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NON-GENETIC FACTORS AND CORRELATION STUDIES IN CATTLE.

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ABSTRACT

The data comprised of 3272 birth weight (BWT), 3091 weaning weight (WWT), 2112 yearling weight (YWT) and 1978 eighteen month weight (18-MO) pedigree records were collected from an experimental indigenous Tuli cattle herd maintained at Matopos Research Station, Bulawayo, Zimbabwe, over the period 1988-1997 were used for this study. The mean BWT, WWT, YWT and 18-MO during the study period were from 28.14± 0.07 kg, 176.43± 0.07 kg, 176.58± 0.07 kg and 242.68 ± 0.07 kg with, respectively. It was found that sire, year of birth, sex of calf, age of dam had significant effect ($p<0.01$) effect on all growth trait. It was inferred that male calves were significantly heavier than female calves. The birth weight and weaning weight were found to be highest in seven and eight year groups, respectively, and the lowest in three-year group. The inconsistency of literature estimates indicates the importance of estimation of environmental factors that affect growth traits within specific experimental herds and environment. Correction of environmental effects is necessary to increase accuracy for selection of growth traits in indigenous Tuli cattle.

In the development of any breeding plan knowledge of various properties of traits under consideration is required. Bivariate and multivariate analyses fitting an animal model, were conducted by means of (ASREML) procedures to obtain the genetic correlations. The fixed effects included in the model were sex, year of birth and age of dam. Heritability estimates for growth traits associated with the bivariate analyses were higher than those obtained using multivariate analyses. The phenotypic correlations between growth traits from both bivariate and multivariate analyses were positive and, were moderate to high. The genetic correlation between birth weight and weaning weight was positive and moderate. The genetic correlation between birth weight and post-weaning growth traits were moderate and positive, indicating that these traits are not under exactly the same genetic control. Selection for yearling weight may increase birth weight due to positive indirect selection response and high heritability (h^2_a). Birth weight is a good indicator of post-weaning growth traits in this herd.

KEY WORDS: Non-Genetic, Correlation, Growth Traits, Beef.

INTRODUCTION

Numerous environmental factors influence growth traits in beef cattle (Holland and Odde, 1992; Fields and Sand, 1994) and the knowledge of the extent of their effects on weight traits enable development of effective management systems for increased beef production. Although some work has been published on environmental factors affecting growth traits in indigenous Nguni cattle of Zimbabwe (Assan, 2006) no such studies have been undertaken in indigenous Tuli cattle of Zimbabwe. To fulfill this purpose a study was therefore planned to investigate various environmental factors that affect growth traits in indigenous Tuli cattle breed.

Growth in cattle is generally described as a series of traits each representing weight within some predefined range in age (Ferraz et al 2000). The potential for change in economically important traits such as weight traits is largely dependent on their genetic variation and correlation (Mohiuddin, 1993) within the predefined range of age. Selection for aggregate genetic improvement in beef cattle is most effective when relationships among the traits selected are known (Splan, et. al., 2002). If phenotypic correlations are estimated more accurately could serve as indicators of the magnitude and sign of the genetic correlation (Lynch and Walsh, 1998). Literature estimates on relationships between growth traits vary widely across authors, years, methods and breeds (Swalve, 1993, Koots, et al., 1994a, 1994b) and the somewhat arbitrary age demarcations in different production systems and countries. Numerous phenotypic and genetic correlations for growth traits have been published and correlations reported in these studies are highly variable (Meyer, 1992). No correlation estimates among growth traits are available for the indigenous Tuli cattle of Zimbabwe

MATERIALS AND METHODS

Matopos Research Station (20 0 23ô S, 310 30ô E.) situated 30 km South West of Bulawayo in Zimbabwe. Altitude is low (800m) experiences low erratic rainfall (<450) per annum (Homann et al 2007). Very high summer temperatures, maximum and minimum mean temperatures of hottest months are 21.6 0 C and 11.4 0 C, respectively. Possibility of severe droughts (Hagreveas et al. 2004). The most common type of vegetation is sweet veld with comparatively high nutritional value of browse and annual grass species (Ward et al 1979). If managed well the rangelands should be able to meet the nutritional requirements of goats and other livestock (Van Rooyen et al 2007).

However, significant proportion of the rangeland are now degraded, resulting in low biomass and thus

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limited feed resource of poor quality particularly during the dry season (Hlatshwayo, 2007). Day et al (2003) and. Gambiza and Nyama (2000) gives a detailed description of the climate and vegetation type, respectively. The management of the herd was described by Assan (2006).

