0.05
**P< 0.01
***P< 0.001

Table 3.6. Least square means ± Standard error (s.e.) depicting the influence of fixed effects on growth traits in the Simbra breed.

	Birth weight		Weaning weight	
Fixed effect	N	kg ± S.E.	N	kg ± S.E.
Overall mean	64794	35.16 ± 0.02	34880	232.52 ± 0.23
Breed		***		*
SI50%BB50%	43625	35.66 ± 0.12	23150	231.29 ± 1.07
SI25%BB75%	1251	35.96 ± 0.12	590	231.46 ± 1.07
SI75%BB25%	19918	35.87 ± 0.12	11100	232.64 ± 1.07
Sex		***		***
Male	31671	36.54 ± 0.12	16710	237.72 ± 1.07
Female	33123	35.21 ± 0.12	18170	224.39 ± 1.07
Dam age (year)		***		***
2	4078	35.34 ± 0.12	1996	229.41 ± 1.07
3	11433	35.77 ± 0.12	6629	235.29 ± 1.07
4	8453	36.47 ± 0.12	5007	237.47 ± 1.07
5	6873	36.91 ± 0.12	3987	238.39 ± 1.07
6	5429	37.29 ± 0.12	3126	241.15 ± 1.07
7	3972	37.09 ± 0.12	2344	240.33 ± 1.07
8	2968	37.29 ± 0.12	1648	242.30 ± 1.07
9+	5748	37.13 ± 0.12	3178	240.47 ± 1.07
Mature cow weight				
Year		***		***
Month		***		***
Breeder		***		***
Birth weight		na		***
Weaning weight		na		na
Yearling weight		na		na

*P< 0.05

**P< 0.01

***P< 0.001

3.4.1. The effect of gender on growth traits in the Simbra breed

Sex was shown to be significant ($P< 0.001$) for all four traits measured. It can be seen from Table 3.2; 3.3; 3.4 and 3.5 that sex contributed 2.25%, 2.02%, 7.17% and 3.50% respectively to BW, WW, YW and 600-day weight total variance. The variance contribution of gender was lower than the findings of Melka (2001) who found a 4.3% and 3.8% contribution for BW and WW respectively. The difference between male and female calves was highly significant for BW, WW, YW and 600-day weight when a multiple comparison was done with Tukey's test.

The effect of gender on pre-weaning and post-weaning weight in beef cattle has been extensively studied (Koger & Knox, 1945; Gregory *et al.,* 1950; Koch & Clark, 1955; Christian *et al.,* 1965*;* Dillard *et al.,* 1980; Ahunu *et al.,* 1997; Krupa *et al*., 2005; Sushma, *et al.,* 2006; Kocak, *et al.,* 2007). Garrick, *et al.* (1989) found that male calves are heavier than females of the same age, which is consistent with the results obtained in this study. Male calves showed a birth weight of 36.54 kg compared to female calves that showed a birth weight of 35.21 kg. Male calves weighed 1.33 kg heavier than female calves generating higher values compared to the obtained literature results. This was also evident for the other weight traits measured indicating that sex differences increased as growth rate increased up till 600-day weight. Male calves had a WW of 238.47 kg, YW of 346.47 kg and a 600-day weight of 421.51 kg compared to female calves with a WW of 225.13 kg, an YW of 309.87 kg and a 600-day weight of 384.53 kg. This indicates that male calves are more responsive to improvements in the environment (Hopkins, 1977). A possible explanation for the observed pattern is the physiological effect of male endocrinology and not so much the influence of the dam. It has been found that testosterone exerts a direct anabolic effect on protein synthesis in many non-reproductive organs and tissues of the body. This accounts mainly for the increased muscle mass associated with male calves and thus heavier body weights (Raff & Widmaier, 2004). However Martin & Blunn (1952) found that 10% of the variation associated with differences in BW between sexes is due to gestation length. An extended gestation period has been found to be responsible for the higher BW associated with bull calves.

3.4.2. The effect of breed composition on growth traits in the Simbra breed

Breed composition of the calf was shown to be significant ($P < 0.001$) for BW and less significant ($P < 0.05$) for WW and 600-day weight. However for YW breed composition was not significant at all. Breed of the calf is composed out of SI25%BB75% or SI50%BB50% or SI75%BB25%. It is evident from Table 3.2, 3.3 and 3.5 that breed composition accounted for 0.04% of the variation associated with BW and 0.02% for WW. Breed composition was the most important in 600-day weight measured at 600 days of age and accounted for 0.05% of the variation. Melka (2001) found that calf genotype was one of the most important factors influencing BW, WW and average daily gain in a multi breed population. Schoeman *et al.* (1993) found that breed composition accounted for 17.3% and 39.9% for BW and WW respectively. The reason for this could be due to several factors. The additive component of the breed, breed maternal, individual heterosis and maternal heterosis is thought to be responsible for the difference in performance (Dillard *et al*., 1980).

A significant difference between SI25%BB75% and SI75%BB25% was found for BW during multiple comparisons by means of Tukey's test. This is apparent in Figure 3.1. Calves with a lower percentage Simmental and higher percentage Brahman weighed more at birth (35.96 kg) than calves with a higher percentage Simmental (35.87 kg). This is in relationship with the results of Franke *et al.* (2001) and Amen *et al.* (2007) that reported higher BW associated with higher Brahman percentage in crossbred calves. The latter may be due to the direct additive effect of the Brahman breed, the heterosis of foetal growth and the possible longer gestation length associated with Brahmans (Amen *et al*., 2007). This is not consistent with the results obtained by Trus & Wilton (1988) who found that BW increased with an increasing percentage of Simmental genes.

The difference between SI25%BB75% and SI75%BB25% diminished with age, but was still significant for WW (Figure 3.2), but not for YW or 600-day weight. Calves with a higher percentage of Simmental weighed more at weaning (232.64 kg) than those with a lower percentage Simmental (231.46 kg). This is consistent with the results reported by Barkhouse *et al.* (1998). This is probably due to the enormous potential of the Simmental for growth intensity traits like ADG compared to the Brahman (Krupa *et al.,* 2005) as well as the elevated quantity of milk produced by dams with a higher percentage Simmental genes. However it is evident from Figure 3.3 that the weight advantage from the high percentage Simmental composition diminished completely with age. Calves with a higher percentage Brahman and lower percentage Simmental reached a higher 600-day weight of 411.22 kg. This is consistent with the results obtained by Pitchford *et al.* (1993) in a study done with Brahman cross Hereford cattle as well as the results reported by Amen *et al*., (2007).

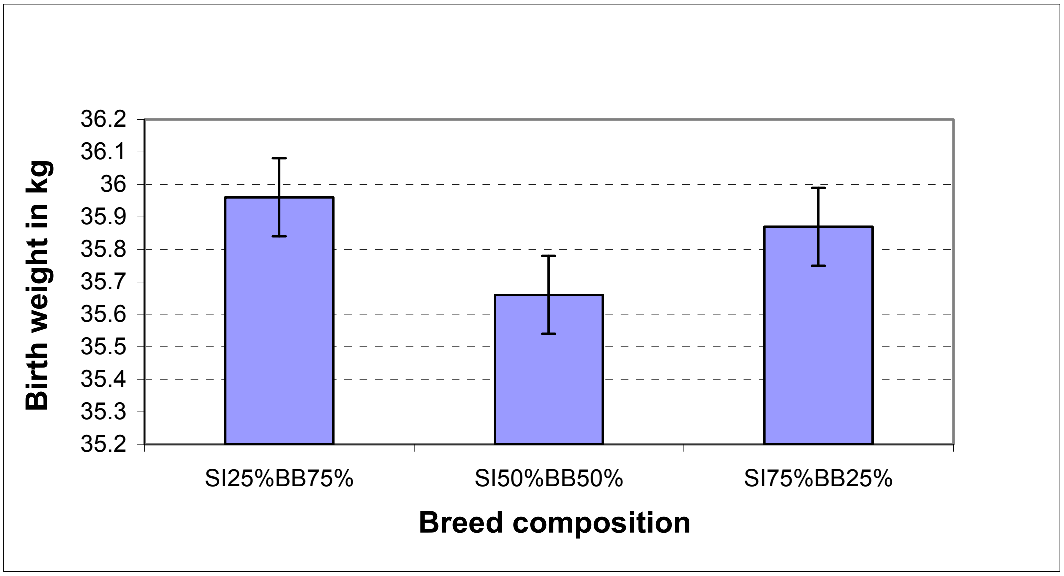

Figure 3.1. The effect of breed composition on birth weight for the Simbra breed. Vertical bars indicate standard errors.

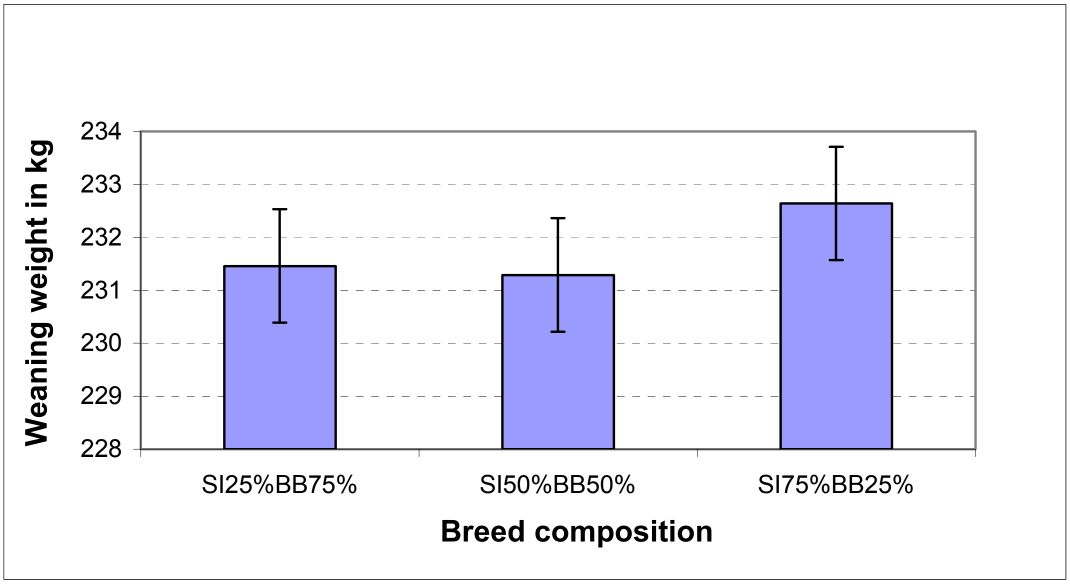

Figure 3.2. The effect of breed composition on weaning weight (200-day) for the Simbra breed. Vertical bars indicate standard errors.

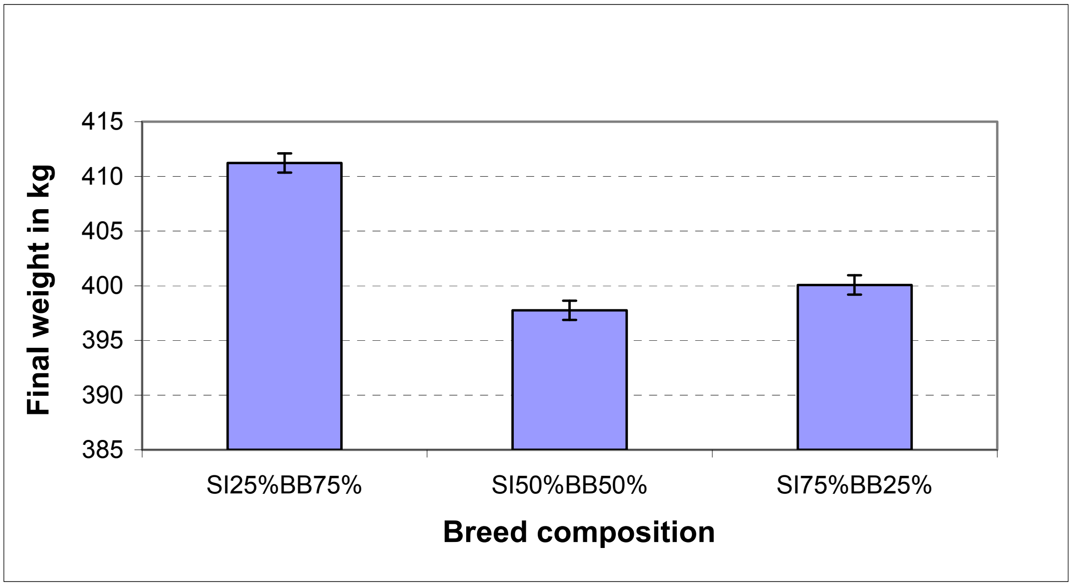

Figure 3.3. The effect of breed composition on 600-day weight for the Simbra breed. Vertical bars indicate standard errors.

