Uganda Journal of Agricultural Sciences, 2012, 13 (1): 35-44 ISSN 1026-0919
Printed in Uganda.

Comparative pre-weaning growth of Zebu cattle and their crosses with Sahiwaland Boran

H.E. Mulindwa[1], G.C. Kifaro[2] and E. Ssewannyana[1]

[1]National Semi-Arid Resources Research Institute (NASARRI), P. O. Box Soroti, Uganda
[2]Sokoine University of Agriculture, P. O. Box 3004, Morogoro, Tanzania

Abstract

A study was carried out to evaluate growth performance of Zebu cattle and their crosses with Sahiwal and Boran at the National Semi-Arid Resources Research Institute (NASARRI), Serere, Uganda. Analysis of variance based on General Linear Model of SAS 2002 was used to analyse the data. The overall means for weights at birth and weaning and pre-weaning average daily gain (ADG) were 18.36$\pm$ 0.076, 100.55 $\pm$ 0.48 kg and 304 1.96 g day^{-1}, respectively. Dry season born calves were significantly (P<0.05) superior to wet season born in both weaning weight and pre-weaning ADG. Parity had a significant (P<0.05) influence on birth weight but not for weaning weight and pre-weaning ADG. Genetic group of the calf (Zebu, Boran or Sahiwal crosses) was a significant (P<0.001) source of variation for all growth traits studied. Rankings of genetic groups for weaning weight and pre-weaning ADG were B_1Sx (SxT), F_1(SxT), B_1(SxT)xT, B_1Bx(BxT), F_1(BxT) and T. Influence of year calving was significant (P<0.01) for weaning weight and pre-weaning and pre-weaning ADG but not for birth weight. Heritability estimates based on sire variance components for birth weight, weaning weight and pre-weaning ADG were 0.41, 0.02 and 0 .02, respectively. Heritability estimates based on both the dam and the sire variance components for birth weight, weaning weight and pre-weaning ADG were 0.41, 0.16 and 0.36, respectively. Based on these results it can be suggested that crosses of Boran and Sahiwal have higher potential for growth than the Zebu cattle. However, backcrossing to either Sahiwal or Boran breeds had no significant advantage over the F_1crosses.

Key words: Birth weight, heritability, pre-weaning growth

Introduction

The East African Shorthorn Zebu to which the Teso cattle belong has been described as a small breed with genetic potential for meat production (Joshi, 1957; Galukande *et al.*, 1962; Mkonyi *et al.*, 1991*)*. However, some *Bos indicus* breeds of cattle, such as the Sahiwal and Boran combine adaptability to tropical environment with ability to produce substantial higher growth rate. Therefore, in areas where husbandry remains relatively poor and where cattle are not only used for beef and milk production but also for draft power, crossbreeding between tropically adapted breeds would be a better approach to produce the most suitable type of animal forimproved farming systems. Some of the important breed characteristics in cattle breeding are birth weight and pre-weaning growth because they are considered as an initial reference point with regard to subsequent growth of individual as well as other characteristics. In this study, data was analysed to evaluate the genetic and environmental factors affecting pre-weaning performance of calves where their dams were milked once a day.

Materials and methods

The study location

The study was carried out at the National Semi-Arid Resources Research Institute (NASARRI), Serere, in Uganda. It is located at 0^0 32' N and 35^0 27' E at 1,128 m above sea level. The sandy soils and annual mean rainfall of 1,427 mm leads to substantial leaching of nutrients. The rainfall is bimodal with peaks in April/May and August/September. The main dry season is from December until March. The mean annual temperature is 24^0C and the relative humidity ranges from 72 to 84%.

Breeding programme at NASARRI

The data for the study was obtained from a crossbreeding programme at NASARRI in Uganda. The data collected covered a period of nine years. In this crossbreeding programme, Teso (T) females were mated to Sahiwal (S) and Boran (B) bulls to produce F_1 of SxT and BxT genotypes, respectively. Contemporary pure Teso calves were also produced alongside. Some F_1 of BxT and SxT females were mated to Boran and Sahiwal bulls, respectively, to produce B_1Bx(BxT) and B_1Sx (SxT) backcrosses. Also F_1 SxT bulls were mated to Teso females to produce B_1(SxT)xT backcrosses. Therefore, F_1(BxT), F_1(SxT), B_1Sx(SxT), B_1Bx(BxT), B_1(SxT)xT and Teso genotypes were available for evaluation for growth traits. All breeding was by natural service. Selected bulls were allowed to run continuously with a specific group of cows to ensure recognition of paternity of calves. Thus calves were born throughout the year.