The data comprised of 3272 birth weight (BWT), 3091 weaning weight (WWT), 2112 yearling weight (YWT) and 1978 eighteen month weight (18-MO) pedigree records were collected from an experimental indigenous Tuli cattle herd maintained at Matopos Research Station, Bulawayo, Zimbabwe, over the period 1988-1997 were used for this study. The effect of sire, sex of calf, year of birth and age of dam at calving were analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) (1999- 2000). Interactions and covariates were not fitted because there were not important. The linear statistical model fitted was:

$Y_{ijklm} = u + G_i + P_j + S_k + A_l + + e_{ijklm}$

Where:

Y_{ijklm} is the l^{th} observation of i^{th} sire, j^{th} year and k^{th} sex;

u is the overall population mean;

G_i is the random effect of i^{th} sire NID (0, ů$^2{}_s$);

P_j is the fixed effect of j^{th} year of birth (j = 1988, 1989,é é , 1997);

S_k is the fixed effect of k^{th} sex of calf (k = male, female);

A_l is the fixed effect of l^{th} age of dam (l = 1, 2,é é , 15);

e_{ijklm} is the random error associated with each observation assumed to be NID (0,ů$^2{}_e$).

Bivariate and multivariate analyses fitting animal models were conducted by means of Average Information Restricted Maximum Likelihood (ASREML) procedures using the program of Gilmour et al (2000) to obtain the phenotypic and genetic correlations. Fixed factors were determined through preliminary analyses using procedure GLM of SAS (1999- 2000). Fixed factors (main effects and interactions) and covariates were tested and removed from the model if found non-significant (P> 0.01). The fixed effects included in the model were sex, year of birth and age of dam. The numbers of records used to estimate the correlations are presented in Table 4. The general statistical model for growth traits.

$Y_{ijkl}=u + A_i + B_j + C_k + e_{ijkl}$

Y_{ijkl}=individual yield (BWT, WWT, YWT, 18-MO);

u=general mean;

A_i=fixed effect of age of dam (i= 3,4,5,15);

B_j=fixed effect of year of birth (j=1983, 1984, 1997);

C_k=fixed effect of sex (k= male, female);

e_{ijkl} =residual error;

The multivariate model used to estimate phenotypic and genetic correlations can be represented as follows:

y=Xb + Zu +e

With:

E[y]=Xb; E[u]=E[e]=0;

Var[u]=G=A # G_0; Var[e]=R=I # R_0

Where y is a vector **Nt*1** of records (**N** number of animal with performances and **t** number of traits), **b** is a vector of fixed environmental effects (sex, year of birth, age of dam), **u** is a vector of breeding values for additive direct genetic effects, **e** is a vector of residuals, $\mathbf{G_0}$ is a matrix the covariances for additive genetic effect among traits, $\mathbf{R_0}$ is a matrix the residuals covariance among traits, **I** represents the identity matrix and **#** Kronecker product, **X** and **Z** are incidence matrices relating the records to the effects of the model

RESULTS AND DISCUSSION

Birth weight and weaning weight

Analysis of variance for BWT and WWT are presented in Table 2 and interactions were excluded because were not important. All effects included in the model were found to be highly significant (p<0.01) sources of variation for BWT and WWT. Estimates of least square means and standard errors are reported in Table 1 and 2. Sires were included as the only random effect to make provision for genetic differences among animals (Kars et. al., 1993). The effect of sire was included in the final model since it increased the residual variance while reducing the standard errors of the main effects.

Table 1. Mean, standard deviation, proportion of total variance explained by each model (R^2,%) and test of significance (F) for sire, age of dam, year of birth and sex for growth traits in indigenous Tuli cattle of Zimbabwe.

SOURCE	df	BWT	WWT	YWT	18-MO
N		3272	3091	2112	1978
Mean (kg)		28.14	176.43	176.58	242.68
SD(kg)		4.04	26.9	26.85	31.37
R-square (%)		0.33	0.45	0.40	0.63
CV (%)		13.25	13.67	13.18	12.23
Significance of effects in the model					
Sire	1	70.87**	172.78**	498.90**	616.33*
Sex	1	661.60***	56940.25***	72357.26***	236014.24***
Year of birth	8	106.24***	8398.37***	4381.71***	40560.24***
Age	12	35.39***	2028.62***	2116.65***	1616.88***
Error		13.90	581.30	541.29	880.03