The possible difference in performance between the different breed compositions can be due to the additive or maternal effects of the breed or heterosis. Dillard *et al*. (1980) have proposed that the difference in average breeding value of sires used could also have a significant influence if the breeding population is small enough. It was also evident from the obtained data that the number of animals partaking in the analysis, with a specific breed combination, varied widely from each other. The latter could have had a noteworthy affect on the outcome of the results.

3.4.3. The effect of breeder on growth traits in the Simbra breed

Breeder effect has been shown to be significant ($P < 0.001$) when fitted for each live weight. It is evident from Tables 3.2; 3.3; 3.4; and 3.5 that breeder accounted for most of the variation associated with each trait. The breeder of the calf represents the farm that it was bred by and grew up on. Every farm is different from one another with the breeder's choice of breeding animals, selection objectives and management regimes that will differ. The breeder effects are more in relationship with the variation associated with that of contemporary groups, that are not available for this data set, and accounts thus for most of the variation associated with WW, YW and 600-day weight. The effect of breeder accounted for 17.55% of the variation in BW, 25.77% for WW, 18.35% for YW and 10.71% for 600-day weight. The great influx and out flow of breeders during the evaluation period of 1987 up till 2009 accounted for a lot of the variation associated with the traits as well as a loss of valuable records of animals that participated at one stage in the recording scheme.

3.4.4. The effect of mature cow weight (MCW) on growth traits in the Simbra breed

Mature cow weight (MCW) measured at the weaning of their calf at 200 days of age was significant ($P < 0.001$) for all of the growth traits measured when fitted as a covariate. It is evident from Tables 3.2; 3.3; 3.4 and 3.5 that MCW contributed 0.29%, 0.04% and 0.27% of the total variation for WW, YW and 600-day weight respectively. This is consistent with results obtained from other studies. Roberson *et al*. (1986) indicated that large cows usually produce large calves with a better milk production, attributable to genetic maternal effects as well as genetically transmitted effects. An increased MCW are often associated with heifers being older and/or heavier at puberty, heavier BW associated with calving difficulty, faster gain rate and heavier WW. It must be kept in mind that heavier cows are often large framed animals with higher nutritional requirements for maintenance and physiological functions. Pitchford *et al.* (1993) reported breed effects to play an important part in MCW with breeds consisting out of a higher Brahman proportion to obtain higher MCW.

3.4.5. The effect of year on growth traits in the Simbra breed

Year of birth affected ($P< 0.001$) all the traits studied. It can be seen from Tables 3.2, 3.3, 3.4 and 3.5 that year contributed 0.24%, 1.53%, 1.25% and 1.10% to BW, WW, YW and 600-day weight respectively. From these recordings it evident that year had a large impact on the variation associated with WW and YW. This was consistent with the results of Shelby *et al.* (1955) who showed that year made the largest contribution to WW compared to the other weights measured.

It is evident from Figures 3.4, 3.5 and 3.6 that weights differed between years. The large amount of variation associated with the earlier years (1987-1992) is mostly due to the small number of animals recorded in those years. This had a significant effect on the outcome of the results. When the number of animals evaluated increased the amount of variation was also reduced. It has been found by numerous recent reports that the differences in environmental conditions are mainly responsible for the variability in growth traits from year to year (Kocak *et al.,* 2007; Raphaka, 2008; Zishiri, 2009). This could be due to climatic conditions with its direct effect on the quantity and quality of grazing available. Other environmental conditions can also include the management of the herd as well as availability and cost of roughage. Genetic composition of the herd has been found to be responsible for the variation on weights on a yearly basis. Human choice variation, that includes selection decisions, can also play an important part from year to year (Sushma *et al.,* 2006).

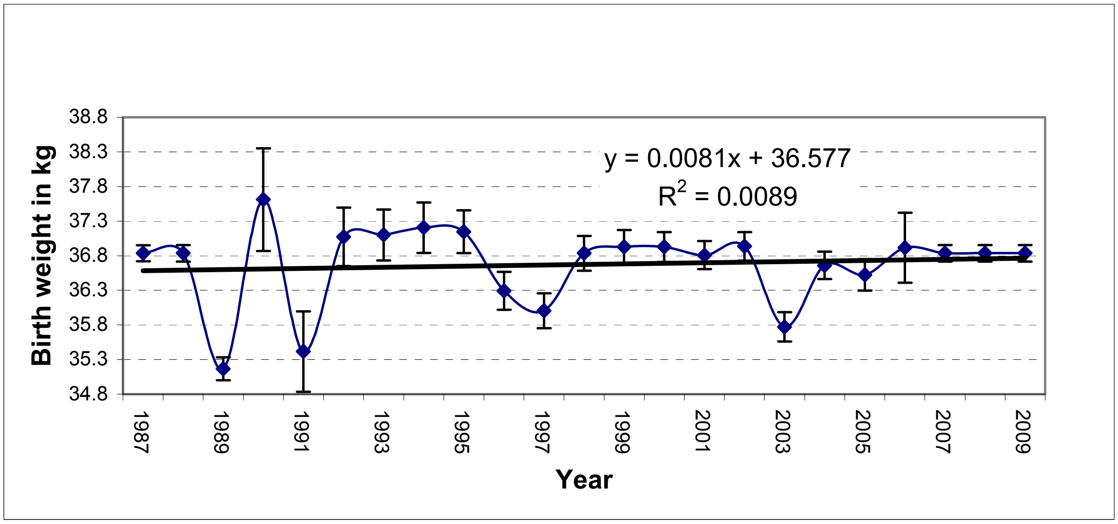

Figure 3.4. The regression of birth weight on year of birth for the Simbra breed. Vertical bars around the observed means denote standard errors.

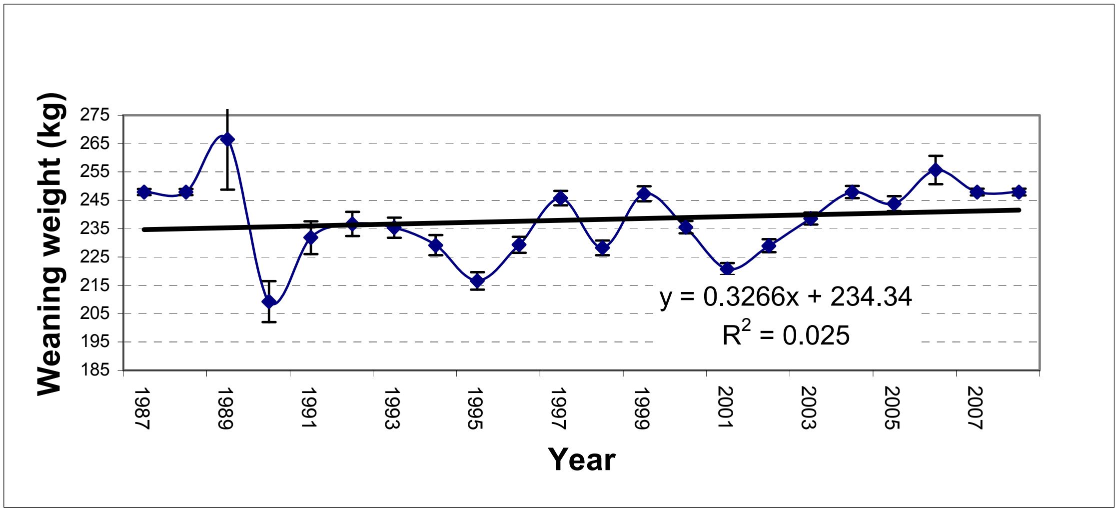

Figure 3.5. The regression of weaning weight (200-day) on year of birth for the Simbra breed. Vertical bars around the observed means denote standard errors.

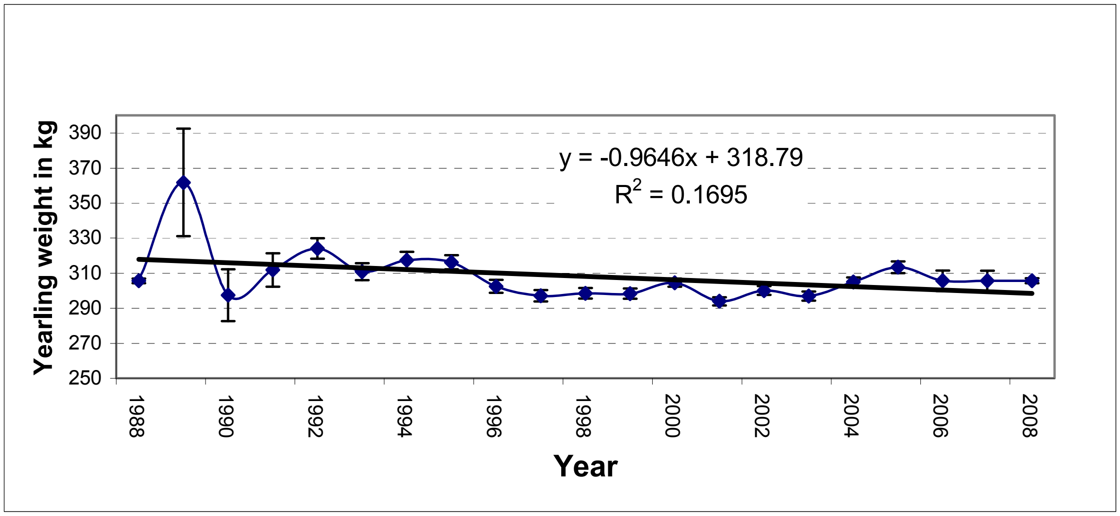

Figure 3.6. The regression of yearling weight (400-day) on year of birth for the Simbra breed. Vertical bars around the observed means denote standard errors.

3.4.6. The effect of month on growth traits in the Simbra breed

Month of birth was found to be highly significant for all growth traits measured. This was consistent with results of Plasse *et al.* (1995) and Sushma *et al.* (2006) who found the effect of month of birth to be significant up to 18-month weight. It can be seen from Table 3.2, 3.3, 3.4 and 3.5 that month had a large impact on the variation associated with all four traits measured. The respective FE % values for month of birth were 0.19, 4.76, 0.92 and 1.82 for BW, WW, YW and 600-day weight. BW was significantly higher for those calves born later in the rainy season (36.31 kg) than those born earlier in the season (35.80 kg). The reason for this significant difference in birth weight is due to the fact that cows with low tissue reserves in a poor condition after the nutritional stressful season will produce lighter calves. Villalba *et al.* (2000) attributed these lighter calves to a decreased fetal growth rate. Dams that had a higher body condition score during the late gestation phase, exposed to sufficient grazing later in the rainy season, produced heavier calves.

It is important to note that the lighter calves, born earlier in the rainy season, received a better nutritional environment from birth to weaning due to dams that produced more milk from an improved and prolonged forage resource. This resulted in calves that grew more rapidly due to a higher proportion of milk early in life and the ability to consume more forage during late lactation (Holloway *et al.,* 1985). These calves were also weaned at an older age and thus weighed even heavier at weaning. The latter was also evident in the current study for calves weighing less at birth and heavier at 200days (250.97 kg). Cows calving late in the rainy season are exposed for a longer period to limited, mature and less digestible pastures than dams of calves born earlier, resulting in a reduced milk yield (Carvalheira *et al*., 1995). These calves resulted in lighter a WW of 215.31 kg measured at 200 days of age for the heavier calves at birth. Maternal performance of beef cows has been found to be accountable for 40% of the variance in WW (Robinson *et al.,* 1978).

3.4.7. The effect of dam age on growth traits in the Simbra breed

Dam age accounted for 1.71% and 1.20% of the total variation associated with BW and WW respectively. It has been shown in numerous studies that BW and WW increase from 2-year-old dams and peak in 5-8 year old dams with a subsequent decline (Smith *et al.,* 1976; Gregory *et al.,* 1978; Reynolds *et al.,* 1980; Dillard *et al.,* 1980; Elzo *et al.,* 1987; Garrick, *et al.,* 1989; Ahunu *et al.,* 1997; Kurpa *et al.,* 2005; Riley *et al.,* 2007). Young *et al.* (1978) found age of dam not to be significant for post-weaning traits. This is evident in the recent study done for the Simbra breed where the age of the dam showed a significant effect ($P < 0.001$) on both BW and WW, but no significant effect on either YW or 600-day weight.

The curvilinear regression, with R^2 values displayed, between dam age and both BW and WW can be seen in Figure 3.7 and 3.8. The R^2 value for BW and WW on dam age was equal to 0.98 and 0.96 respectively. These values indicate a strong relationship between the two variables. The BW showed a steady increase of 35.34 kg at two years of dam age up to 37.29 kg at eight years of dam age. BW then declined with the advancing dam age of nine years and older. WW showed the same tendency with a weight of 229.41 for 2-year-old dams to 242.30 kg at eight years of age and a decline with a dam age of nine years and older. The age of dam had no significant effect on either YW or 600-day weight. The reason for the latter is due to the fact that the pre-weaning growth of the calf is influenced by the genes transmitted from their dam as well as the maternal environment provided to weaning (Brown & Galvez*,* 1969).