Raising of calves and dams

Calves were weaned at 9 months of age. After weaning, males were separated from the female weaners to avoid premature breeding. Heifers were turned to bulls when about 30 months of age. Calves were left to run with their mothers during the day and penned separately from their dams overnight. This prevented suckling and facilitated partial milking the next morning. Milking was done once a day. Health management involved routine dipping against ticks, deworming and vaccination for the control of foot and mouth disease and Brucellosis. Weights were taken once every month having starved the animals for 16 hours prior to weighing. All weights were taken on a weigh bridge except birth weight, which was taken on a portable scale. All the stock was reared under the same grazing environment. The animals were raised entirely on natural pastures without any supplementary feeding except minerals and *ad-lib* supply of water.

Statistical analyses

Data was analysed by using General Linear Model (GLM) procedure of SAS (2002). The fixed effects included in the analysis were genotype, year of calving, season of calving, sex of the calf, parity, season-year interaction, genetic group-sex interaction for birth weight, weaning weight and pre-weaning average daily gain (ADG). Since weaning dates were not available, adjustment for age at weaning was not possible.

Heritability estimates

Heritability was estimated based on the sire variance component and both the sire and dam variance components. Data on offspring were used to estimate heritability. VARCOMP procedure of SAS (2002) was used to obtain estimates of sire and dam variance components using MIVQUE method. The model used is similar to the one described above with the inclusion of the effect of the sire and dam as random effects. Dams were nested within sires. Heritability estimates based on sire variance component was then calculated as $4\delta^2_S/\delta^2_P$ while heritability estimates based on both sire and dam variance components were calculated as $2(\delta^2_S+ \delta^2_D)/\delta^2_P$ δ^2_S was sire variance component, δ^2_D was dam variance component and δ^2_P phenotypic variance.

Heritability was estimated for weights at birth, weaning and pre-weaning ADG. Standard errors of heritabilities were estimated according to Falconer (1989) as SE (h^2) = 2/ $\surd$N, where SE (h^2) = standard error of heritability, and N = Total number of progeny.

Results

Birth weight

The least squares means, standard errors and levels of significance of parity, sex and season are presented in Table 1. The overall mean birth weight was 18.36 0.195 kg. Sex of the calf did not significantly affect birth weights although male calves were heavier than female calves by 0.64 (3.6%). Analysis of variance showed that parity did not significantly (P>0.05) influence birth weight. There was a general trend for the birth weight to increase from the first to the third parity and to start declining from the fourth parity. Season of birth had no effect (P>0.05) on birth weights. However, calves born in the dry season were 0.40 kg (2.2%) heavier than their counterparts born in the wet season. The effects of year of birth and genotype of the calf are presented in Table 2.

Genotype of the calf had a highly significant (P<0.001) influence on birth weight. Superiority sequence in terms of birth weight among the genotypes was F_1(BxT), F_1(SxT), Teso, B_1Sx(SxT), B_1Bx(BxT) and B_1(SxT)xT. Birth weight of pure bred Zebu did not differ significantly (P>0.05) from birth weight of the crosses except B_1(SxT)xT, which had the lowest birth weight. Influence of year of birth on birth weight was not significant (P>0.05) though calves born in year 2001 were heaviest followed by those born in year 2000, 2003 and 2002, respectively. None of the interactions

Table 1. Estimated least squares means (LSM) and standard errors (S.E) for the effect of sex, season and parity on birth weight, weaning weight and pre-weaning ADG

	Trait					
	Birth weight		Weaning weight		Pre-weaning ADG	
Effect	N	Mean (kg)	N	Mean (kg)	N	Mean (g)
Overall	241	18.36 (0.195)	236	100.55 (0.48)	236	304.28 (1.97)
CV (%)		16.50		7.32		9.93
Season		NS		***		***
Wet	110	17.82 (0.75)	108	92.07^a (2.26)	108	271.90^a (0.01)
Dry	131	18.22 (0.40)	128	101.92^b (0.99)	128	309.48^b (0.01)
Sex		NS		*		NS
Female	125	17.70 (0.48)	123	95.32^a (1.35)	123	285.48 (0.01)
Male	116	18.34 (0.57)	113	98.67^b (1.55)	113	295.90 (0.01)
Parity				NS		NS
1	47	17.51 (0.62)	47	96.39 (1.65)	47	290.20 (0.01)
2	105	18.37 (0.50)	103	96.56 (1.46)	103	287.45 (0.01)
3	69	18.92 (0.53)	67	97.12 (1.47)	67	288.09 (0.01)
4	20	17.29 (0.79)	18	97.90 (1.98)	18	297.02 (0.01)