SD=Standard Deviation, R^2 = Coefficient of Determination, CV= Coefficient of Variation
*p<(0.05), **p<(0.01), ***p<(0.001)

Table 2. **Least squares means for growth traits in indigenous Tuli cattle of Zimbabwe**

Effects	BWT	WWT	YWT	18-MO
Sex				
Male	29.55±0.36	177.19± 1.52	180.89±1.73	263.49±2.35
Female	27.55±0.38	165.40±1.53	161.29±1.59	227.53±2.13
Age of dam				
3	27.14± 0.34	169.68 ±2.19	169.83± 2.40	247.03± 3.32
4	27.81 ±0.47	174.14 ±2.39	174.37± 2.54	252.64± 3.41
5	29.01±0.45	183.84 ±2.17	181.42± 2.27	255.46 ±3.03
6	29.73 ±0.44	180.79± 2.29	180.16± 2.37	255.21± 3.34
7	29.87 ±0.50	181.90± 2.66	180.84 ±2.79	252.21 ±3.52
8	29.28 ±0.47	184.77± 2.55	185.10 ±2.58	259.26 ±3.52
9	29.13± 0.50	181.02±2.69	176.93 ±2.75	250.44 ±3.68
10	28.45 ±0.60	175.82 ±3.35	175.96± 3.47	256.54± 4.79
11	27.76 ±0.80	171.63 ±3.52	173.48 ±3.58	248.33 ±4.86
12	28.37 ±1.24	168.66 ±3.98	165.85 ±3.83	235.23 ±5.17
13	29.80 ±1.35	162.02 ±4.44	160.51 ±4.27	229.36 ±5.62
14	29.22 ±1.29	146.25± 4.67	146.89± 4.49	217.80± 6.02
15	26.56 ±2.87	146.35 ±8.61	152.82 ±8.07	232.11 ±10.76
Year of birth				
1988	30.08 ±0.52	172.13 ±2.70	170.77± 2.55	254.68 ±3.87
1989	28.15 ±0.51	165.19± 2.76	163.95 ±2.60	202.92 ±3.40
1990	26.77± 0.52	158.97± 3.09	158.01 ±3.33	211.32 ±4.35
1991	26.74± 0.50	144.52 ±2.90	170.02± 3.13	255.00± 4.10
1992	25.47 ±0.63	198.33± 4.32	172.27± 5.07	292.78 ±9.65
1993	28.73±0.64	148.91 ±4.47	161.46 ±4.99	224.34 ±6.65
1994	27.25± 0.68	166.83± 4.79	166.26 ±5.24	213.64 ±6.89
1995	28.72 ±0.90	182.49± 6.09	189.16 ±6.20	284.13± 8.11
1996	32.23 ±0.83	185.96± 5.43	176.69 ±5.99	267.68 ±7.88
1997	31.36± 0.78	159.18 ±5.20	162.67± 5.78	-

Table 3 Genetic correlations in beef cattle

Reference	BWT: WWT	BWT: YWT	BWT: 18-MO	WWT: YWT	WWT: 18-MO	YWT: 18-MO
Alenda & Martin (1987)	0.57	0.75				
Bergh (1990)	0.64	0.65	0.47	0.99	0.69	0.71
Bosso et al 2009		0.28	0.23			0.82
Bourdon & Brinks (1982)	0.61	0.62		0.89		
Dezfuli and Mashayekhi, 2009	0.50					
Koch et al 1994				0.78		
Koster (1992)	051	0.91				
Swanepoel & Heyns (1988)	0.79					
present study (bivariate)	0.62	0.56	0.37	0.61	0.56	0.89
present study (multivariate)	0.59	0.42	0.32	0.71	0.58	0.67

Table 4. Phenotypic (r_p) and genetic (r_g) correlations between growth traits using bivariate and multivariate analyses.