Younger as well as older dams gave birth to lighter calves when compared to mature dams. This trend is a reflection of the greater ability of mature cows to provide the foetus with the necessary nutrients and environmental conditions for its development (Elzo *et al.,* 1987). Presumably, changes in weight, size and physiological function, which are associated with ageing, might be expected to influence this environment and consequently have a direct effect on BW and WW. The young dams that are not physically or biologically mature enough, the consumed nutrients are not only used for maintenance, lactation and gestation, but also towards their own growth (Rumph & Van Vleck, 2004). Christian *et al.* (1965) found that the calves of mature cows were heavier at birth, got more milk from their dams, consumed more feed and were heavier at weaning than the calves of two-year-old dams. Maternal performance of beef cows has been found to be accountable for 40% of the variance in WW (Robinson *et al.,* 1978). Drewry *et al.* (1959) found significant correlations of 0.43 and 0.29 between BW of the calf and milk production of the dam during the first and third months of lactation, respectively. Interestingly enough Robinson *et al.* (1978) found that milk yield estimates increased noticeably in middle age cows with the remainder being fairly level. However milk yield showed a sharp decrease after 8 years of age. Christian *et al.* (1965) also found that the amount of butterfat and non-fat solids produced by the dam is even more important that the milk volume produced. This is due to the fact that the young calf's consumption is limited by the capacity of its stomach and is in need of a higher energy source at this stage.

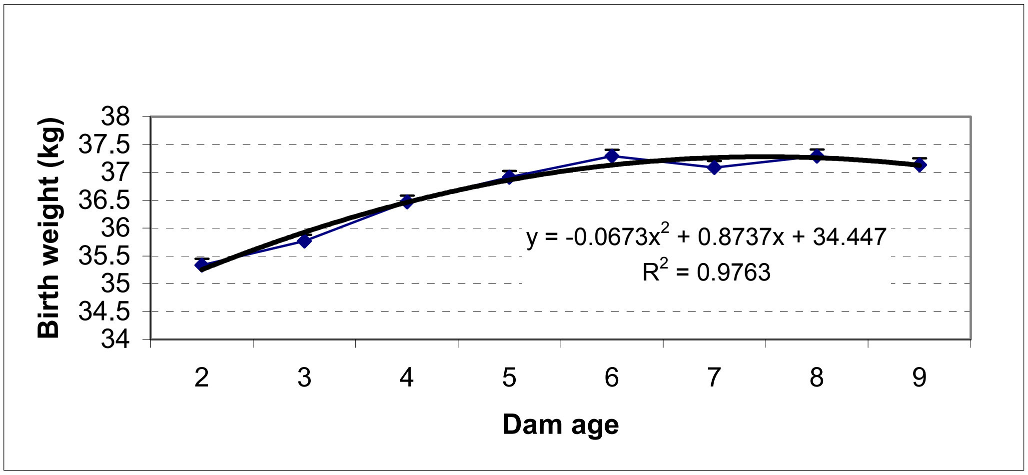

Figure 3.7. The regression of birth weight on dam age for the Simbra breed. Vertical bars around the observed means denote standard errors.

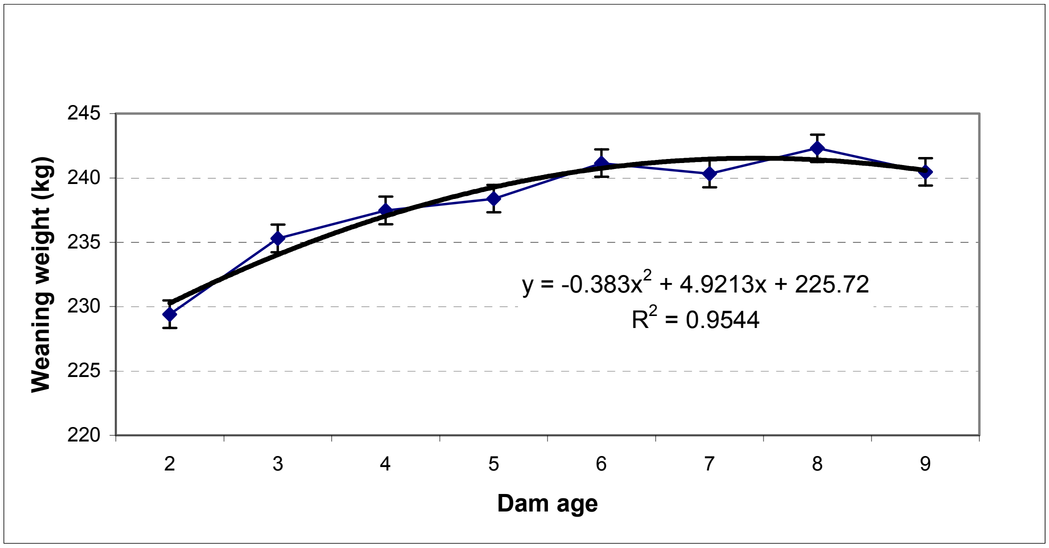

Figure 3.8. The regression of weaning weight (200-day) on dam age for the Simbra breed. Vertical bars around the observed means denote standard errors.

3.5. Conclusion

The non-genetic factors of MCW, dam age, month of birth, year of birth, sex of calf, breed composition of calf as well as the breeder of the calf have been shown to be significant sources of variation for live weight traits at different stages of the animal's life. These factors should be considered when selection procedures are developed. Breed composition can be most favorable when implemented in the correct production system. It has been shown that calves with higher Simmental percentages weigh heavier at weaning than that of higher Brahman. Thus these heavier calves would be perfect for a weaner production system where quick growing calves are of essence for the system to be effective and economical. The calves with a higher percentage of Brahman composition reached a heavier 600-day weight than calves with higher Simmental origin. These calves with higher Brahman would be better for a finishing production system where there is sufficient feed all year round to keep calves till 600 days and sell at a later stage at a heavier weight. It can also been seen from the results that the breeder of the calf played a notable role accounting for most of the variation associated with WW, YW and 600-day weight. Thus, the opportunity exists for inferior breeders to buy superior genetics from the more advanced studs or even learn from them to improve the overall mean for the traits studied for the Simbra breed.

Considering the impact of the non-genetic factors in growth of the Simbra breed it is important to adjust performance records for known environmental effects to increase expected genetic change through selection (Marlowe *et al.*, 1965; Raphaka, 2008). Adjustment procedures and adjustment factors often vary for different populations within species. Many breeds have their own set of adjustment factors. Although adjustment factors are easily obtainable in literature it may be deficient for the Simbra breed. The age of dam adjustment factor enables fair comparison within the Simbra breed during performance evaluations. BW and WW are well known traits that include the adjustment of dam age and sex of calf (Raphaka, 2008).

3.6. References

Ahunu, B.K., Arthur, P.F. & Kissiedu, H.W.A., 1997. Genetic and phenotypic parameters for birth and weaning weights of purebred and crossbred Ndama and West African Shorthorn cattle. *Livestock Production Science. 51*, 165-171.

Amen, T.S., Herring, A.D., Sanders, J.O. & Gill, C.A., 2007. Evaluation of reciprocal differences in *Bos indicus x Bos taurus* backcross calves produced through embryo transfer: II. Post weaning, carcass, and meat traits. *Journal of Animal Science. 8,:* 373-379.

Barkhouse, H.L., Van Vleck, L.D., Cundiff, D.S., Buchanan, D.S. & Marshall, D.M., 1998. Comparison of sire breed solutions for growth traits adjusted by mean expected progeny differences to a 1993 base. *Journal of Animal Science. 76*, 2287-2293.

Brown, J.C. & Galvez, M., 1969. Maternal and other effects on birth weight of beef calves. *Journal of Animal Science. 28*, 162-167.

Burrow, H.M., 2001. Variances and covariances between productive and adaptive traits and temperament in a composite breed of tropical beef cattle. *Livestock Production Science. 70*, 213-233.

Carvalheira, J.G., Blake, R.W., Pollak, E.J. & Van Soest, P.J., 1995. Comparison of Landim and Afrikaner cattle in southern Mozambique: Body weights and growth. *Journal of Animal Science*. *73*, 3519-3526.

Christian, L.L., Hauser, E.R. & Chapman, A.B., 1965. Association of preweaning and postweaning traits with weaning weight in cattle. *Journal of Animal Science. 24*, 652-659.

Dillard, E.U., Rodriquez, O. & Robinson, O.W., 1980. Estimation of additive and non-additive direct and maternal genetic effects from crossbreeding beef cattle. *Journal of Animal Science. 50*, 653-663.

Drewry, K.J., Brown, C.J. & Honea, R.S., 1959. Relationships among factors associated with mothering ability in beef cattle. *Journal of Animal Science. 18*, 938-946.

Elzo, M.A., Quaas, R.L. & Pollak, E.J., 1987. Effects of age of dam on weight traits in the Simmental population. *Journal of Animal Science. 64*, 992-1001.

Franke, D.E., Habet, O., Tawah, L.C., Williams, A.R. & DeRouen, S.M., 2001. Direct and maternal genetic effects on birth and weaning traits in mutibreed cattle data and predicted performance of breed crosses. *Journal of Animal Science.* 79, 1713-1722.

Garrick, D.J., Pollak, E.J., Quaas, R.L. & Van Vleck, L.D., 1989. Variance heterogeneity in direct and maternal weight traits by sex and percent purebred for Simmental-sired calves. *Journal of Animal Science. 67*, 2515-2528.

Gilmour, A.R., Gogel, B.J., Cullis, B.R., Welham, S.J. & Thompson, R., 2002. ASREML user guide release 1.0 VSN International Ltd. Hemel Hempstead. UK.

Gregory, K.E., Blunn, C.T. & Marvel, L.B., 1950. A study of some of the factors influencing the birth and weaning weights of beef calves. *Journal of Animal Science. 9*, 338-346.

Gregory, K.E., Cundiff, L.V., Smith, G.M., Laster, D.B. & Fitzhugh, H.A., 1978. Characterization of biological types of cattle. Cycle II. I. Birth and weaning traits. *Journal of Animal Science. 47*, 1022-1030.

Holloway, J.W., Butts, W.T., Jr., J.R., McCurley, E.E., Beaver,H.L., Peeler,H.L. & Backus,W.L., 1985. Breed x nutritional environment interactions for beef female weight and fatness, Milk production and calf growth. *Journal of Animal Science. 61*, 1354-1363.

Hopkins, I.R., 1977. The effect of level of environment on sex differences in preweaning growth rate in beef cattle. *Animal Production. 25*, 47-51.

Kocak, S., Tekerli, M., Ozbeyaz, C. & Yuceer, B., 2007. Environmental and genetic effects on birth weight and survival rate in Holstein calves. *Turkey's Journal of Veterinary Animal Sciences. 31*, 241-246.

Koch, R.M. & Clark, R.T., 1955. Influence of sex, season of birth and age of dam on economic traits in range beef cattle. *Journal of Animal Science. 14*, 386-397.

Koger, M. & Knox, J.H., 1945. The effect of sex on weaning weight of range valves. *Journal of Animal Science. 4*, 15-19.

Krupa, E, Oravcova, M, Polak, P, Huba, J., & Krupova, Z., 2005. Factors affecting growth traits of beef cattle breeds raised in Slovakia. *Czech Journal of Animal Science*. *50*, 14-21.

Leighton, E.A., Willham, R.L. & Berger, P.J., 1982. Factors influencing weaning weight in Hereford cattle and adjustment factors to correct records for these effects. *Journal of Animal Science. 54*, 957-963.

Marlowe, T.J., Mast, C.C. & Schalles., 1965. Some non-genetic influences on calf performance. *Journal of Animal Science. 24*, 494-501.

Martin, J.B. & Blunn, C.T., 1952. Some factors affecting gestation length and birth weight of beef cattle. *Journal of Animal Science. 11*, 34-41.

Melka, H.D., 2001. Genetic parameter estimates for weaning traits in a multibreed beef cattle population. Magister Thesis, University of Stellenbosch, South Africa.

Nephawe, K.A., 1998. An investigation into sire x ecological region interactions for birth and weaning weight in Bonsmara cattle. Magister Thesis, University of the Orange Free State, South Africa.

Pico, B.A., 2004. Estimation of genetic parameters for growth traits in South African Brahman cattle. Magister Thesis, University of the Free State, South Africa.

Pitchford, W.S., Barlow, R. & Hearnshaw, H., 1993. Growth and calving performance of cows from crosses between the Brahman and Hereford. *Livestock Production Science. 33*, 141-150.

Plasse, D., Fossi, H., Hoogensteijn, R., Verde, O., Rodriguez, R., Rodriguez, M.C. & Bastidas, P., 1995. Growth of F_1 *Bos taurus* x *Bos indicus* vs *Bos indicus* beef cattle in Venezuela. I. Weights at birth, weaning and 18 months. *Journal of Animal Breeding and Genetics. 112,* 117-132.

