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Full Length Research Paper

Sex specific genetic and environmental trends for birth weight in indigenous Nguni conservation cattle herd of Zimbabwe

Assan N.[1]*, Dube B.[2], Ngwenya S.[2], Nyoni K.[2], Tambo G.[2] and Matshe F.[2]

[1]Department of Agriculture, Faculty of Science, Zimbabwe Open University, Matabeleland South Region, Box 346, Gwanda, Zimbabwe.
[2]Matopos Research Station, P Bag 5137, Bulawayo, Zimbabwe.

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Best linear unbiased predictors (BLUP) of breeding values for additive direct and additive maternal genetic effects were estimated from pedigree birth weight (BWT) records 4272 in indigenous Nguni cattle born between 1988 and 1997. Data was partitioned according to sex and breeding values for direct additive and maternal additive were estimated using a univariate animal model. Estimates of sex specific genetic trends for direct and maternal effects were obtained by averaging corresponding breeding values for partitioned data for animals born in a given year, and regressing these averages on their year of birth. The regression of average direct breeding values on year for males and females was –0.0236 kg/yr and –0.1263 kg/yr, respectively, and the regression of average maternal breeding values on year of birth were -0.0355 kg/yr and –0.0173 kg/yr for males and females, respectively. Environmental trends observed a positive trend for both sexes but was non significant. Estimation of sex specific variance components had no significant influence on the direction and magnitude of genetic trends and indication of homogeneity of variance by sex for birth weight in this population.

Key words: Variance components, sex, trends, birth, Nguni.

INTRODUCTION

Nguni cattle of Zimbabwe forms part of the Sanga group of cattle which includes most of the type indigenous to East, Central and Southern Africa (Faulkner and Epstein, 1957). In Zimbabwe there are three indigenous breeds of cattle (Nguni, Tuli and Mashona). Nguni are medium sized pure African Sanga breed with color pattern which varies widely. The frequent pattern involves white hair with pigmented skin, black, brown red, dun, yellow are common, either as solid colors or in various combinations (black and tan or bridle).

The breed has become popular for meat production and is well known for their ability to produce and reproduce under harsh environmental conditions, their natural immunity against endemic diseases and its suitability as a dam line in terminal crossbreeding has generated interest in the breed amongst many local cattle farmers.

Birth weight can be considered as a selection criterion in local beef cattle herds if properly weighted in a multitrait selection index taking into account its association with further live weights and presence of genetic variability within sexes. Estimates of genetic parameters and trends for birth weight in Sanga cattle in sub tropical environment are scarce (Beffa, 2005) particularly within sexes and from reasonably large data sets using the current commonly adopted mixed model and REML (restricted maximum likelihood) procedures described by Henderson (1984) fitting an animal model, however where such analysis are available old analytical methods used tend to be inadequate (Kars et al., 1994). Elsewhere in Sub Sahara some genetic improvement programs showed that the potential to significantly improve indigenous breeds in terms of productivity do exist in Africa (Ebangi et al., 2000). Sex specific genetic

*Corresponding author. E-mail: neverssan@yahoo.com. Tel: 26308422965/6. Fax: 26308422967.

Abbreviations: BLUP, Best linear unbiased predictors; **BWT,** birth weight; **REML,** restricted maximum likelihood.

parameters and covariance components have been studied for growth traits (Jung et al., 2004; Mercadante et al., 2003). The great influence of maternal genetic and maternal environment effects on birth weight is well documented (Dezfuli and Mashayekhi, 2009). Studies on homogeneity and heterogeneity on genetic trends which are sex specific are scarce in literature. Mostly genetic trends on pooled data have been reported and have shown to be a very useful tool to evaluate the effects of the genetic improvement programmed (Bosso et al., 2009). Annual trends for weight traits should be monitored over time to check the validity of the predict-tions made and to investigate direction of genetic change and whether the selection strategies implementted could reach a selection limit or have unexpected other effects (Intaratham et al., 2008).