	Bivariate analysis			Multivariate analysis		
Traits	**n**	**r_p**	**r_g**	**n**	**r_p**	**rg**
BWT*WWT	3712	0.86±0.04	0.62±0.22	2048	0.71±0.05	0.59±0.02
BWT*YWT	3548	0.76±0.05	0.56±0.38	2048	0.59±0.05	0.42±0.02
BWT*18-MO	2470	0.55±0.05	0.37±0.40	2048	0.44±0.05	0.32±0.01
WWT*YWT	3010	0.95±0.001	0.61±0.001	2048	0.92±0.005	0.71±0.00
WWT*18-MO	2144	0.85±0.001	0.56±0.02	2048	0.82±0.02	0.58±0.13
YWT*18-MO	2345	0.86±0.01	0.89±0.02	2048	0.84±0.01	0.67±0.13

The effect of year of birth was highly significant for BWT and WWT (p<0.001). BWT and WWT t were below average among calves born and weaned between (1988-1992) and average or above in the other years. The below average BWT and WWT in 1991- 1992 was due to prevailing drought in Zimbabwe which translated into low forage availability to animals on veld. In 1992 BWT and WWT were lightest while those born in 1996 were heaviest because of normal rain season experienced during this year. The result is substantiated by other findings (Assan , 2006) who reported that large differences in rainfall lead to marked differences between years in the quality and quantity of forage available and this is reflected in differences in calf BWT and WWT between years. Thorpe, et al., (1980) also reported that high variation in BWT due to year of birth could be explained by variation in the amount of rainfall, which in turn influence pasture production and availability of feed. Influence on birth weight operates through its effect on the dam's uterine environment mostly in late gestation (Eltawil et. al. 1970). Apart from the year's effect mainly caused by climate and its influence on the availability of pasture (Carles and Riley, 1984) and milk production of the dam (Shelby, et al., 1955) environmental factors including management, diseases control and the administrative ability of the persons responsible come into play. In the present study the influence of year of birth on BWT and WWT is expected due to the prevailing extensive farming conditions in which the herd was managed.

The data was tabulated according to the sex of calf to determine the effects of sex on BWT and WWT. It was observed that out of total births 49.36 and 50.63 percent were males and females , respectively and weaners of females and male ratios were 61 and 38 percent, respectively. The mean BWT were 29.55±0.36 and 27.55±0.38 in males and females, respectively, mean WWT were 177.19±1.52 and 165.40±1.53 kg in males and females, respectively. The results revealed that sex had a significant (p<0.01) effect on BWT and WWT (Table 2). At birth and weaning, male calves were 2.00 kg or 11.79 kg heavier than females (P<0.01), respectively. Influence of sex of calf on weight traits have been accounted for in animal models as fixed effects (Pico. 2004; Bosso et al 2009). The influence of gender on BWT and WWT has been attributed to hormonal differences between sexes and their resultant effects on growth (Bell et. al., 1970).

To quantify the effect of age of cow on BWT and WWT of calf the data were divided into 10 groups on yearly interval basis starting from three years including twelve years and above in one group due to small number of records beyond this limit. The maximum BWT (29.87±0.50 kg) and WWT (184.77±2.55 kg) were found in seven year group and eight year group, respectively, and minimum BWT (27.14±0.34 kg) and WWT (169.68±2.19 kg) both in the three year group (Table 2). As expected , BWT and WWT were affected by age of dam. This is in agreement with reports in literature by Gregory, et al., (1985) who found that age of dam affects BWT and WWT significantly (p<0.01), whereas Swanepoel and Heyns (1988) found no significant effect of age of dam on WWT in the case of Afrikaner cattle. Relative to calves from three-year-old dams, those with highest mean BWT and WWT were 2.73 kg and 15.09 kg heavier, respectively (Table 2). There was evidence of peak BWT and WWT for calves born of intermediate age (seven to eight). The effect of age of dam on BWT and WWT has been reported elsewhere (Ferraz et al 2000). Bosman and Harwin (1967) also found out that BWT and WWT increases with age of dam and reaches a maximum at about seven years after which it tends to decline. This trend was observed in the present study. The increase in calf BWT and WWT with age of dam partly is due to an increase in cow weight with age (Richardson et. al., 1979). Tawonezvi et. al., (1986) noted that BWT was positively correlated with cow weight at calving and the increased cow weight is due the advanced age. BWT has been shown to be influenced by age of dam because with young dams, which have not reached adult size, continue to grow during their first pregnancy and thus provide sterner competition with the fetus for the available nutrients. Most reports indicate a curvilinear relationship between age of dam and weight of her calves with the highest values from 6 to 10 years for Bos indicus (Venter, 1977), which agrees with the present study. The results from literature indicate that there is consistent pattern in different breeds and herds for the effect of age of dam on BWT and WWT. In small stock influence of dam age on birth weight and weaning weight has been reported. Young dams tend to produce smaller progenies at birth and lighter progeny at weaning in sheep and goats (Wilson, 1987).