Pribyl, J., Sebo, K. & Pribylova, J., 2000. Breeding value and variance components estimation of birth and 120 days weight of Charolais cattle with respect to direct and maternal genetic effect. *Czechoslovakian Journal of Animal Science. 45,* 397-403.

Raff, H., Strang, K.T. & Widmaier, E.P., 2004. Blood and homeostasis. IN Human physiology: The mechanisms of body function 9th Edition. Ed. M. Watnick. McGraw-Hill Companies Inc. New York, USA.

Raphaka, K., 2008. Estimation of genetic and non-genetic parameters for growth traits in two beef cattle breeds in Botswana. Magister Thesis, University of Stellenbosch, South Africa.

Reynolds, W.L., DeRowen, T.M., Moin, S. & Koonce, K.L., 1980. Factors influencing gestation length, birth weight and calf survival of Angus, Zebu and Zebu cross beef cattle. *Journal of Animal Science. 51*, 860-867.

Riley, D.G., Chase, C.C., Coleman, S.W. & Olson, T.A., 2007. Evaluation of birth and weaning traits of Romosinuano calves as purebreds and crosses with Brahman and Angus. *Journal of Animal Science. 85*: 289-298.

Roberson, R.L., Sanders, J.O. & Cartwright, T.C., 1986. Direct and maternal genetic effects on preweaning characters of Brahman, Hereford and Brahman-Hereford crossbred cattle. *Journal of Animal Science. 63*, 438-446.

Robinson, O.W., Yusuff, M.K.M. & Dillard, E.U., 1978. Milk production in Hereford cows. I. Means and correlation. *Journal of Animal Science. 47*, 131-136.

Rumph, J.M. & Van Vleck, L.D., 2004. Age-of-dam adjustment factors for birth and weaning weight records: A review. *Genetics and Molecular Research. 3*, 1-17.

SAS, 2004. Statistical Analysis Systems user's guide. (Version 9). SAS Institute Inc., Cary, North Carolina, USA.

Schoeman, S.J., Van Zyl, A. & De Wet, R., 1993. Direct and maternal additive and heterotic effects in crossbreeding Hereford, Simmentaler and Afrikaner cattle. *South Africa Journal of Animal Science. 23*, 61-66.

Shelby, C.A., Clark, R.T. & Woodward, R.R., 1955. The heritability of some economic characteristics of beef cattle. *Journal of Animal Science. 14, 372-385*.

Smith, G.M., Laster, D.B. & Gregory, K.E., 1976. Characterization of biological types of cattle. I. Dystocia and preweaning growth. *Journal of* Animal *Science. 43*, 27-36.

Sushma, G., Ramesh Gupta, B., Vinoo, G.V., Reddy, N. & Reddy,S., 2006. Influence of genetic and non-genetic factors of body weights and body measurements of Ongole cattle. *Indian Journal of Animal Science. 75,* 228-235.

Trus, D. & Wilton, J.W., 1988. Genetic parameters for maternal traits in beef cattle. *Canadian Journal of Animal Science. 68*, 119-128.

Villalba, D., Casasus, I., Sanz, A., Estany, J. & Revilla, R., 2000. Pre-weaning growth curves in Brown Swiss and Pirenaica calves with emphasis on individual variability. *Journal of Animal Science. 78*, 1132-1140.

Young, L.D., Cundiff, L.V., Crouse, J.D., Smith, G.M. & Gregory, K.E., 1978. Characterization of biological types of cattle. VIII. Post-weaning growth and carcass traits of tree-way cross steers. *Journal of Animal Science. 46*, 1178-1191.

Zishiri, O.T., 2009. Genetic analyses of South African terminal sire sheep breeds. Magister Thesis. University of Stellenbosch, South Africa.

CHAPTER 4

GENETIC FACTORS INFLUENCING GROWTH TRAITS IN SIMBRA CATTLE

4.1. Abstract

Genetic factors affecting growth in Simbra cattle are reported for the first time in South Africa in this study. Co (variance) components were estimated for the Simbra breed by means of ASREML procedures. Traits studied included birth weight (BW), weaning weight at 200 days (WW), yearling weight at 400 days (YW) and 600-day weight. The most suitable animal models were used to construct genetic parameters. The model for BW included direct additive effects (h^2), maternal additive effects (m^2), and the correlation between the two (r_{am}). A h^2 value of 0.56 ± 0.08, m^2 value of 0.15 ± 0.05 and a r_{am} value of -0.75 ± 0.07 was obtained for BW. The model for WW included the same effects as for BW except for the effect of dam permanent environment (c^2) that had to be added. A h^2 value of 0.67 ± 0.09, m^2 value of 0.25 ± 0.09, c^2 value of 0.04 ± 0.05 and a r_{am} value of -0.93 ± 0.07 was obtained for WW. The model for YW included the exact same effects as that for BW. A h^2 value of 0.70 ± 0.11, m^2 value of 0.18 ± 0.07 and a r_{am} value of -0.85 ± 0.08 was obtained for YW. The model for 600-day weight only included direct additive effects and an h^2 value of 0.10 ± 0.03 was obtained. Genetic and environmental correlations were estimated using multivariate analysis. The genetic correlations between the traits studied were favourable although low and indicated that selection for one trait will improve the other traits in a desired direction.

Keywords: heritabilities, correlations, single-trait, multi-trait, growth

4.2. Introduction

Growth rate has been proved to be the main selection criterion for most beef breeders around the world, thus consistent information about the traits indicating growth potential is of great importance (Liu *et al*., 1991). Live weight traits throughout the animals' life have been shown to be an effective indicator of growth potential (Pico 2004). Live weight traits include birth weight (BW), weaning weight (WW), yearling weight (YW) and 600-day weight measurements. To implement sound breeding principles and evaluate ongoing breeding programs knowledge about these genetic parameters are important. Genetic parameter estimates enable beef breeders to genetically improve production, as well as reproduction traits, by means of well-constructed breeding plans and precise selection. The latter will contribute to higher profit margins that are the main objective of any beef producer and for that matter any other livestock producer.

Genetic parameter estimates for growth traits were readily available for European and some prominent tropical beef cattle breeds (Demeke *et al.,* 2003). Even though literature results also included estimates for the Simmental (Trus & Wilton, 1988; Bennet *et al.,* 1996) and Brahman (Pico 2004; Martinez & Galindez., 2006), which form the genetic basis of the Simbra, Mohd-Yusuff &

Dickerson (1991) found that the genetic variance in a composite population may be more or less than for the parental breeds. Even if estimates were available for the Simbra breed the genetic parameter estimates only applies to a specific population and may change over time due to selection and management practises (Bourdon, 2000; Meyer, 1994). The genetic parameters that are of interest include heritability, genetic- and phenotypic correlation as well as repeatability. The latter are computed as functions of their (co) variance components. The resemblance between genetically related animals can be used in the estimation of trait heritability. This is where the computation of variance components within and between family members plays a fundamental part (Bourdon, 2000).

There is thus a constant need for regular (co) variance component estimation to keep the genetic parameters as accurate as possible to improve the traits under selection in the breed under investigation. The objective of this study was to estimate (co) variance components for BW, WW (200-day), YW (400-day) and 600-day weight for the Simbra breed. This was done by means of restricted maximum likelihood procedures (ASREML) (Gilmour *et al.*, 2002).

4.3. Materials and Methods

4.3.1. Records

The full description of the data as well as the editing is given in Chapter 3.

4.3.2. Statistical Analysis

The ASREML program (Gilmour *et al*., 2002) was used for the estimation of (co) variance components for each trait separately and all pairs of traits jointly. The traits under investigation were BW, WW at 200 days, YW at 400 days and 600-day weight. The animal model is considered the model of choice for a wide range of applications and was implemented in the analysis of the four traits measured (Meyer, 1992). The model incorporated all pedigree information available to minimize bias due to selection and to increase the accuracy of estimation through additional ties between animals. Six alternative models were implemented that included the direct genetic effect, maternal genetic and permanent environmental effects for the traits studied. Model six was the comprehensive model with another five reduced models, which ignored one or two of the maternal effects and/ or assumed no covariance between the direct and maternal genetic effects. The fixed effects (see Chapter 3) that were found to be significant ($P < 0.05$) were incorporated into the operational models. The models fitted included the fixed effects of breed composition, breeder, year, month and dam age. BW, WW, YW and MCW were included as covariates where appropriate. The random effects were then added to the analytic models subsequently. The contribution of each random effect was assessed by means of Likelihood Ratio tests (LRT) to establish the significance of each random term contribution. The LRT is a statistical test of the goodness-of fit between hierarchically nested models. LRT is based on principle of testing twice the increase in Log-likelihood from adding a random effect to the analytic model as a Chi^2 statistic. Alternatively, assuming that the fixed effects are identical for each model with the same number of random effects, the model with the higher Log-likelihood value will fit the data best (Zishiri, 2009).

The following single-trait animal models (in matrix notation) were fitted for each trait:

1. $Y = Xb + Z_1a + e$
2. $Y = Xb + Z_1a + Z_2m + e$ with cov (a,m) = 0
3. $Y = Xb + Z_1a + Z_2c + e$
4. $Y = Xb + Z_1a + Z_2m + Z_3c + e$ with cov (a,m) = 0
5. $Y = Xb + Z_1a + Z_2m + R_{am} + e$ with cov (a,m)
6. $Y = Xb + Z_1a + Z_2m + Z_3c + R_{am} + e$ with cov (a,m)

Where:

Y = the vector of the calf's record for each growth trait

X = a known incidence matrix that relates **Y** to **b**

b = the vector of fixed effects

Z_1, Z_2 and Z_3 = known incidence matrices relating the observation (Y) to the unknown random effects of a, m and c

a = a random vector for the calf's own additive genetic effects

m = a random vector of maternal additive genetic effects

c = a random vector of permanent maternal environmental effects

e = a vector of random residual errors

R_{am} = the covariance between the additive and maternal additive genetic effects

It is furthermore assumed that:

$V(a) = A\sigma^2_a$

$V(m) = A\sigma^2_m$

$V(c) = I\sigma^2_c$

$V(e) = I\sigma^2_e$

$Cov(a,m) = A\sigma_{am}$

Where:

A	= the numerator relationship matrix
σ^2_a	= additive genetic variance
σ^2_m	= maternal additive genetic variance
σ^2_c	= maternal permanent environmental variance
σ^2_{am}	= genetic covariance between direct and maternal effects
σ^2_e	= the residual error variance
I	= an identity matrix

Heritabilities were estimated as follows:

1. Direct additive genetic effects

   $h^2_a = \sigma^2_a / \sigma^2_p$ where σ^2_p is the phenotypic variance

2. Maternal genetic effects

   $h^2_m = \sigma^2_m / \sigma^2_p$

3. Genetic correlation between direct and maternal effects

   $r_{am} = \sigma_{am} / (\sigma^2_a \sigma^2_m)^{0.5}$

With A being a numerator relationship matrix between animals and I being an identity matrix. Where σ^2_a, σ^2_m, σ^2_c and σ^2_e direct additive genetic variance, maternal additive genetic variance, the maternal permanent environmental variance and the variance of residual error.

In order to compute the genetic and phenotypic relationships of the traits a three-trait analysis was conducted for birth weight (BW), weaning weight (WW) and yearling weight (YW). The number of records used for the analysis showed a significant decline when compared to that of the single trait analysis.

4.4. Results and Discussion

4.4.1. Model Selection

Log likelihood values were obtained for single-trait analyses of the respective traits. Inclusion of random factors such as direct additive effects, direct additive maternal effects, dam permanent environmental effects and the correlation between direct additive and maternal additive effects resulted in significant improvements in log likelihood values. The results that were obtained during model construction are depicted in Table 4.2. Models with the highest log likelihood values were chosen for the analysis of the traits respectively. Model 5 was most suitable for BW and YW analysis with log likelihood values of –6779.49 and –8987.32 respectively. This was consistent with the results of Demeke *et al.* (2003) and Meyer (1992). Model 6 was most suitable for WW (200-day) with a log likelihood value of –11838.50. This result was consistent with the study of Meyer (1992) where a compressive model that included dam permanent environment was used. Model 1 was used for the 600-day weight analysis with a log likelihood value of –632.58.

Table 4.1. Log likelihood ratios for the respective random effects models fitted to growth traits in the Simbra breed.