MATERIALS AND METHODS

Matopos Research Station (20° 23’S, 31° 30’E) is situated 30 km South West of Bulawayo in Zimbabwe on an altitude of 800 m and 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℃ and 11.4℃, respectively, with possibility of severe droughts (Hagreveas et al., 2004). Managed properly, the rangelands in Zimbabwe should be able to meet the nutritional requirements of livestock species, 2007;. However due to degradation, significant proportion of the rangeland are now degraded, resulting in low biomass and thus limited feed resource of poor quality particularly during the dry season. Day et al. (2003) and Gambiza and Nyama (2000) give a detailed description of the climate and vegetation type, respectively. Herd history, selection procedure (selection emphasis were for maternal traits-fertility and calf survival and weaning weight) and management were described by Brownlee (1977). Data on separate birth weight on males and females were extracted from records of animals born from 1988 through 1997 at Matopos Research Station. A mixed model equation was fitted to obtain BLUP breeding values using ASREML computer programme (Gilmour et al., 2000) for additive direct and maternal genetic effects. The annual mean breeding values were calculated as the simple average records of males and females born in a particular year. Genetic trends were estimated as a regression of predicted average breeding values for additive direct and maternal effects on year of birth. Environmental values were directly obtained from the estimates of the fixed effects solutions of year of birth of males and females. The animal model fitted was:

$$Y= X_1b+ Z_1\ a+ Z_2m+ e$$

Where, Y is a vector of observations; X is a known incidence matrix relating observations to fixed effects; b is a vector of fixed effects consisting of year of birth, age of dam; Z_1a, Z_2m, is the known incidence matrices relating elements of a and m to y; a, a random vector of direct additive genetic effects; m, a random vector of maternal additive genetic effects and e is the random vector associated with residual errors.

RESULTS AND DISCUSSION

The results of linear regression of mean annual direct, mate nal breeding values, environmental and phenotypic values on year of birth for female and male calves are presented in Table 1. The direct and maternal trends for birth weight (BWT) in females and males are depicted in Figures 1, 2, 4 and 5, respectively. The regression of average direct breeding values on year of BWT for males and females were –0.0236 kg/yr and –0.1263 kg/yr, respectively, and the regression of average maternal breeding values on year for BWT for males and females were -0.0355 kg/yr and -0.0173 kg/yr, respectively, The differences between the maximum and minimum direct average breeding values for BWT were higher in females which showed larger genetic variability in females than within males which was unexpected due to low selection intensity in females where 80% of the females were retained in the herd after selection.

The maximum gain in maternal ability in females was observed between 1988 to 1991 of 0.622 kg/yr (R^2 = 0.98) and was highly significant. Female maternal effects were significantly depressed by –0.287 kg/yr (R^2 = 0.75). The average direct breeding values were almost zero in males this may be as a result of ineffective sire selection were it was based on phenotypic values than on genetic merit. Much of selections of sires were on visual assessment by members of the Nguni breed society which could compromise selecting of high performance bulls. In this population, progeny testing could assist to improve selecting bulls of high genetic merit. The maternal genetic trend showed a superior genetic varia-bility in females than males and this could be expected because one of the major objectives of this breeding program was selection of maternal ability creating an opportunity for developing a dam line. However the population still maintained males which were heavier than female at birth; however males were less affected by the environment as indicated by the slightly positive environ-mental values. The latter result possibility to the small numbers of sires used in the breeding scheme. This is a very important facet of the production system in harsh environmental semi arid tropics. It was easily noted that there were less antagonistic tendency of direct and maternal additive genetic trends in males which was quite different with females which showed some antagonistic tendency between direct and maternal trends. This may warrant the inclusion of both direct and maternal genetic effects in a selection program in this population if pooled data is used for genetic evaluation.

The relationship between direct and maternal annual average breeding values showed a positive unantago-nistic behavior, which do not support the notion that the correlations between direct-maternal genetic effects were weak, strong and negative (Meyer, 1992). However, posi-tive relationships between direct and maternal effects have also been reported in a Sanga breed for birth weight (Biff, 2005). Understanding of the relationship between direct-maternal effects facilitates formulation of optimum breeding plan and improvement of selection efficiency (Robison, 1981). The results in literature dealing with the genetic correlation between direct and maternal effects

Table 1. Linear regression analysis of mean, annual direct and maternal breeding values (D), maternal additive breeding values (M), environmental values (E) and phenotypic values (P) for male and female BWT on year of birth for the period 1982 to 1997.