Yearling weight and eighteen months weight

Differences between sire, year of birth, sex and age of dam were highly significant ($p<0.001$) for both post-weaning traits this conforms to reports in literature (Pico, 2004). The significance for sire effect for post-weaning weight did not declined even this could be probable sire influence carry over effects unlike the maternal influence which tend to decline with progressed age of the animal. Post-natal influence that has been estimated is the sum of the effects of the ‘true’ postnatal maternal environment and probably also the carried over effect of the prenatal maternal which would have declined by age of 1 year. Much of the sire-estimated effects are much of genetic potential than environmental for post-weaning growth. Bull calves were 11% and 14% heavier than heifers at 1-year weight and eighteen months weights, respectively.

Correlation

As reported in numerous studies estimates of the (direct) genetic correlations between subsequent weights of growing beef cattle were high. Values were some what lower for Zebu than Angus, indicating that the genetic determinants of growth at various ages are more diverse in a tropical than temperate environment (Meyer, 1992). Literature estimates for direct heritability are variable and range from low to high, however the direct heritability obtained in the present study were on the upper side (Table 5). The reason for the variability may be due to differences in statistical methods employed (e.g. sib analysis methods vs. regression of offspring on parent method) and models used (e.g. univariate, bivariate or multivariate analysis) (Lee et al 2000; Ferreira, et al,. 1999; Splan, et al,. 1998; Mercadante, et al. 1997) . The estimates of phenotypic and genetic correlations between the traits under consideration and their heritability estimate associated with the bivariate and multivariate analyses are presented in table 4 and 5, respectively. Albuquerque and Meyer (2001) reported estimates of genetic direct correlations were 0.65, 0.53, 0.44, 0.93, 0.82 and 0.97 between BWT and WWT, BWT and YWT, BWT and 18-MO, WWT and 18-MO, and YWT and 18-MO of age, respectively which agrees quiet well with the results of the present study. Mercadante et al (1995), in a review, reported weighted mean genetic correlations of 0.63, 0.41, 0.40 0.78, 0.71 and 0.77, respectively, at the same ages for Zebu breeds in the tropics. The genetic correlation between BWT and WWT in the present study positive and considerably agreeable with those estimates reported in literature (Bergh, 1990). The phenotypic correlation between birth weight and weaning weight in the present study is in close agreement with Kars (1994) in Nguni cattle in South Africa. The genetic correlation between BWT and YWT, and BWT and 18-MO were moderate and positive which is in agreement with other published results (Vesely, et al., 1971). The positive genetic correlation between BWT, YWT and 18-MO in the present study support the findings of Leighton (1982) that BWT may be a good indicator of post-weaning growth weights. Selection for YWY or 18-MO may increase BWT due to positive indirect selection response and the moderate heritability (h^2_a) derived from bivariate analysis. The positive genetic correlation of BWT and post-weaning growth traits in beef cattle appears common (Pico, 2004; Bosso et al 2009, Ferraz et al , 20000). This illustrate that genetic improvement will be possible with a positive genetic correlation as an intended increase in BWT may result in improved post-weaning growth in the herd. The positive genetic correlation may be an indication that BWT received greater attention or selection procedure was based on dams who produced heavier calves but, however increased birth weight could have not reached an extent of increased cases of dystocia in the herds’ breeding program. BWT has a potential economic importance through its positive effects on post-weaning growth hence increasing the economic success of producing heavier slaughter animals in this herd. The author suggests that an intermediate optimum for BWT in the herd has not been reached, however because of BWT positive genetic correlation with post-weaning weights there is a danger were excessively large calves liable to dystocia could be produced unlike excessively small calves which may be at risk of death from hypothermia , starvation, respiratory diseases and other causes. Therefore, it appears likely that a breeding program were an increase in BWT were calf survival is maximized would be desirable in this herd. However, studies should be carried out to ascertain the BWT range were calf survival may be maximized without increasing the rate at which dams suffer from dystocia, but at the same time maximizing improvement in post-weaning growth weights due to increased BWT. The use of a selection index with an appropriate weighting for BWT would be desirable in this case taking into account birth weight’s positive and moderate correlation with the post-weaning growth. The correlation amongst WWT, YWT and 18-MO were close to unity, indicating a part–whole relationship between these traits, which suggest that they could be influenced by the same genes. The high genetic correlation plus high heritabilities indicate that selection for increased WWT may successfully increase YWT and 18-MO. Selection for WWT is expected to improve YWT (Irgang, et al., 1985) and live weight at all other ages from birth to maturity (Barlow, 1978). BWT and WWT have been shown to be influenced by maternal additive genetic effects hence the prediction of correlated responses to selection should take into account maternal genetic effects (Hanrahan, 1976). In the case of YWT and 18-