Effects	**Birth weight**	**Weaning weight (200-day)**	**Yearling weight (400-day)**	**600-day weight**
Fixed effects only	-6887.71	-11909.3	-9029.65	-651.61
Fixed + h^2	-6828.28	-11866.1	-9001.19	**-632.58**
Fixed + h^2 + m^2	-6827.33	-11866.1	-9001.14	-632.58
Fixed + h^2 + c^2	-6827.33	-11865.2	-9001.19-	-632.58
Fixed + h^2 + m^2 + c^2	-6827.33	-11877.3	-8987.32	-632.58
Fixed + h^2 + m^2 + r_{am}	**-6779.49**	-11877.8	**-8987.32**	-632.58
Fixed+ h^2 + m^2 + r_{am}+ c^2	-6799.36	**-11838.5**	-8987.32	-632.58

4.4.2. Single-trait analysis

The direct additive heritability estimates for BW and WW were consistent with that of Gutierrez *et al.* (1997); Schoeman *et al.* (2000) and Wasike *et al.* (2006) respectively. It can be seen from Table 4.3 that the direct additive heritabilities (h^2) for BW (0.56 ± 0.08), WW measured at 200-days (0.67 ± 0.09) and YW measured at 400-days (0.70 ± 0.11) was relatively high compared to the bulk of estimates in Table 2.2. The h^2 estimate for YW was also much higher when compared to that of Bishop (1992); Meyer (1992); Bennett & Gregory (1996) and Shenu *et al.* (2008). Skrypzeck *et al.* (2000) found even a higher direct additive heritability for BW in a multibreed beef cattle population in South Africa with an estimate of 0.72 (see Table 2.2.). A much lower direct additive heritability estimate of 0.10 ± 0.03 was obtained for 600-day weight. Although present literature was scarce for this trait it was not consistent with the results of Swiger (1961) and Shelby *et al.* (1955) that obtained a value of 0.47 and 0.84 respectively. The reason for this might be the data structure and a lot of environmental variance compared to genetic variance. The environmental variance could be due to calf management after yearling weight since environmental stress markedly affects the magnitude of the additive genetic variance for growth traits (Demeke *et al.,* 2003). However, the low direct additive heritability obtained for 600-day weight was roughly in agreement with that reported by Pico (2004), who obtained a value of 0.18, for South African Brahman cattle.

The higher estimates for direct additive heritability, together with a high coefficients of variation for BW, WW and YW implies high genetic variability in the Simbra breed and therefore offers the opportunity of improvement of these traits through selection. Skrypzeck *et al.* (2000) and Bennett & Gregory (1996) found that these high direct heritabilities reported for composites are in fact fqairly common compared to that of purebreds. Rodriquez-Almeida *et al*. (1995) suggested that the variability in heritability estimates might be due to the inclusion of non-additive genetic variances. The dominance effect is one of the factors associated with the higher and possibly biased estimates in crossbred populations and were not fitted in the current model. Ferreira *et al*. (1999) suggested dominance effects as well as the epistatic variance to be partly responsible for inflated estimates associated with animal model estimates of composite breeds.

Maternal additive heritability was lower than direct heritability for BW, WW and YW. The latter implies that body weights were determined more by genetic characteristics of the calf than by those of the dam. This was consistent with most findings in literature and is a well-known feature. Maternal additive heritability estimates of 0.15 ± 0.05, 0.25 ± 0.07 and 0.18 ± 0.07 were obtained respectively for the weights measured. This was not consistent with the findings of Raphaka (2008); Martinez & Galindez (2006); Pico (2004); Tosh *et al.* (1999) and Eler *et al*. (1995) that obtained much lower values for the maternal additive heritability for both BW and WW. The current findings were more similar to those of Wasike *et al.* (2006); Skrypzeck *et al.* (2000) and Schoeman *et al*. (2000) that obtained slightly higher maternal additive heritabilities. This is also in agreement with the findings of De los Reyes *et al.* (2006); Burrow. (2001); Ahunu *et al.* (1997); Gutierrez *et al*. (1997); Waldron *et al.* (1993) and Trus & Wilton (1988) that reported even higher maternal additive heritabilities for BW and WW. There was not much stated in literature for YW maternal additive heritability estimates, except for the report of Meyer (1992) that reported a value of 0.04 for Angus, 0.11 for Hereford and 0.14 for Zebu cross cattle in Australia. The reason for these low estimates was due to the diminishing ‘carry-over’ effect of the maternal influence till weaning on YW (Meyer, 1992). This is also the reason for the little information found in literature, for the maternal effects associated with post weaning traits. Many authors regard maternal effects as unnecessary for post-weaning traits and do not even include them in the genetic evaluation (Garrick *et al.,* 1989 and Koch & Clark, 1955). The high additive maternal heritabilities for BW and WW indicate that, together with a high coefficient of genetic variation, considerable opportunity exists for the improvement of these traits.

It must be kept in mind that the rather large direct and maternal genetic estimates are substantially inflated due to the exclusion of both heterosis and recombination effects. The inflation was of higher importance for maternal effects than the direct additive heritabilities (Demeke *et al*., 2003).

The dam permanent environment (c^2) estimates were only obtained for WW with a value of 0.04 ± 0.05. This effect is coded as an effect of the dam e.g., possibly due to uterine capacity, feeding level in late gestation and maternal behaviour (Eler *et al.,* 1995). The c^2 was smaller than the maternal additive heritability. This was consistent with the findings of Meyer (1992); Dodenhoff *et al*. (1998) and Tosh *et al*. (1999). This is also in concurrence with the results reported by Wasike *et al*. (2006) and Demeke *et al*. (2003), but not with that reported by Melka (2001); Skrypzeck *et al.* (2000) and Bennett & Gregory (1996) that obtained values of respectively 0.24, 0.12 and 0.13 for permanent maternal environment for WW. The results were also fairly consistent with their parental breeds estimates. Pico (2004) and Lee *et al.* (1997) reported c^2 estimates of 0.07 and 0.03 for South African Brahman and American Simmental respectively.

The genetic correlation between direct and maternal effects (r_{am}) was highly negative for BW (r_{am} = -0.75 ± 0.07), WW (r_{am} = -0.93 ± 0.07) and YW (r_{am} = -0.85 ± 0.08). Negative estimates are howeverommon in beef cattle for preweaning growth traits (Skrypzeck *et al.,* 2000). The r_{am} estimates reported throughout the literature had conflicting magnitude and direction. The r_{am} estimates for birth weight were not in agreement to those summarized in the reviews of Raphaka (2008); Martinez & Galindez (2006); Tosh *et al.* (1999); Meyer (1994); Waldron *et al.* (1993) and Meyer, (1992) that found positive genetic correlations between direct and maternal additive effects. Although the estimates obtained by Sarmiento & Garcia (2007); De los Reyes *et al.* (2006); Burrow (2001); Schoeman *et al.* (2000); Skrypzeck *et al*. (2000); Haile-Mariam & Kassa-Mersha, (1995) and Koch (1972) showed a negative correlation between direct additive and maternal additive effects, the values was still not as strongly negative than those obtained in the current study. The results were however in agreement with those reported by Melka (2001) for a muti breed population in South Africa and Eler *et al.* (1995) for Nelore cattle in Brazil. Meyer (1992) also obtained relatively strong negative r_{am} values (-0.78) for WW and YW (-0.39) in Zebu cross cattle. It was indicated that these values are most possibly inflated by environmental co-variance. This environmental co-variance could have been the result of i.e. daughters of dams with superior maternal abilities that provide an inferior maternal environment for their offspring. Fatty udder syndrome is a well-known occurrence where dams with superior maternal ability overfeed their daughters, which inhibits proper development of its daughter's udder resulting in below-average maternal ability of the daughter (Meyer, 1997).

The high negative values obtained in this study indicate an antagonistic effect between direct additive and maternal additive, suggesting a slow selection response for the four growth traits measured. Both effects should be taken into account in selection processes to achieve optimum genetic progress (Dezfuli & Mashayekhi, 2009). Thus selection of genetically superior animals for growth traits will result in genetically inferior animals for maternal genetic components for these traits.

The reason for this strong negative r_{am} estimates can be partially explained by the poor and small data/population structure and not the true antagonistic biological relationship between the direct and maternal genetic effects. Robinson (1996); Roso *et al*. (2005); Heydarpour *et al*. (2008) found that the data structure can affect both the magnitude as well as the standard error of the large negative values obtained for r_{am} estimates. This was also reported in a recent study done for South African bred sheep done by Zishiri (2009). The data used for the analysis resembles that of field data and tend to be highly unbalanced with missing records and poor linkage between generations and herds. The latter is primarily due to inconsistent recording and small herd sizes of the Simbra breed (Wasike *et al.,* 2006). Meyer (1997) attributed the negative r_{am} estimates to unaccounted sources of variation due to management practices. Dodenhoff *et al.* (1998) and Meyer (1997) proposed that if models were to be fitted with regression of offspring performance on maternal phenotype and sire by herd-year interaction affects the magnitude of the direct-maternal correlation would decline. Wasike *et al.* (2006) reported the same results with Kenyan Boran cattle. Meyer (1992) suggested further research is required into the modelling of maternal effects in beef cattle.

The inflated direct additive heritabilities for BW, WW and YW together with the large negative correlation between direct and maternal effects need further investigation.

Table 4.2. Estimates of variance components and ratios from single-trait analysis of growth traits in the Simbra breed.

Variance Components	**Birth weight**	**Weaning weight (200day)**	**Yearling weight (400 day)**	**600-day weight**
Direct additive (σ_a^2)	6.54 ± 6.40	690.38 ± 6.31	707.98 ± 5.38	3269.25 ± 3.86
Maternal additive (σ_m^2)	1.79 ± 3.31	260.52 ± 3.24	183.40 ± 2.65	na
Maternal permanent environment (σ_c^2)	na	48.95 ± 0.95	na	na
Direct additive and maternal additive covariance (σ_{am})	-2.57 ± -4.23	-398.02 ± -5.39	-305.69 ± -3.93	na
Total phenotypic (σ_p^2)	11.72 ± 0.32	1020 ± 32.70	1006 ± 38.03	32635 ± 645.6
Residual (σ_e^2)	5.95 ± 9.68	417.93 ± 6.02	420.65 ± 5.33	29366.7 ± 32.20
Direct additive (h^2 ± SE)	0.56 ± 0.08	0.67 ± 0.09	0.70 ± 0.11	0.10 ± 0.03
Maternal additive (m^2 ± SE)	0.15 ± 0.05	0.25 ± 0.07	0.18 ± 0.07	na
Dam permanent environment (c^2 ± SE)	na	0.04 ± 0.05	na	na
Direct additive and maternal additive correlation (r_{am} ± SE)	-0.75 ± 0.07	-0.93 ± 0.07	-0.85 ± 0.08	na

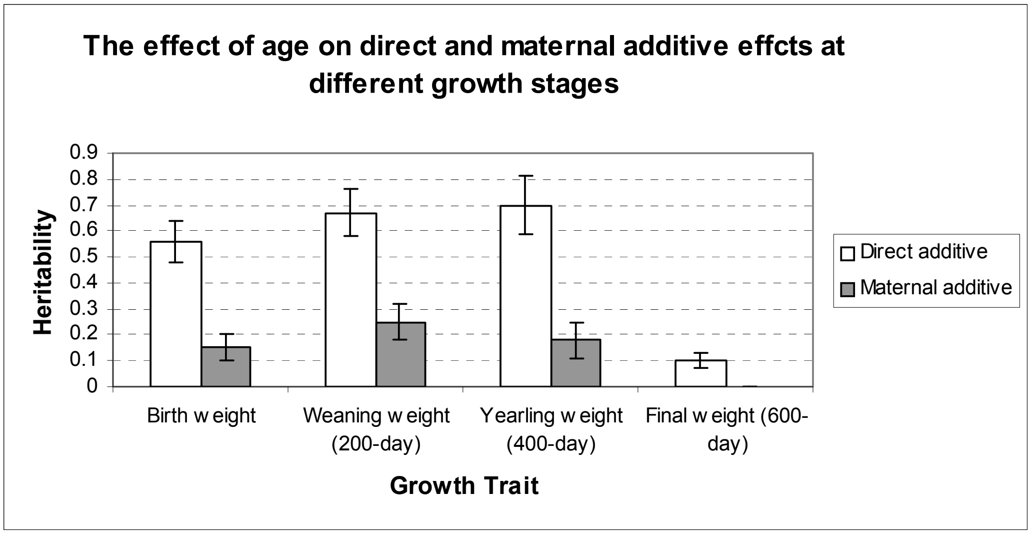

Figure 4.1. Trends in h^2 and m^2 respectively for the Simbra breed with an increase in the age at which weights were recorded. Vertical bars around the observed means denote standard errors.

4.4.3. Three-trait analyses

A three trait analysis was done for BW, WW at 200-days and YW at 400-days. After editing a total of 12585 animals with complete weight records were kept for analysis. A lot of the animals were thus removed due to incomplete records and the loss of genetic linkage was inevitable. It was obvious from the log likelihood ratio tests that the animal model only containing additive genetic effects was the most suitable for the three-traits analysis. It can be seen from Table 4.3 that the direct additive heritability estimates (h^2) for BW (0.24 ± 0.07), WW measured at 200-days (0.33 ± 0.06) and YW measured at 400-days (0.38 ± 0.07) were in comparison with the bulk of estimates in Table 2.2. The direct additive heritability estimates for BW and WW was also identical to those obtained by Haile-Mariam & Kasse-Messa (1995) and Tosh *et al*. (1999).