Levels of significance ***=P<0.001, ** = P<0.01, *P=<0.05 and NS = not significant
In brackets are standard errors for the respective means

Table 2. Estimated least squares means (LSM) and standard errors (S.E) for the effect of genotype and year on birth weight, weaning weight and pre-weaning ADG

	Trait					
	Birth weight		Weaning weight		Pre-weaning ADG	
Effect	N	Mean (kg)	N	Mean (kg)	N	Mean (g)
Genotype		***		***		***
$B_1Bx(BxT)$	6	17.06^{ab} (1.57)	6	97.68^{b} (3.87)	6	296.84^{bc} (0.02)
$B_1Sx(SxT)$	40	18.35^{a} (0.57)	39	106.48^{a} (1.60)	39	324.64^{a} (0.01)
$B_1(SxT)xT$	64	16.21^{b} (0.50)	63	98.05^{b} (1.32)	63	301.94^{b} (0.01)
$F_1(BxT)$	22	19.22^{a} (0.76)	21	95.67^{b} (2.03)	21	280.25^{c} (0.01)
$F_1(SxT)$	62	18.94^{a} (0.51)	60	104.56^{a} (1.39)	60	315.43^{a} (0.01)
Teso	47	18.35^{a} (0.55)	47	79.52^{c} (1.48)	47	225.05^{d} (0.01)
Year		NS		**		**
2000	38	18.15 (0.59)	38	98.30^{b} (1.44)	38	296.94^{a} (0.01)
2001	124	18.41 (0.39)	123	101.49^{a} (0.95)	123	307.73^{a} (0.01)
2002	53	17.67 (0.54)	53	100.58^{ab} (1.33)	53	306.74^{a} (0.01)
2003	26	17.84 (1.19)	22	87.61^{c} (3.99)	22	251.36^{b} (0.02)

Levels of significance ***=P<0.001, **=P<0.01, *=P<0.05 and NS= Not Significant
In brackets are standard errors for the respective means
For crossbred calves, the breed of sire is listed first

included in the model significantly (P<0.05) influenced birth weight.

Weaning weight

The overall weaning weight was 100.55 0.48, and 7.32% coefficient of variation (CV) was observed (Table 1). Season of calving significantly (P<0.001) influenced weaning weight. Calves born in the dry season weighed on average 9.85 kg more at weaning than those born in the wet season. The influence of sex of calf on weaning weight was significant (P<0.05). Male calves were 3.35kg (3.5%) heavier than the female calves. Parity of the dam had no significant effect (P>0.05) on weaning weight though there was a mild trend of weaning weight to increase to increase with increase in parity.

The effects of year of birth and genotype of the calf on weaning weight are presented in Table 2. Genotype of the calf had a significant (P<0.001) influence on weaning weight. $B_1Bx(BxT)$, $B_1Sx(SxT)$, $B_1(SxT)xT$, $F_1(BxT)$ and $F_1(SxT)$ crosses were 18.09, 26.99, 18.5, 16.19 and 24.96 kg, respectively, heavier (P<0.05) at weaning than the Teso pure breed. Both $B_1Sx(SxT)$ and $F_1(SxT)$ crosses were significantly (P<0.05) heavier than both $B_1Bx(BxT)$ and $F_1(BxT)$ crosses. Year of calving was significant (P<0.01). Largest weaning weights were observed in calves born 2001 followed by 2002, 2000 and 2003, respectively. Season-year interaction was also significant (P<0.01).

Pre-weaning ADG

The overall pre-weaning ADG was 3041.96 with a coefficient of variation of 9.9% (Table 1). Genotype of the calf significantly (P<0.001) influenced pre-weaning ADG (Table 2).