MO, which are not subject to major maternal effects, correlated response in these traits can be obtained without taking maternal effects into consideration when selection is for either BWT and WWT. Caution should be applied in some cases because maternal effects on post weaning growth traits of beef cattle have been found in some breeds (Meyer, 1992). The genetic correlation between YWT and YWT corresponds closely with Bergh, (1990) which is little lower than the value reported by Kars, (1994). The pattern between genetic and phenotypic correlations is similar in that the correlations decrease as the age distance between weights increase. In particular, genetic correlation between subsequent ages approaches unity, however, the genetic correlation between early and late weights is moderate suggesting that early weights are not under exactly the same genetic control as weights taken at an older age. This has implications for potential to select on the shape of the growth curve as an animal can be above average weight at younger ages, but can be below average at older ages or vice versa. In addition, genetic correlations between weights at younger ages are lower than the correlations between weights taken at older ages with the same time lag. This is attributable to the influence of the part-whole relationship between weights, whereby weights at later ages depend on earlier weights, thus as time progresses the correlations between later weight increases as they are more dependent on the previous weight measured. A similar pattern has been demonstrated in genetic correlations between growth data at different ages in cattle (Meyer, 2002, pigs (Huisman, 2002) and sheep (Lewis and Brother-stone, 2002; Fischer, 2004).

CONCLUSION

Sire, year of birth, sex of calf and age of dam were found to be highly significant ($p<0.01$) sources of variation for growth traits in indigenous Tuli cattle at Matopos Research Station, as a result these environmental factors must be taken into consideration when selection procedures are developed. It is recommended that these effects be included in a model to describe the data as it may increase the residual variance while reducing the standard errors. The inconsistency of published indicates the importance of quantifying the effects of environmental factors on growth traits within a specific herd and environment, which the present study was trying to achieve. Failure to adjust for age of dam will result in selection biased against the progeny of younger dams with a resulting increase in generation interval and reduced selection intensity.

The estimates of phenotypic correlations between various growth traits in the present study were found to be positive, and were moderate to high. The genetic correlation between birth weight and weaning weight was moderate and positive, and suggest both traits should be included in a selection index with an appropriate weight age of birth weight to prevent undesirable increase in birth weight to minimize dystocia in the herd. This strategy could be adopted until an intermediate optimum for birth weight has been reached where calf survival is maximized. The genetic correlation between post-weaning growth traits were high some close to unity, indicating a part ïwhole relationship between these traits hence suggesting that post weaning growth traits are exactly under the same genetic control, as a result only one trait should be included in a breeding plan to facilitate considerable genetic improvement in post-weaning growth traits. Inclusion of yearling weight in breeding plan would enhance the improvement of both weaning weight and eighteen months. The pattern between genetic and phenotypic correlations is similar in that the correlations decrease as the age distance between weights increase.

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REFERENCES

Albuquerque, L.G. and Meyer, K., 2001. Estimates of covariance functions for growth from birth to 630 days of age in Nelore cattle. J. Anim. Sci. 79: 2776-2789.

Assan, N., 2006. A phenotypic study of growth traits in indigenous Nguni cattle of Zimbabwe. Afr. J. Agric. Res. 1 (2): 24- 26.

Barlow, R., 1978. Biological ramifications of selection for preweaning growth in cattle. A review. Anim. Breed. Abstr. 46:

Bell, G.H., Davidson, J.N. and Scarborough, H., 1970. Textbook of physiology and biochemistry. Longmans, Edinburgh, UK.

Bergh, L., 1990. Die gebruik van die kleiberverhouding in vleisbeesteelt. MSc (Agric) Thesis, Univ. Orange Free State. RSA.

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

Bosso, N.A., Van der Waaij, E.H., Agyemang, K. and. van Arendok, J.A. M., 2009. Genetic parameters for growth traits in NôDama cattle under tsetse challenge in the Gambia. Liv Res. Rural Dev. 21(3).

Brownlee, J.W.I., 1977. The Nguni cattle of Rhodesia. Rhodesia Agric. Sci. 58:878-886.

Carles, A.B. and Riley, J., 1984. Methods of analyzing the effect of season of birth on weaning weight in a Zebu* Temperate beef herd in Kenya. Anim. Prod. 38: 429.