Table 4.3. Estimates (SE in brackets) of genetic (above diagonal), direct heritability estimates (h^2) (on diagonal) and environmental correlation estimates (underneath diagonal) using a three-trait analysis in the Simbra breed.

	Birth weight	**Weaning weight**	**Yearling weight**
Birth weight	**0.24 (0.07)**	0.18 (0.16)	0.27 (0.16)
Weaning weight	0.09 (0.06)	**0.33 (0.06)**	0.52 (0.10)
Yearling weight	0.07 (0.06)	0.45 (0.05)	**0.38 (0.07**)

When analysing for more than one trait in ASREML it becomes very complicated to specify the variance structure. When conducting a multiple trait analysis the error structure for the residual must be specified as two-dimensional with independent records and unstructured variance matrix across traits. This is mainly due to missing records in different patterns that are handled internally during the analysis. Finding initial values to commence the iteration sequence further exacerbates this and in some cases ASREML is coded to work some values out from the data (Zishiri, 2009; Gilmour *et al*., 2002).

4.4. Correlation among traits

The genetic (above diagonal) and environmental (underneath diagonal) correlation estimates are presented in Table 4.3. Genetic correlations between the traits studied were favourable indicating that selection for one trait will improve others in a desired direction. Compared to literature estimates the obtained estimates were much lower for all the traits studied. A value of 0.18 ± 0.16 was obtained for the genetic correlation between BW and WW indicating a small but positive relationship between the two traits. This correlation estimates is not consistent with other estimates reported in literature for BW and WW. From the published literature available r_g estimates ranged from 0.23 to 0.79 (Meyer, 1994; Eler *et al.,* 1995; Plasse *et al*., 2002; Pico 2004). An r_g estimate of 0.27 ± 0.16 was obtained for BW and YW. This is a stronger positive correlation than that of BW and WW, but still not as elevated as some of the estimates reported in literature. Meyer (1994) reported estimates of 0.70 and 0.79 for Angus and Zebu cross cattle in Australia. Pico (2004) reported a value of 0.47 for the South African Brahman. Interesting enough Eler *et al.* (1995) reported an even lower genetic correlation estimate (0.16) between BW and YW. A value of 0.52 ± 0.10 was obtained for the genetic correlation between WW and YW indicating a strong positive correlation between the two traits. However the latter is still not consistent with the estimates obtained in literature. Meyer (1994) reported a value of 0.95 and 0.79 for Angus and Zebu cross cattle. Pico (2004) reported a 0.88 r_g estimate.

The environmental correlations between BW and WW as well as BW and YW were relatively low (0.09 ± 0.06 and 0.07 ± 0.06) respectively. The r_e estimate (0.45 ± 0.05) between WW and YW was much higher and indicated a strong positive relationship between the two traits. These results were consistent with that reported by Pico (2004). Although the correlation estimates were relatively low, compared to that of literature (Eler *et al.,* 1995), they were still positive indicating that selection for high BW will result in higher WW as well as YW. High BW selection is generally not recommended to avoid economic loss because of dystocia.

Genetic correlation estimates are found to be renowned for their inconsistency and large standard errors. The reason for the diversity of estimates reported could be due to the fact that all estimates of r_g depend on the models that were utilized as well as the random factors included in the model development (Zishiri, 2009). However, the present correlation estimates is uncharacteristically low and need to be further investigated.

4.5. Conclusion

Heritability estimates (both direct additive and additive maternal) were high compared to literature results from purebreds but not that of composites during single trait analyses for BW, WW and YW. 600-day weight however showed a remarkable low direct heritability and could have been due to large environmental variance associated with this trait. When a three-traits analysis was done for the same traits it was found that the heritability estimates dropped remarkably as well. The obtained direct additive heritability estimates from both analyses indicates that genetic improvement is possible through selection and should be implemented in such a manner that growth rate is maximized while BW is kept at an optimal level to avoid dystocia. The low r_g estimates obtained between BW and WW as well as YW makes it possible to select for increased WW and YW and still avoid dystocia. The correlation estimates between direct additive and maternal additive was very strong negative for BW, WW and YW indicating a strong antagonistic effect between direct and maternal additive and must be kept in mind during selection procedures. However, due to the data structure these estimates could have been inflated and does perhaps not reflect the true biological values for the traits. Correlations were obtained during the three-trait analysis and indicated weak, but positive relationships between the traits studied. These correlation estimates were much smaller than that reported in most literature.

4.6. References

Ahunu, B.K., Arthur, P.F. & Kissiedu, H.W.A., 1997. Genetic and phenotypic parameters for birth and weaning weights of purebred and crossbred Ndama and West African Shorthorn cattle. *Livestock.* 51, 165-171.

Bishop, S.C., 1992. Phenotypic and genetic variation in body weight, food intake and energy utilization in Hereford cattle. I. Performance test results. *Livestock Production Science*. *30*, 1-18.

Burrow, H.M., 2001. Variances and co variances between productive and adaptive traits and temperament in a composite breed of tropical beef cattle. *Livestock Production Science. 70*, 213-233.

Bennett, G.L. & Gregory, K.E., 1996. Genetic (co) variances among birth weight, 200-day weight, and postweaning gain in composites and parental breeds of beef cattle. *Journal of Animal Science. 74,* 2598-2611.

Bourdon, R.M., 2000. The genetic model for quantitative traits. IN: *Understanding Animal Breeding. 2nd Edition.* Ed. K, Linsner & M, Carnis. Charles, E. Stewart, Jr. Prentice-Hall Inc. P. 110-120.

Demeke, S., Neser, F.W.C. & Schoeman, S.J., 2003. Variance components and genetic parameters for early growth traits in a mixed population of purebred *Bos indicus* and crossbred cattle. *South African Journal of Animal Science. 84*, 11-21.

De los Reyes, A., Elzo, M.A., Fries, L.A., Roso, V.M. and Carvalheiro, R., 2006. Non-genetic, additive and non-additive genetic effects for animal model analyses of weaning weights in a

Nellore x Hereford mutibreed population in Brazil. 8^{th} *World Congress on Genetics Applied to Livestock Production.*

Dezfuli, T.B. & Mashayekhi, R.M., 2009. Genetic study of birth weight and weaning weight in Najdi calves. *Journal of Animal and Veterinary Advances. 8,* 276-280.

Dodenhoff, J., Van Vleck, L.D., Kachman, S.D. & Koch, R.M., 1998. Parameter estimates for direct, maternal, and grand maternal genetic effects for birth weight and weaning weight in Hereford cattle. *Journal of Animal Science. 76*, 2521-2527.

Eler, J.P., Van Vleck, L.D. & Ferraz, J.B., 1995. Estimation of variances due to direct and maternal effects for growth traits of Nelore cattle. *Journal of Animal Science. 73*, 3253-3258.

Ferreira, G.B., Mac Neil, M.D. & Van Vleck, L.D., 1999. Variance components and breeding values for growth traits from different statistical models. *Journal of Animal Science. 77,* 2641-2650.

Garrick, D.J., Pollak, E.J., Quaas, R.L. & Van Vleck, L.D., 1989. Variance heterogeneity in direct and maternal weight traits by sex and percent purebred for Simmental-sired calves. *Journal of Animal Science. 67*, 2515-2528.

Gilmour, A.R., Gogel, B.J., Cullis, B.R., Welham, S.J. and Thompson, R., 2002. ASREML user guide release 1.0 VSN International Ltd. Hemel Hempstead. UK.

Gutierrez, J.P., Canon, J. & Goyache, F. 1997. Estimation of direct and maternal genetic parameters for pre-weaning traits in the Australian de los Valles beef cattle breed through animal and sire models. *Journal of Animal Breeding and Genetics. 114,* 261-266.

Haile-Mariam, M. & Kassa-Messa, H., 1995. Estimates of direct and maternal (co)variance components of growth traits in Boran cattle. *Journal of Animal Breeding and Genetics. 112*, 43-52.

Heydarpour, M., Schaeffer, L.R. & Yazdi, M.H., 2008. Influence of population structure on estimates of direct and maternal parameters. *Journal of Animal Breeding and Genetics*. 1*25*, 89-99.

Koch, R.M. & Clark, R.T., 1955. Genetic and Environmental relationships among economic characters in beef cattle. II. Correlations between offspring and dam and offspring and sire. *Journal of Animal Science. 14*, 786-791.

Koch, R.M., 1972. The role of maternal effects in animal breeding: VI. Maternal effects in beef cattle. *Journal of Animal Science. 35*, 1316-1323.

Lee, C., Van Tassell, C.P., & Pollak, E.J., 1997. Estimation of genetic variance and covariance components for weaning weight in Simmental cattle. *Journal of Animal Science. 75,* 325-330.

Liu, M.F., Makarechian, M. & Tong, K.W., 1991. Relationships between measures of absolute growth rate and between measures of relative growth rate in growing meat animals. *Journal of Animal Breeding and Genetics. 108*, 187-191.

Maiwashe, A.N., Bradfield, M.J., Theron, H.E. & van Wyk, J.B., 2002. Genetic parameter estimates for body measurements and growth traits in South African Bonsmara cattle. *Livestock Production Science. 75*, 293-300.

Martinez, G. & Galindez, R., 2006. Genetic and environmental trends for birth and weaning weights in registered Brahman cattle. *In: Procedures of the 8th World Congress for Genetic Applied Livestock. Production. Belo Horizonte. Brazil*.

Melka, H.D., 2001. Genetic parameter estimates for weaning traits in a multibreed beef cattle population. Magister Thesis, University of Stellenbosch, South Africa.

Meyer, K., 1992. Variance components due to direct and maternal effects for growth traits of Australian beef cattle. *Livestock Production Science. 31*, 179-204.

Meyer, K., 1994. Estimates of direct and maternal correlations among growth traits in Australian beef cattle. *Livestock Production Science*. *38*, 91-105.

Meyer, K., 1997. Estimates of genetic parameters for weaning weight of beef cattle accounting for direct-maternal environmental co variances. *Livestock Production Science. 52*, 187-199.

Mohd-Yusuff, M.K. & Dickerson, G.E., 1991. Genetic variation in composite and parental populations: expectation for levels of dominance and gene frequency. *Journal of Animal Science. 69*, 3983-3988.

Pico, B.A., 2004. Estimation of genetic parameters for growth traits in South African Brahman cattle. Magister Thesis, University of the Free State, South Africa.

Plasse, D., Verde, O., Fossi, H., Romero, R., Hoogesteijn, R., Bastidas, R. & Bastardo, J., 2002. (Co)variance components, genetic parameters and annual trends for calf weights in a pedigree Brahman herd under selection for three decades. *Journal of Animal Breeding Genetics. 119*, 141-153.

Raphaka, K., 2008. Estimation of genetic and non-genetic parameters for growth traits in two beef cattle breeds in Botswana. Magister Thesis, University of Stellenbosch, South Africa.

Robinson, D.L., 1996. Models which might explain negative correlation between direct and maternal genetic effects. *Livestock Production Science. 45*, 111-122.

Rodriquez-Almeida, F.A., Van Vleck, L.D., William, R.L. & Northcutt, S.L., 1995. Estimation of non-additive genetic variances in three synthetic lines of beef cattle using an animal model. *Journal of Animal Science. 73*, 1002-1011.

Roso, V.M., Schenkel, F.S., Miller, S.P. & Wilton, J.W., 2005. Additive, dominance and epistatic loss effects on preweaning weight gain of crossbred beef cattle from different *Bos tarus* breeds. *Journal of Animal Science. 83*, 1780-1787.

Sarmiento, R.M. & Garcia, J.P., 2007. Estimation of genetic parameters and variance components for growth traits in Romosinuano cattle in the Colombian humid tropics. *Genetic Molecular Research. 6*, 482-491.

Schoeman, S.J., Jordaan, G.F. & Skrypzeck, H., 2000. The influence of proportion of Simmental breeding in a multibreed synthetic beef cattle population on preweaning growth traits. *Journal of Animal Science. 30*, 98-109.

Shelby C.A., Clark., R.T. & Woodward, R.R., 1955. The heritability of some economic characteristics of beef cattle. *Journal of Animal Science. 14,* 372-385.

Shehu, D.M., Oni, O.O., Olorunju, S.A.S. & Adeyinka, I.A., 2008. Genetic and phenotypic parameters for body weight of Sokoto Gudali (Bkoloji) cattle. *International Journal of Applied Sciences. 2*, 64-67.

Skrypzeck, H., Schoeman, S.J., Jordaan, G.F. & Neser, F.W.C., 2000. Pre-weaning growth traits of the Hereford breed in a multibreed composite beef cattle population. *South African Journal of Animal Science. 30*, 220-229.