B_1Sx(SxT) crosses had the highest pre-weaning ADG (324.640.010) though it was not significantly (P>0.05) different from F_1(SxT) crosses while purebred Teso calves had the least pre-weaning ADG (225.050.01 g day^{-1}). The influence of year of birth was significant (P<0.01) whereby calves born in year 2001 showed the highest pre-weaning ADG followed by those born in 2002 and 2000 with those born in 2003 having the least pre-weaning ADG (251.360.02 g day^{-1}) (Table 2). Parity of the dam did not show any significant (P.0.05) importance and there was definite trend for the various parturition numbers. Influence by sex of the calf did not significantly affect pre-weaning ADG though male calves gained 10.42 g per day more than the female calves. Season of calving significantly (P<0.05) influenced pre-weaning ADG in the sense that the calves born in the dry season gained 37.58 g per day more than dry season born calves. Season x year interaction had significant (P<0.001) influence while genetic groupx season interaction was not significant (P>0.05).

Heritability for birth, weaning weight and pre-weaning ADG

Variance component estimates for birth, weaning and pre-weaning ADG are presented in Table 3. Heritability estimate for birth based on either the sire component or both the sire and dam components was 0.410.13 (Table 3), which was moderate. Estimates of heritability for weaning and pre-weaning ADG based on the sire component of variance were 0.02 0.13 and 0.020.13, while heritability estimates based on both the sire and dam components of variance were 0.16 0.13 and 0.360.13, respectively (Table 3).

Phenotypic correlation coefficients for growth traits

Correlation coefficients between body weights are presented in Table 3. Correlation between birth weight and weaning weight was -0.07, between birth weight and pre-weaning ADG was -0.435, while that between pre-weaning ADG and weaning weight was 0.929. All correlations were highly significant except that between birth weight and weaning weight.

Discussion

Birth weight

The average birth weight in this study was comparable to that reported by Rwabushaija (1998) but lower than those reported for the East African Shorthorn Zebu crossbreds (Mwandotto, 1981; Trail *et al.*, 1985; Mwatawala, 2001). This is because the Teso

Table 3. Estimated variance components and heritabilities for birth weight, weaning weight and pre-weaning gain

Variance component	Trait		
	Birth weight	Weaning weight	Pre-weaning gain
δ^2_s	0.96629	0.30747	0.000004817
δ^2_e	7.61219	52.32172	0.0007963
δ^2_D	0.96561	4.08215	0.0001714
h^2_s	0.41	0.02	0.02
h^2SD	0.41	0.16	0.36
s.e(h^2)	0.128	0.130	0.130

δ^2s = Sire variance component δ^2e = Error variance component
δ^2D = Dam variance component h^2s = Heritability based on sire variance component
h^2 SD = Heritability based on both the sire and dam variance components

type is a smaller breed compared to other Zebu breeds in the region (Rwabushaija, 1998).

The effect of sex on birth weight was not significant (P>0.050), which is consistent with findings by Mbap and Ngere (1991) and Rege *et al.* (1993) but contrary to the significant sex influences reported by Mwandotto(1981), Kifaro and Mchau (1986), Saeed *et al.* (1987), Ibeawuch (1990) and Tawah *et al.* (1993). Mwandotto (1981) and Tawah *et al.* (1993) reported a difference of 1.28 kg and 1.0 kg, respectively. Though the difference between the male and female calves in this study was not significant, male calves were 4% heavier than the female calves and this is attributed to the longer gestation period of males as was observed by Ibeawuch (1990).

Significant breed influences on birth weight have been reported (Sacker *et al.*, 1971; Mwandotto, 1981; Mbap and Ngere, 1991; Mwatawala, 2001; Said *et al.*, 2001). In this study, there was no significant difference in birth weight between F_1 Sahiwal and Boran crosses with the Teso calves. Mwandotto (1981) reported a superiority of 1.02 kg (5%) and 1.85 kg (10%) of Sahiwal and Boran crosses over the EASZ, respectively; while Mwatawala (2001) reported 2.1 kg (10.3%) superiority for Boran crosses over the Tanzanian Shorthorn Zebu. The difference between the findings of this study and those of other reports could be due to differences in climatic conditions. The magnitude of birth weight for Teso calves in this study (18.35 kg) was comparable with 19.43 kg earlier reported in the same herd by Rwabushaija (1998).