Day, K.A., Maclaurin, G., Dube, S., Hlatshwayo, A. and Trevor, C., 2003. Capturing the benefits of seasonal climate forecasts in agricultural management. Final Report for Australian Centre for International Agricultural Research (ACIAR). June 2003. Sub Project 3- Grazing Systems in Zimbabwe, 67 pp.

Eltawil, L.E., Hazel, L.N., Sidwell, G.M. and Terril, C.E. , 1970. Evaluation of environmental factors affecting birth, weaning and yearling traits in Navajo sheep. J. Anim. Sci. 31: 823-827.

Ferraz, J.B.S., Eler, J.P. and Ribeiro, P.M.T., 2000. Genetic study of Santa Getrudis cattle in Brazil. Liv. Res. Rural Dev. 12(2): 130- 137.

Ferreira, G.B., MacNeil, M.D. and Van Vleck, L.D., (1999). Variance components and breeding values for growth traits from different statistical models. J. Anim. Sci.77; 2641- 2650.

Gambiza, J. and Nyama, C., 2000. Country pasture/forage resource profiles. Country profiles, Zimbabwe. Food and Agriculture Organization of the United Nations.

Gilmour, A.R., Cullis, B.R., Welham, S.J. and Thompson, R., 2000. ASREML Reference Manual
.
Gregory, K.E., Trail, J.C.M., Marples, H.J.S. and Kakonge, J., 1985. Characterization of breeds of Bos indicus and Bos Taurus for maternal and individual traits. J. Anim. Sci. 60:1165.

Hagreveas, S.K., Bruce D. and Beffa, L.M., 2004. Disaster mitigation options for livestock production in communal farming systems in Zimbabwe. 1. Background information and literature review. P.O. Box 776, Bulawayo, Zimbabwe: ICRISAT and FAO Rome, Italy 56pp.

Hanrahan, J.P., 1976. Maternal effects and selection response with an application to sheep data. Anim. Prod. 22:359.

Hlatshwayo, A., 2007. The effects of soil type and woody cover on grass production on rangelands in Zimbabwe. Bsc Thesis Zimbabwe Open University, Bulawayo, Zimbabwe.

Homann, S., van Rooyen, A.F., Moyo, T. and Nengomahsa, Z., 2007. Goat production and marketing: Baseline information for semi-arid Zimbabwe. P.O. Box 776. Bulawayo, Zimbabwe: International Crops Research Institute for the Semi-Arid Tropics. 84pp.

Huisman, A.E., 2002. Genetic analysis of growth and feed intake patterns in pigs. PhD thesis, Wageninngen Institute of Animal Sciences. The Netherlands.

Irgang, R. Dillard, E.U., Tess, M.W. and Robison, O.W., 1985. Selection for weaning weight and post-weaning gain in Hereford cattle. III. Correlated responses to selection in milk yield, preweaning and post weaning traits. J. Anim. Sci. 60:1156.

Kars, A.A., Easmus, G.J. and . Van der Westhuizen, J., 1994. Factors influencing growth traits in the Nguni cattle stud at Bartlow Combine. S. Afri. J. Anim. Sci. 24: 18-21.

Koots, K.R., Gibson, J.P., Smith, C. and Wilton, J.W., 1994a. Analyses of published genetic parameter estimates for beef production traits. 1. Heritability. Anim. Breed. Abstr. 62:309-338.

Koots, K.R., Gibson, J.P., Smith, C. and Wilton, J.W., 1994b. Analyses of published genetic parameter estimates for beef production traits. 2. Phenotypic and genetic correlations. Anim. Breed. Abstr. 62:825-853.

Lee, J.W., Choi, S.B., .Jung, Y.H., Keown, J.F. and Van Vleck, L.D., 2000. Parameter estimates for direct and maternal genetic effects on yearling weight, eighteen-month and slaughter weights of Korean native cattle. J. Anim. Sci. 78:1414-1421.

Leighton, E.A., Willham, R.L. and Berger, P.J., 1982. Factors influencing weaning weight in Hereford cattle and adjustment factors to correct records for these effects. J. Anim. Sci. 54:957- 963.

Lewis, R.M and Brotherstone, S., 2002. A genetic evaluation of growth in sheep using random regression techniques. Anim. Sci. 74: 63-70.

Lynch, M and Walsh, B., 1998. Genetics and analysis of quantitative traits. 980 pp Sinauer Associates, Sunderland, M.A.