Swiger, L.A., 1961. Genetic and environmental influences of gain of beef cattle during various periods of life. *Journal of Animal Science. 20*, 183-188.

Tosh, J.J., Kemp, R.A. & Ward, D.R., 1999. Estimates of direct and maternal genetic parameters for weight traits and back fat thickness in a multibreed population of beef cattle. *Canadian Journal of Animal Science. 79*, 433-439.

Trus, D. & Wilton, J.W., 1988. Genetic parameters for maternal traits in beef cattle. *Can. Journal of Animal Science. 68,* 119-128.

Waldron, D.F., Morris, C.A., Baker, R.L. & Johnson, D.L., 1993. Maternal effects for growth traits in beef cattle. *Livestock Production Science. 34*, 57-70.

Wasike, C.B., Ilatsia, E.D., Ojango, J.M.K. & Kahi, A.K., 2006. Genetic parameters for weaning weight of Kenyan Boran cattle accounting for direct-maternal genetic co variances. *South African Journal of Animal Science. 36*, 275-281.

Zishiri, O.T., 2009. Genetic analyses of South African terminal sire sheep breeds. Magister Thesis. University of Stellenbosch, South Africa.

CHAPTER 5

GENETIC TRENDS IN THE SIMBRA BREED

5.1. Abstract

Estimated breeding values were obtained through single trait analysis for birth weight (BW), weaning weight (WW) and yearling weight (YW) to construct genetic trends for the genetic evaluation of the Simbra breed. The single trait analyses were conducted by means of ASREML. The three traits under investigation was birth weight (BW), weaning weight at 200-days (WW) and yearling weight at 400-days (YW). During the evaluation period of 1987 to 2009 a general decline in annual predicted breeding values (PBV) for WW and YW was found together with a slight increase in BW PBV's. A regression coefficient of 0.003 ± 0.005 and an R-square (R^2) of 0.03 were obtained for BW. An annual increment in BW of 0.01 % was established for the breed. A regression coefficient (b) of –0.11 ± 0.06 was obtained for the linear regression of annual predicted breeding value on WW with a R^2 equal to 0.30. In general the genetic trends for BW are acceptable while those for WW and YW are not improving. It is thus important that the breeding objectives for the latter be revised in able to improve genetic trends in future generations for the Simbra breed.

Keywords: genetic trends, Simbra, birth weight, weaning weight, yearling weight

5.2. Introduction

Genetic trends are the result of selection pressured on specific traits in a particular direction. Genetic trends indicate the amount of genetic improvement over time, or lack thereof, in a population for certain traits (Zishiri, 2009). Due to the fact that genetic trends change over time, owing to the evolution of the breed, these trends are being routinely published and enable improvement programs should the breed lack sustained genetic improvement (Sullivan *et al*., 1999). Genetic trends for growth traits have been found to be almost always positive across breeds. However the magnitudes varied considerably among breeds for the traits. Genetic changes will accumulate in the population over time and, as the breed moves towards higher levels of production, improvements in environmental conditions would also be necessary. Stronger genetic trends have been reported for lighter breeds and weaker genetic trends for heavier breeds (Sullivan *et al*., 1999). Annual genetic trends can be estimated by regressing the mean annual breeding value of the animals on the corresponding birth years (Plasse *et al.,* 2004). The estimated genetic merit within breeds enables the fair comparison of across-breed genetic comparisons when combined with appropriate breed difference estimates this is ideal for across-breed selection to improve the breed lacking genetic merit. It is also important to note that where poor genetic links (connectedness) exists the comparisons of predicted breeding values (PBV) might be biased. The objective of this study was to evaluate and quantify the genetic progress achieved in the Southern African Simbra breed.

5.3. Materials and Methods

5.3.1. Records

Refer to Chapter 3 for the full description, as well as editing, of records obtained in this study.

5.3.2. Statistical Analysis

The ASREML program (Gilmour *et al*., 2002) was used for the estimation of (co) variance components as well as the prediction of breeding values for each trait during single trait analyses utilizing all available pedigree information. Genetic trends were calculated as the regression of average predicted breeding value on year of birth.

The traits under investigation were BW, WW at 200 days and YW at 400 days. The animal model is considered the model of choice for a wide range of applications and was implemented in the analysis of the three traits measured (Meyer, 1992). The model incorporated all pedigree information available in order to minimize bias due to selection and to increase the accuracy of estimation through additional ties between animals. Six alternative models (as described in Chapter 4) were implemented that included direct genetic-, maternal genetic- and permanent environmental effects for the traits studied. Model six was the comprehensive model with another five reduced models, which ignored one or two of the maternal effects and/or assumed no covariance between the direct and maternal genetic effects (Demeke *et al.*, 2003). The fixed effects that were found to be significant ($P < 0.05$) were incorporated into the operational models. The models fitted included the fixed effects of breed composition, breeder, year, month and dam age. BW, WW, YW and MCW were fitted as covariates where appropriate. The random effects were then added to the analytic models subsequently. The contribution of each random effect was assessed by means of Likelihood Ratio tests (LRT) in order to establish the significance of each random term contribution. The LRT is a statistical test of the goodness-of fit between hierarchically nested models. LRT is based on principle of testing twice the increase in Log-likelihood from adding a random effect to the analytic model as a Chi^2 statistic. Alternatively, assuming that the fixed effects are identical for each model with the same number of random effects, the model with the higher Log-likelihood value will fit the data best. (Zishiri, 2009)

5.4. Results and Discussion

It is evident from Figure 5.1 that the mean annual predicted breeding values (PBV) for BW display great variation between years ranging from 1987 to 2009. The little number of records available from 1987 to 1996 (Figure 5.2) probably accounted for the large amount of variation associated with the predicted breeding values (PBV) compared to the later years. BW showed an increase from –0.35 kg in the year 1987 to reach a peak of +0.19 kg in 1996. The mean breeding value then declined from 1998 to reach a low of –0.12 in 2008. The overall regression coefficient (b) of the predicted breeding value for BW was 0.003 ± 0.005 and the R^2 was 0.03 for the linear regression of annual predicted breeding value on BW during the evaluation period of 1987 to 2009. Expression of b as a percentage of the least square mean of BW (35.16 kg) yielded an annual increment in BW of 0.01%. A genetic improvement of 0.01% *per annum* in BW is not high, but this is equal to a 0.004 kg increase per year and over a few years this could become problematic for the breed if not evaluated on a regular basis. In a study done by Plasse *et al*. (2004) he found a 0.08 kg increase per year, which was much higher compared to the current study results. However, Plasse *et al*. (2002) obtained similar results for Brahman in Venezuela. Unlimited increase in BW selection will lead to excessive large calves, dystocia and substantial economic loss (Brown & Galvez, 1969). BW has been shown to be an important factor also associated with perinatal calf losses, losses of cows at calving and on calf growth rate (Holland *et al.,* 1977). Patterson & Thompson (1971) found that cows that experience calving difficulty also had a subsequent reduction in reproductive performance as well as a decreased milk production. It is thus important that the selection objectives need to be reviewed for the Simbra breed to avoid future loss.

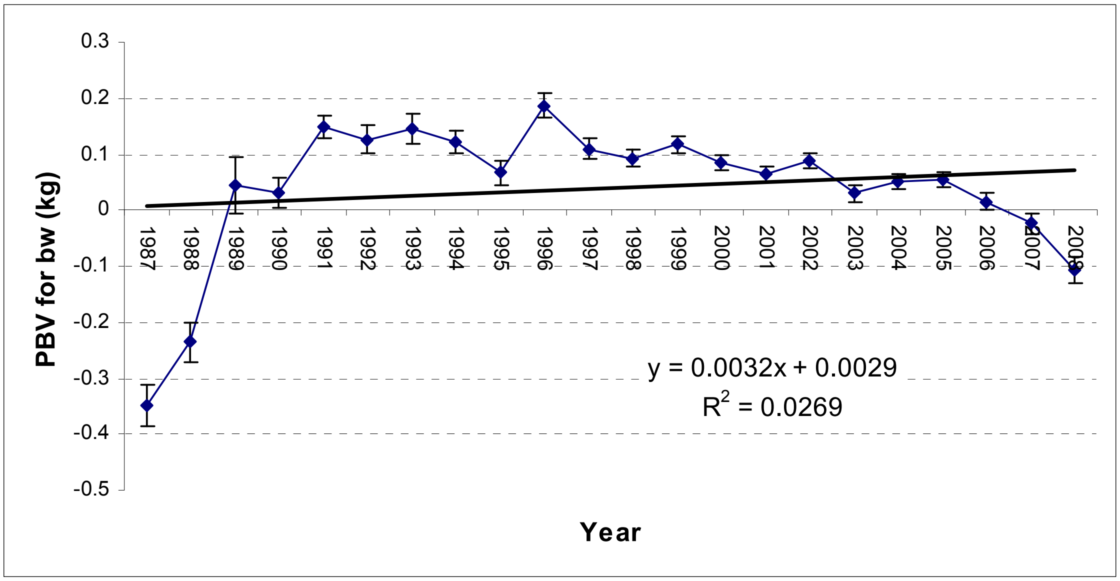

Figure 5.1. Mean annual predicted breeding values (PBV) for birth weight (BW) for the Simbra breed. Annual means are accompanied by the relevant standard error.

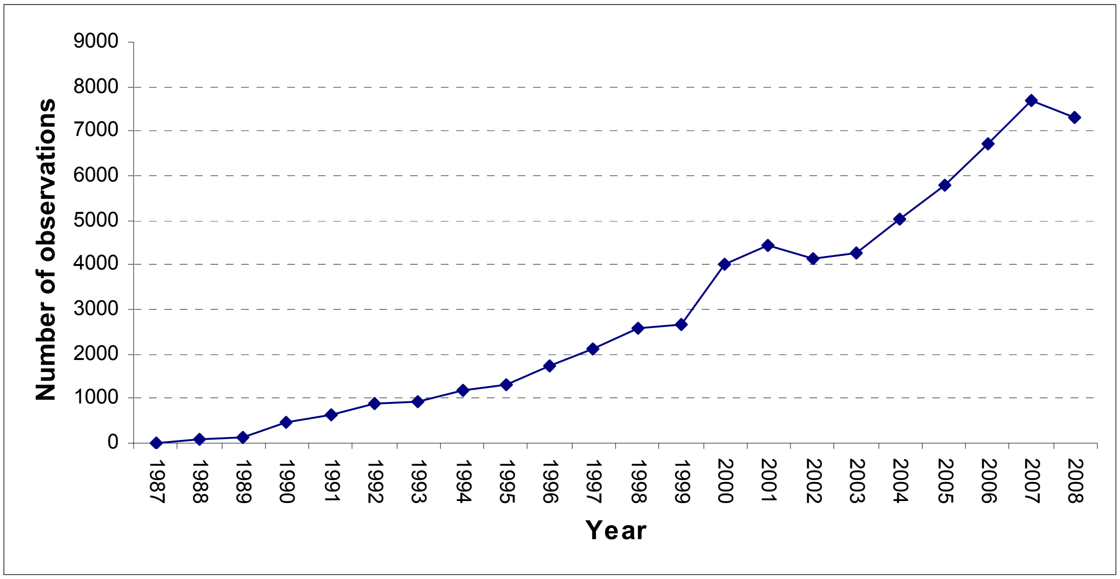

Figure 5.2. The number of observations per year used for analyses for the Simbra breed.

Figure 5.3 indicates a large amount of variation associated with annual predicted breeding values for WW for the Simbra breed. This is in association with that of annual breeding values for BW. The annual PBV's showed fluctuations of increased and decreased estimates throughout the evaluation period of 1987 to 2008. However the overall trend showed a decline for annual predicted breeding values for WW. This is of vast concern for the Simbra breed and needs to be addressed with immediate effect. A regression coefficient (b) of –0.10 ± 0.06 was obtained for the linear regression of annual predicted breeding value on weaning weight with a R^2 of 0.26.

Expression of b as a percentage of the least square mean of WW (232.52 kg) yielded an annual decline in WW of 0.04 %. The latter is equal to a 0.09 kg decline per year. This is not in agreement with most literature results that reported positive genetic trends for weaning weight across various breeds. (Sullivan *et al*., 1999; Kaps *et al*. 1999) Enns & Nicoll (2008) and Plasse *et al.* (2002) reported annual increases of 0.43 kg and 0.14 kg respectively for weaning weight. Although 0.04 % does not account for a great deal it can easily lead to substantial economic loss if not handled carefully. The current findings were not in agreement with that reported in other evaluation studies done for beef cattle. Plasse *et al*. (2004) showed a highly significant annual increase of 0.52 kg per annum fro Brahman cattle.