Birth weight was increasing with parity up to the third parity and thereafter declined. This is similar to findings reported elsewhere (Kifaro and Mchau, 1986; Wakhungu *et al.*; 1991; Banjaw and Haile-Marian, 1994; Winroth, 1990). This trend is due to the fact that young dams, which have not reached adult size, continue to grow during their first pregnancies and thus compete with the foetus for available nutrients. In addition, the maternal environment also apparently changes with parity and possibly the degree of development and vascularity of the uterus (Hafez and Dyer, 1969).

Influence of season of birth on birth weight was not significant (P>0.05) in this study though dry season born calves were 0.48 kg heavier than those born in a wet season. This small difference could be attributed to the abundant forages available during the last stages of pregnancy for animals calving in the wet season. Hafez and Jainudeen (1975) showed that the growth of the foetus during the last trimester is apparently dependent on the caloric intake of the dam hence maternal nutrition exerts an important effect on the foetal growth.

Non-significantyear effects were observed in this study, which supports Rege *et al.* (1993) findings among the White Fulani cattle. The environmental differences between the years were probably not diverse to cause any significant variation in birth weight.

Weaning weight and pre-weaning ADG

The effect of sex on weaning weight was significant (P<0.05) whereby weaning weight of male calves was 3.35 kg (3.5%) heavier and grew 3.6% faster than female calves. This was consistent with earlier reports by Mwandotto (1988), Sacco *et al.* (1989) and Udo (1993). Gregory *et al.* (1978) reported that males gained 0.04 kg faster than females. Higher weaning weight and pre-weaning ADG among male calves is attributed to higher androgen concentrations in males than in females.

The effect of year on weaning weight was highly significant (P<0.01). As observed in the present study, the significant effect of year on weaning weight was also reported elsewhere in the tropics (Oni *et al.*, 1988; Mwandotto, 1988). Because of the changes that occur in climate and pasture conditions from year to year, differences in weaning weight among years are expected. Annual rainfall pattern is translated into a clear pattern in milk production of the dams from which the sucking calves benefits. Highest rainfall was received in year 2001 followed by 2002, 2003 and 2000 in that sequence. Weaning weights showed a similar trend though not for 2003 and 2000.

The seasonal differences in weaning weight and pre-weaning growth rate indicate an advantage for dry season born calves and this is consistent with previous result in the tropics (Drewry *et al*., 1959; Lhoste, 1968; Abassa *et al.*, 1993; Udo, 1993; Mwantawala, 2001). In view of the findings in this study, having calvings during the start of the dry season is advantageous because supplementary feeding of the pregnant dams may not be necessary. However, its implementation under traditional management is limited by lack of controlled breeding in communal grazing areas where all age groups, both male and female are grazed together.

Previous studies have shown the effect of genetic group on weights at weaning (Trail *et al*., 1984; Kasonta, 1992). Mwandotto (1988) observed no significant difference between Boran x EASZ and Sahiwal x EASZ crosses whereas in the current study, F_1 (SxT) were significantly (P<0.001) heavier than F_1(BxT) crosses. The superiority sequence for average weaning weight and pre-weaning ADG was in the order of B_1Sx(SxT), F_1(SxT), B_1(SxT), B_1Bx(SxT), F_1(BxT) and T (Teso breed). For B_1Sx(SxT) crosses to show the highest weaning weight (106.481.6) kg in this study, is not surprising because the feed of the calves during the suckling period is based largely on milk hence their weights at weaning reflect to a considerable extent the milk production level of their dams. Therefore, the heavy weaning weight of B_1Sx (SxT) crosses is probably due to the fact that these calves were born by F_1 (SxT) dams, which have been found to have a relatively higher milk production potential than Teso and F_1(BxT) crosses.

Anido and Topps (1993) reported a similar observation in which calves born to Sahiwal crosses gained live weight at a significantly faster rate than those born by Boran, Boran-Hereford and East African Zebu dams. Phenotypic correlation between milk yield, total or cumulative milk production and gain from birth to weaning or weaning weight are of the order of 0.5-0.8 (Koch, 1972; Robison *et al*., 1978), suggesting important differences in maternal ability as measured by milk production.

Secondly, it is probable that the Sahiwal genes have a greater potential for growth than the other genetic groups. This is mainly manifested by the fact B_1(SxT)xT crosses, although they had managed to attain a relatively higher weaning weight than the Boran crosses and Teso pure breed. The Teso calves had the lowest weaning weight and its magnitude (79.521.48 kg) was lower than the 146, 121.670.49, 1082.5 and 86.11.85 kg reported by Trail *et al*. (1985), Mwandotto (1988), Rwabushaija (1998) and Mwatawala (2001), respectively, but higher than the 65kg for the Kenya for the Kenya Maasai cattle (Semenye and De leeuw, 1984) or 61 kg reportedfor cattle in Mali pastoralists system (Diollo *et al*., 1981).