Value	Sex	b	SE	R^2 (%)	P-value
D	F	-0.1266	0.2246	0.0380	0.5892
	M	-0.0236	0.0138	0.2677	0.1256
M	F	-0.0173	0.0640	0.0091	0.7932
	M	-0.0355	0.0194	0.2790	0.1057
E	F	0.1999	0.2019	0.1093	0.3501
	M	0.0286	0.0448	0.0478	0.5439
P	F	0.2699	0.1980	0.1892	0.2090
	M	0.6838	0.2199	0.5473	0.0144*

b, Regression slope; SE, standard error; R^2, R-square (%); P, probability; * ($p<0.05$).

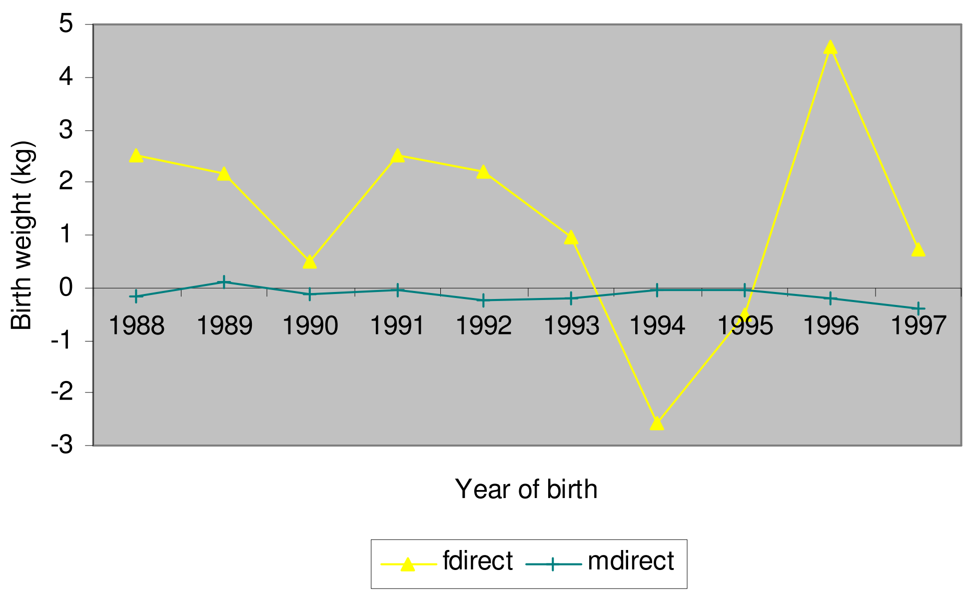

Figure 1. Direct additive genetic trends for birth weight in male (mdirect) and female (fdirect) indigenous conservation Nguni cattle herd.

for birth weight vary (Meyer, 1992). Positive literature estimates for direct-maternal genetic correlation for birth weight have been previously reported (Choi et al., 2000). And substantial difference for direct-maternal covariance may exist among breeds (Meyer, 1992). However, the size of maternal effects and their relationship among themselves and with direct genetic effects within sexes are less clear and far from being known. The reasons for positive estimates of correlation between direct and maternal genetic effects obtained in previous studies could not conclusively be explained by most authors (Dodenhoff et al., 1999a, b).

There is a tendency of ignoring a real genetic effect (positive correlations), which could be silently influencing selection results in many breeding programs to the extent that the actual and expected response to selection may vary with a wider margin. In the case of the low and positive genetic correlation of direct and maternal effects observed here, no satisfactory conclusive explanation can be given as in the case in most published results (Beffa, 2005). However, it can speculated that under different environments or sexes, gene interaction or complexities may differ affecting a trait (Falconer, 1981) which seem reasonable to assume that also co-variances which might occur between direct additive and maternal additive breeding values may differ in either direction (positive or negative) and may result in heterogeneity of trends by sex which was contrary to the findings in the