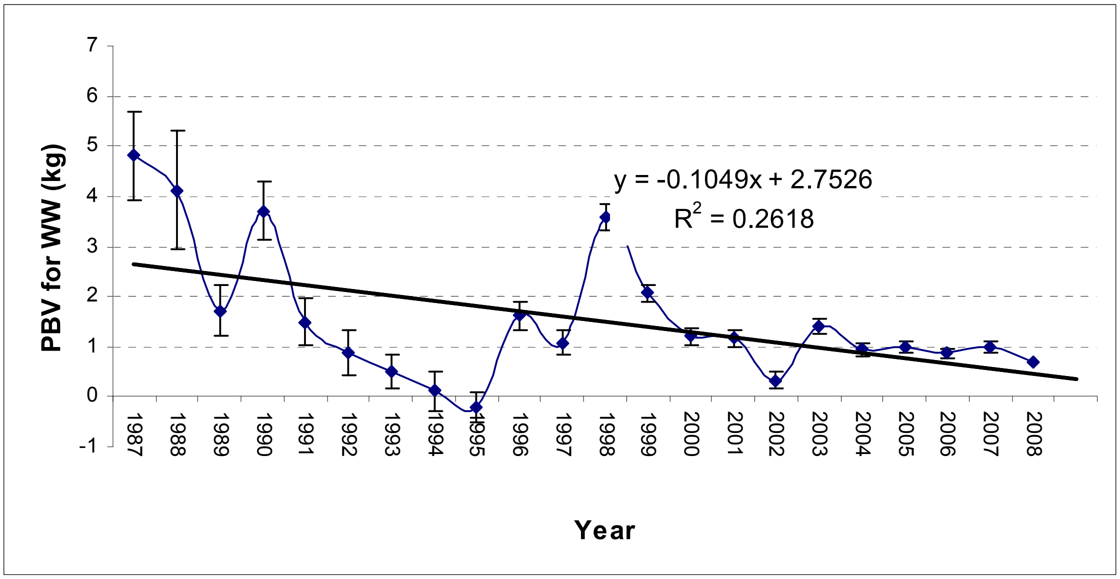

Figure 5.3. Mean annual predicted breeding values (PBV) for weaning weight for the Simbra breed. Annual means are accompanied by the relevant standard error.

The annual predicted breeding value for YW (Figure 5.4) showed a decline from 1987 to 1996 with a value of 3.33 kg in 1987 and an ultimate low value of –0.24 kg in 1996. After 1996 PBV'S increased to 0.57 kg in 2000. PBV's showed another decline from 2000 up till 2003. PBV's improved considerably after 2003 to reach a peak of 2.84 kg in 2007. The latter indicates improvement in YW PBV's, but the overall trend was still negative for the majority of YW PBV's with another decline of 0.28 kg in 2008. A regression coefficient (b) of –0.05 ± 0.05 was obtained for the linear regression of annual predicted breeding value on YW with a R^2 of 0.10. Expression of b as a percentage of the least square mean of WW (302.60 kg) yielded an annual decline in YW of 0.02%. This is not in agreement with other literature results that reported positive genetic trends throughout for YW (Sullivan *et al*., 1999; Kaps *et al*., 1999). Enns & Nicoll (2008) reported an annual genetic trend of 0.72 ± 0.06 for YW in Angus cattle. As with WW, 0.02% does not account for a great deal, but it can easily lead to great economic loss if not treated with concern. This accounts for 0.06 kg decline annually for YW.

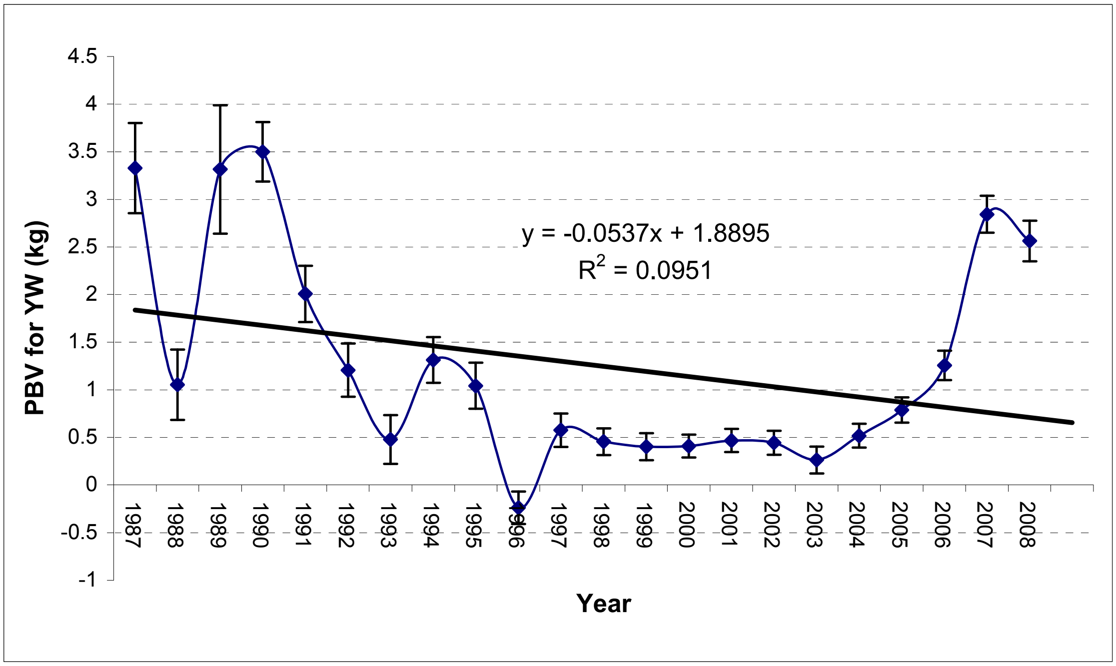

Figure 5.4. Mean annual predicted breeding values (PBV) for yearling weight for the Simbra breed. Annual means are accompanied by the relevant standard error.

5.5. Conclusion

Genetic trends varied between years for the traits studied indicating either changing selection objectives or selection deficiencies. The high to very high heritability estimates obtained for YW (0.70 in the single trait analysis and 0.38 in the three trait analysis) as well as for WW (0.67 in the single trait analysis and 0.33 in the tree trait analysis) infers that live weight did not receive much attention. Thus we can only attribute this variability in the genetic trends due to different selection objectives for other traits rather than for live weight. According to the Southern African Simbra association more value is given to reproduction traits rather than growth traits and this could have been the reason for the trend obtained. The decline in WW and YW is detrimental for any slaughter breed due to the direct effect on profitability and will lead to a reduced competitiveness for the Simbra breed in future generations. It is needed to urgently revise the selection objectives for these traits with immediate effect. Larger and better recorded datasets as well as improved genetic evaluation procedures may improve the accuracy of genetic predictions and thus result in more accurate genetic trends. Newman *et al*. (1973) found that the selection differential accumulates very slowly in a herd in the first few years of a breeding program and the expected genetic change can take many years before the effect is evident. It is thus important to determine selection objectives and to implement them with immediate effect.

5.6. References

Brown, J.C. & Galvez, M., 1969. Maternal and other effects on birth weight of beef calves. *Journal of Animal Science. 28*, 162-167.

Enns, R.M. & Nicoll, G.B., 2008. Genetic change results from selection on an economic breeding objective in beef cattle. *Journal of Animal Science. 86*, 3348-3357.

Gilmour, A.R., Gogel, B.J., Cullis, B.R., Welham, S.J. and Thompson, R., 2002. ASREML user guide release 1.0 VSN International Ltd. Hemel Hempstead. UK.

Holland, B.J.M., Mullaney, P.D. & Hopkins, I.R., 1977. Breed and environmental factors affecting birth weight in Victorian beef cattle. *Journal of Animal Science. 17*, 5-9.

Kaps, M., Herring, W.O., & Lamberson, W.R., 1999. Genetic and environmental parameters for mature cow weight in Angus cattle. *Journal of Animal Science. 77,* 569-574.

Newman, J.A., Rahnefeld, G.W. & Fredeen, H.W., 1973. Selection intensity and response to selection for yearling weight in beef cattle. *Canadian Journal of Animal Science. 53*,1-12.

Patterson, H.D. & Thompson, R., 1971. Recovery of inter-block information when block sizes are unequal. *Biometrika. 58*, 545-554.

Plasse, D., Verde, O., Fossi, H., Romero, R., Hoogesteijn, R., Bastidas, R. & Bastardo, J., 2002. (Co)variance components, genetic parameters and annual trends for calf weights in a pedigree Brahman herd under selection for three decades. *Journal of Animal Breeding and Genetics. 119,* 141-153.

Plasse, D., Arango, J., Fossi, H., Camaripano, L., Llamozas, G., Pierre, A. & Romero, R., 2004. Genetic and non-genetic trends for calf weights in a *Bos indicus* herd upgraded to pedigree Brahman. *Livestock Research for Rural Development. 16*, 142-159.

Raphaka, K., 2008. Estimation of genetic and non-genetic parameters for growth traits in two beef cattle breeds in Botswana. Magister Thesis, University of Stellenbosch, South Africa.

Sullivan, P.G., Wilton, J.W., Miller, S.P. & Banks, L.R., 1999. Genetic trends and breed overlap derived from multiple-breed genetic evaluations of beef cattle for growth traits. *Journal of Animal Science. 77,* 2019-2027.

Zishiri, O.T., 2009. Genetic analyses of South African terminal sire sheep breeds. Magister Thesis, University of Stellenbosch, South Africa.

CHAPTER 6

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Genetic and non-genetic factors affecting growth traits in Simbra cattle are reported in this study for the first time. Non-genetic factors have been found to affect live weights measured throughout the animal's life. Live weight includes birth weight (BW), weaning weight (WW), yearling weight (YW) and 600-day weight. The fixed effects, which included gender of calf, breed composition of calf, breeder of calf, year of birth, month of birth and dam age, should be incorporated during genetic evaluation of live weight traits. However dam age did not affect YW or 600-day weight significantly. Breed was found to not be significant enough to be encountered during yearling trait analysis. Fitting mature cow weight as a covariate significantly ($P < 0.05$) affects all live weight traits studied. During multiple comparison of least square means, a difference between the breed compositions were encountered for BW and WW. Calves with higher Brahman inheritance were heavier at birth, while calves with higher Simmental inheritance were heavier at weaning. Calves with a higher Simmental component would probably be more suitable for less challenging areas where weaner production is of higher importance. In areas where the environment is more challenging and extensive cattle farming is practised with more available space to keep calves longer, a higher Brahman component is recommended due to the higher 600-day weight. Male calves have also been found to weigh heavier than female calves up till 600-day weight. Some years and months also showed significant differences for the traits, with some years and months revealing higher weights than others. There is thus a need to adjust for some of these factors to enable a fair comparison between animals.

During single trait analyses for each of the live weight traits relatively high heritability estimates were obtained for BW, WW and YW, except for 600-day weight, with very small direct maternal and maternal permanent environment effect estimates. The Direct heritability estimates obtained during the three-trait analysis were lower than that of the single trait analyses and were more realistic. The latter indicates that live weight traits are mostly under direct genetic control and provides the potential of genetic improvement through selection. The genetic correlation estimates obtained during the multi-trait analyses were relatively small, but positive for all traits studied, indicating a favourable response for YW when selecting for WW. Positive genetic correlation between BW and later weights may be a cause for concern as an increase in BW could be associated with an increase in the incidence of dystocia, resulting in economic loss. The correlation between direct and maternal effects obtained in the single trait analyses was highly negative for BW, WW and YW indicating an antagonistic effect.

However, care should be taken when interpreting results from a scientific analysis because the accuracy and validity could have been jeopardised by unforeseen factors and does not reflect the true biological principle. The data structure has been found unsatisfactory in many ways and was the possible reason for the loss of valuable genetic information and some inflated values. During the multi trait analyses 91.54% of the records were discarded and not useful for genetic analysis. It is thus very important that breeders need to be informed about the accurate and regular measurements of traits to obtain proper results.

Genetic trends were constructed for BW, WW and YW. Although some of the years indicated positive means for the predicted breeding values the overall trend was negative for both WW and YW with large variation between years. This is of great concern due to the fact that Simbra's are supposed to be used for their effective growth. Due to the large amount of variation within the Simbra breed the opportunity exists for genetic improvement for the various live weight traits, thereby improving the growth potential of the Simbra. When these traits are combined in a suitable selection index together with other important traits like carcass and reproduction, the same genetic gain can be made. It is important that a proper selection balance between traits of economic importance without an over emphasis on growth traits. The emphasis should rather be on the genetic and environmental improvement of total cow efficiency as well as functional efficiency. Although selection for the latter would be difficult because most of the fitness, adaptability and functional efficiency traits are hard to measure and low in heritability, it should still be investigated and implemented. During the analysis it was found that the stability of cows was very low. This could have been due to the in and out flow of breeders during the analysis or due to inadequate cow performance. This is surely a trait that needs investigation due to the fact that heifers are expensive to maintain till they can reproduce and should at least remain in the herd for 6-8 years to optimise the farming system. Maximising the rate of genetic change can indeed be valuable, but only when selection objectives are valid.