Mercadante, M.E.Z., Lobo, R.B. and de los Reyes, A., 1995. Parametros geneticos para caracteristicas de crecimiento en cebuinos de carne. Una revision. Arch. Latinoam. Prod. Anim. 3:45- 89.

Mac Neil, M.D., Urick, J.J. and Snelling, W.M., 1998. Comparison of selection by independent culling levels for below average birth weight and high yearling weight with mass selection for yearling weight in line 1 Hereford cattle. J. Anim. Sci. 76: 458-467.

Mercadante, M.E.Z. and Lobo, R.B., 1997. Estimates of covariance components and genetic parameters for growth traits due to direct and maternal effects in Nelore heifers. Revista Brasileira de Zootecnia. 26: 1124-1133.

Meyer, K., 1992. Variance components due to direct and maternal effects for growth traits of Australian beef cattle. Livest. Prod. Sci. 31:179-204.

Meyer, K., 2002. Estimates of covariance functions for growth of Australian beef cattle from a large set of field data. Proc. Seventh World Congr. Genet. Appl. Livest. Prod. CD-ROM communication, vol. 11-01. Montpellier, France.

Mohiuddin, G., 1993. Estimates of genetic and phenotypic parameters of some performance traits in beef cattle. Anim. Breed. Abstr. 61:495-522.

Ncube, S., 2005. The role of proanthocyanidins and related flavonoids in the utilization of sorghum grain varieties as feed for ruminant in the semi arid areas of Zimbabwe. PhD. Thesis , University of Zimbabwe, Mt Pleasant, Harare, Zimabwe.

Pico, B.A., 2004. Estimation of genetic parameters for growth traits in South African Brahman cattle MSc Thesis, University Of Orange Free State, Bloemfontein, RSA

Richardson, F.D., Oliver, J. and Clarke, G.P.Y., 1979. Analysis of some factors, which affect the productivity of beef cows and their calves in a marginal rainfall area of Rhodesia. 3. Factors affecting calf birth weight, growth to 240 days and use of concentrates by cows and their calves. Anim. Prod. 38: 199-211.

SAS (Statistical Analysis System) (1999- 2000). SAS Institute., Inc., Cary, NC. USA.

Shelby, C.E., Clark, R.T. and Woodward, R.R., 1955. The heritability of some economic characteristics of beef cattle. J. Anim. Sci. 14:372.

Splan, R.K., Cundiff, L.V., and Van Vleck, L.D., 1998. Genetic parameters for sex-specific traits in beef cattle. J. Anim. Sci. 76:2272- 2278.

Splan, R.K., Cundiff, L.V., Dikeman, M.E. and Van Vleck, L.D., 2002. Estimates of parameters between direct and maternal genetic effects for weaning weight and direct genetic effects for carcass traits in crossbred cattle. J. Anim. Sci. 80: 3107-3111.

Swalve, H., 1993. Estimation of direct and maternal covariance components for growth traits in Australian Simmental beef cattle J. Anim. Bred. Genet. 110:241- 252.

Swanepoel, F.J.C. and Henys, H., 1988. Die invloed van ouderdom en produksiestatus van Afrikaner-en Hereford koeie op die eieskappe van hul speenkalewrs. S. Afr. J. Anim. Sci. 18:47.

Tawonezvi, H.P.R., Brownlee, J.W.I. and Ward, H.K. , 1986. Studies on growth of Nkone cattle: Environmental influences on body mass. Zimbabwe J. Agric. Res. 24: 17-29.

Thorpe, W., Cruickshank, D.K.R. and Thompson, R., 1980. Genetic and environmental influences on beef cattle production in Zambia. 1. Factors affecting weaner production from Angoni, Barotse and Boran dams. Anim. Prod. 33:165-177.

Van Rooyen, A.F., Freeman, A. Moyo, S. and Rohrback, D., 2007. Livestock Development in Southern Africa. Future Research and Investment Priorities. ICRISAT Bulawayo, Zimbabwe.

Venter, H.A.W., 1977. The efficiency of preweaning growth of certain beef, dual-purpose and crossbred cattle in the Northern Transvaal sweet bushveld. DSc (Agric) thesis, Univ. Pretoria (Afrikaans).

Vesely, J.A. and Robison, O.W., 1971. Genetic and maternal effects on preweaning growth and type score in beef calves. J. Anim. Sci. 32:825.

Ward, H.K., Richardson F.D., Denny R.P. and Dye, P.J., 1979. Matopos Research Station. Department of Research and Specialist Services. A Perspective, p.5-6.