Figures in Table 3 indicate that the growth rate was higher in the crossbreds than the purebreds. It agrees with the results of Mwatawala (2001), Mwandotto (1988) and Trail and Gregory (1981c) and this indicates that cross breds mature at much earlier age than the pure Teso Zebu. Heavier weights at weaning of Sahiwal and Boran crosses show that tremendous increase in weight can be achieved by crossing the Teso cattle to Sahiwal and Boran bulls. Backcrossing to respective Boran and Sahiwal sire breeds was not advantageous because there was no difference between F_1 and the backcrosses. This is because heterosis reduces by 50% when backcrossing is carried out.

Heritability estimates

Estimate of heritability of 41% for birth weight based on the sire variance component was within the range of estimates (39-44%) reported for other tropical studies (Tonn, 1976; Tawah *et al*., 1993; Rwabushaija, 1998; Wakhungu *et al*., 1991; Mwatawala, 2001) but greatly higher than those reported by Trail *et al*. (1971b), Mwandotto (1986), Arnason and Kassa-Mersha (1987), Saeed *et al*. (1987) and Galip *et al*. (2004). The heritability estimate in this study indicates that birth weight could give an appreciable response to direct selection for this particular trait. Heritability estimates for both the weaning and pre-weaning ADG using both methods in the study were lower than corresponding estimates in the literature (Tawonezui, 1989b; Tawah *et el*., 1993; Mekonnen, 1996; Mwatwala, 2001). The difference could be due to the fact that previous studies on genetic parameters for birth and pre-weaning growth of calves were done under different environments and management. For calves sucking their dams, growth during pre-weaning period is mostly dependant on the dam's milk production. This is reflected by low heritability for weight at weaning (Acker, 1983).

Trail *et al*. (1971b) observed that growth to weaning, especially under fairly harsh range conditions is very subject to maternal influences, and calf genotype may be masked to a greater degree. This could have been the case in this study because the dam variance component was higher than the sire component. Heritability estimate of weaning weight based on both the sire and dam component was higher than the estimate based on sire component indicating that the weaning weight was highly influenced by maternal effects. Birth weight being less affected by environmental conditions than the weaning weight had heritability estimates on both sire component alone, and both sire plus dam components being similar.

Acknowledgements

The financial support from SUA-MU ENRECA project is highly acknowledged for enabling authors conduct this study successfully. Also the staffs of SAARI, the custodians of this data are acknowledged.

References

Abassa, P.K., Mbah, D.A., Zambia, P., Tawah, L.C., Messine, O. and Oumate, H. 1993. Factors which affect Gudali and Wakwa calf weights at birth and weaning on the Adamawa plateau, Cameroon. *Tropical Animal Health and Production* 9: 143-149.

Acker, D. 1983. Animal Science and Industry. Third edition.Prentice-Hall.New Jersey USA. pp. 131-141.

Anido, A.O. and Topps, J.H. 1993. The effects on production of milking crossbred suckler cows grazing a semi-arid area of Kenya. II. The performance of calves from birth to weaning. *East African Agricultural and Forestry Journal* 59(2): 113-122.

Arnason, T. and Kassa-Mersha, M. 1987. Genetic parameters of growth of Ethiopian Boran cattle. *Animal Production* 44: 201-208.

Banjaw, K. and Haile-Mariam, M. 1994. Productivity of Boran cattle and their Friesian crosses at Abernossa ranch, rift valley of Ethiopian. *Tropical Animal Health and Production* 26: 49-57.

Dillo, A., Wagenaar, K. and De leeuw, P.N. 1981. Livestock productivity and nutrition systems research in the arid zones of Mali. *International Livestock Center for Africa*. Addis Ababa. Research Report. No. 5.

Falconer, D.S. 1981. *Introduction to quantitative genetic*s. Longman Group U.K. LTD. England. Pp 318.

Falconer, D.S. 1996. *Introduction to quantitative genet*ics. Longman Group U.K. LTD. England. Fourth Edition. Pp 464.

Galip, B., Kaygisiz, A. and Ulker, H. 2004. Estimates of genetic and phenotypic parameters for birth weight in Holstein Friesian cattle. *Pakistan Journal of Biological Sciences* 7(7): 1221-1224.

Gregory, K.E., Cundiff, L.V., Smith, G.M., Laster, D.B. and Fitzhugh, H.A. 1978. Characterization of biological types of cattle-cycle II: Birth and weaning traits. *Journal of Animal Science* 47 (5): 1022-1030.

Hafez, E.S.E and Dyer, I.A. 1969. *Animal Growth and Nutrition*. Lea and Febiger. pp. 402.

Hafez, E.S.E and Jainudeen, M.R. 1975. Reproductive failure in females. In: *Reproduction in Farm Animals*. Lea and Febiger. Philadelphia. Pp. 351-372.

Ibeawuch, J.A. 1990. A study of some factors influencing the birth weight of Friesian calves in a tropical environment. *Bulletin of Animal Health and Production in Africa* 38(2): 107-111.

Kasonta, J.S. 1992. Comparative growth and reproductive performance of Tanzania Shorthorn Zebu and Mpwapwa cattle breeds and various crosses.Mimeograph, ILCA, Addis Ababa. Pp. 83.

Kifaro, G.C. and Mchau, K.W. 1986. Environmental factors affecting birth and weaning weights of Friesian calves at Uyole Agricultural Center. *The Uyole Agricultural Bulletin* 1(1): 30-35.

Koch, R.M. 1972. The role of maternal effects in animal breeding.VI. Maternal effects in beef cattle. *Journal of Animal Science* 35(6): 1316-1323.

Koots, K.R., Gibson, J.P. and Wilton, J.W. 1991. Analysis of genetic parameters for beef cattle. *Journal of Animal Science* 69:205-206.

Lhoste, P. 1968. Seasonal behavior of Zebu cattle in Adamawa, Cameroon. II. Pre-weaning growth of indigenous and half-breed Brahman calves. *Revue d'Elevage et de Médecine veterinaries des pays tropicaux* 21:499-517.

Mbap, S.T. and Ngere, L.O. 1991. Breed and Environmental factors affecting the performance of some imported and crossbred cattle in Ibadan, Nigeria. *Bulletin of Animal Health and Production in Africa* 68: 181-185.

Mekonnen, H. 1996. Genetic evaluation of Ethiopian Boran cattle for growth traits. Paper presented in: All African conference on Animal Agriculture. 1-4 April 1996. Pretoria. Conference handbook and abstracts.1.D.16.

Msanga, Y.N.1984. Growth performance of Mpwapwa cattle and their crosses from birth to 108 weeks of age. Unpublished dissertation for award of MSc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania. Pp. 100.

Mwandotto, B.A.J. 1981. Some factors affecting birth weight of cattle in Kiboko Kenya. *Bulletin of Animal Health and Production in Africa* 29 (3): 225-235.

Mwandotto, B.A.J. 1986. A note on heritability of growth of Sahiwal heifers to bulling age and its correlation with milk yield. *East African Agricultural and Forestry Journal* 52 (2): 127-129.

Mwandotto, B.A.J. 1988. Weaning weight and 18-month weights of Boran, East Africa Shorthorn Zebu and Sahiwal breeds or crosses in Kenya. *Tropical Agriculture (Trinidad)* 65(3): 257-264.

Mwatawala, H. 2001. Comparative growth and reproductive performance of Tanzania shorthorn Zebu, Boran and their crosses.Unpublished Dissertation of award of MSc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania. Pp. 96.

Oni, O.O., Buvanendran, V. and Dim, N.I. 1988. Factors affecting birth weight and performance to weaning of Bunaji calves. *Journal of Agricultural Science, Cambridge* 111: 407-410.

Rege, J.E.O., Von Kaufmann, R.R., Mwenya, W.N.M., Otchere, E.O. and Mani, R.I. 1993. On-farm performance of Bunaji (White Fulani) cattle.Growth, reproductive performance, milk off take and mortality. *Animal Production* 57: 211-220.

Robison, O.W. 1981. The influence of maternal effects on the efficiency of selection. *Livestock Production Science* 8: 121-137.

Rwabushaija, B. 1998. Phenotypic and genetic trends of growth characteristics of the small East African Zebu at Serere Agricultural and Animal Production Research Institute, Uganda. Unpublished Dissertation for Award M.Sc. Degree at Makerere University, Kampala, Uganda. Pp. 96.

Sacco, R.E., Baker.J.F., Cartwright, T.C., Long, C.R. and Sanders, J.O. 1989. Production characteristics of straight-bred, F_1 and F_2 cows: Birth and weaning characteristics of terminal crosses calves. *Journal of Animal Science* 26: 1972-1979.

Sacker, G.D., Trail, J.C.M. and Fisher, I.L. 1971. Cross breeding of beef cattle in western

Uganda. 2. Environmental influences on body weight. *Animal Production* 13: 143-152.

Saeed, A.M., Ward, P.N., Light, D., Durkin, J.W. and Wilson, R.T. 1987. Characteristics of Kenana cattle at Um Banein, Sudan. *International Livestock center for Africa Addis Ababa, Ethiopi*a. Research Report. No.16.

Said, R., Bryant, M.J. and Msechu, J.K.K. 2001. *Growth and survival of crossbred beef cattle in Tanzania*. A paper presented at the 17th Scientific conference of the Tanzania Society of Animal Production. Arusha International Conference Center.

Semenye, P.P. and De leeuw, P.N. 1984. Milk for calves or man in a Maasai pastoral system in East Africa.*International Livestock center for Africa*. Nairobi, Kenya.

Statistical Analysis System SAS, 2002.The Statistical Analysis System, Version 8.01 for windows. SAS Institute, inc., Cary, N.C. USA.

Tahir, M., Ahmed, N. and Shah, S.I.H. 1984. Comparative study on birth weight and weaning weights of purebred and crossbred Sahiwal calves in Pakistan. *Indian Journal of Animal Science* 54(1): 102-103.

Tawah, C.L., Mbah, D.A., Rege, J.E.O. and Oumate, H. 1993. Genetic evaluation of birth and weaning weight of Gaduli and two breed synthetic Wakwa cattle populations under selection in Cameroon: Genetic and phenotypic parameters. *Animal Production* 57: 73-79.

Tawonezui, H.P.R. 1989b. Growth of Mashona cattle on range in Zimbabwe. II. Estimation of genetic parameters and predicted response to selection. *Tropical Animal Health and Production* 21: 170-174.

Tonn, R. 1976. Selection criteria for beef cattle breeding under extensive conditions. *Animal Research and Development* 3:105-111.

Trail, J.C.M., Sacker, G.D. and Fisher, I.L. 1971a. Crossbreeding of beef cattle in western Uganda. I. Performance of Ankole, Boran and Zebu cows. *Animal Production* 13: 127-141.

Trail, J.C.M., Sacker, G.D. and Fisher, I.L. 1971b. Crossbreeding of beef cattle in western Uganda.Genetic analysis of body weight. *Animal Production* 13: 153-163.

Trail, J.C.M. and Gregory, K.E. 1981a. Characterizations of the Boran and Sahiwal breeds of cattle for economic characters. *Journal of Animal Science* 52: 1286-1293.

Trail, J.C.M. and Gregory, K.E. 1981b. Rotation crossbreeding with Sahiwal and Ayrshire cattle in the tropics. *Journal of Dairy Science* 64: 1978-1984.

Trail, J.C.M. and Gregory, K.E. 1981c. Sahiwal cattle: an evaluation of their potential contribution to milk and beef production in Africa. International Livestock Center for Africa. Monoegraph. No. 3.

Trail, J.C.M. and Gregory, K.E., Marples, H.J.S. and Kakonge, J. 1985a. Comparison of Bostauras-Bos indicus breed crosses with straight bred Bos indicus breeds of cattle for maternal and individual traits. *Journal of Animal Science* 60: 1165-1174.

Udo, M.G. 1993. Comparative study on growth and lactation performance of different crosses in Mpwapwa cattle herd. Unpublished dissertation for award M.Sc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania. Pp. 147.

Wakhungu, J.W., Rege, J.E.O. and Tulya, S. 1991. Genetic and phenotypic parameters and trends in production and reproductive performance of the Kenya Sahiwal cattle. *Bulletin of Animal Health and Production in Africa* 39 (4): 365-372.

Winroth, H. 1990. Effects of non-genetic factors and development of adjustment factors for live weight at different ages in beef breeds. Proceedings 4th World Congress on genetics applied to livestock production. XV Pp. 229-303.