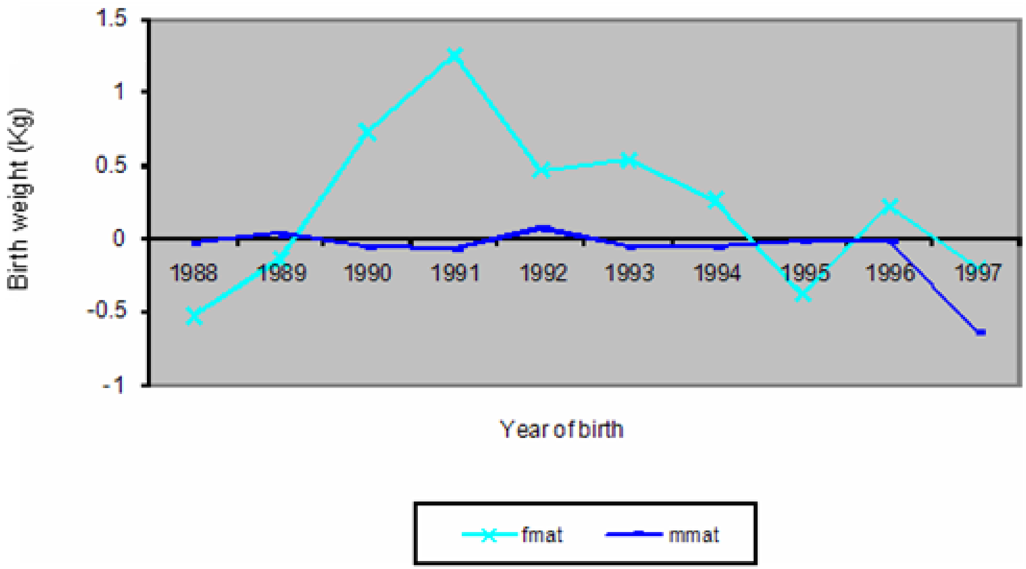

Figure 2. Maternal additive genetic trends for birth weight in male (mmat) female (fmat) in indigenous conservation Nguni cattle herd.

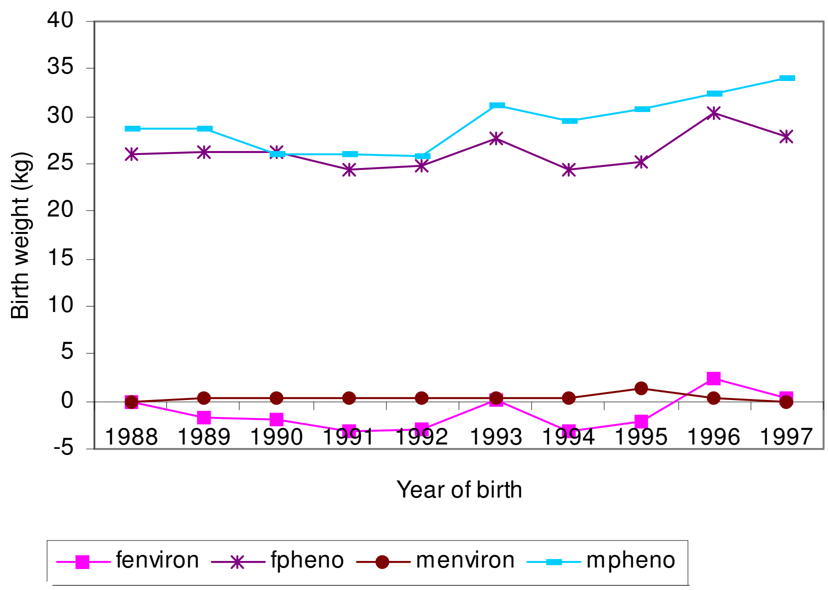

Figure 3. Phenotypic and environmental trends for weight in male and female in indigenous conservation Nguni cattle herd.

present study. Similarly, influence of interactions (that is, affecting the size and magnitude of co-variances of direct and maternal genetic effects may vary in their relative importance from region to region which may be an over sight to rule out differences in co-variances across different regions. Already some studies have reported differences in estimates of variance and co-variance of cattle in tropics and sub tropics from temperate regions (Hertzel et al., 1990) which makes possible to observe positive co-variance in the present study as compared to the weak and strong co-variances reported for temperate breeds (Bennet and Gregory, 1996). Gerstmayr (1992) found in a simulation study that correlation between direct and maternal genetic effects was strongly affected by the population structure. Exclusion of all dam -daughter relationships may reduce the magnitude and direction of the effects of environment furnished by the dam on the future maternal ability of its daughters, opposite to the direct influence on their phenotypic biasing the co-variance. Partitioning of data by sex definitely changed

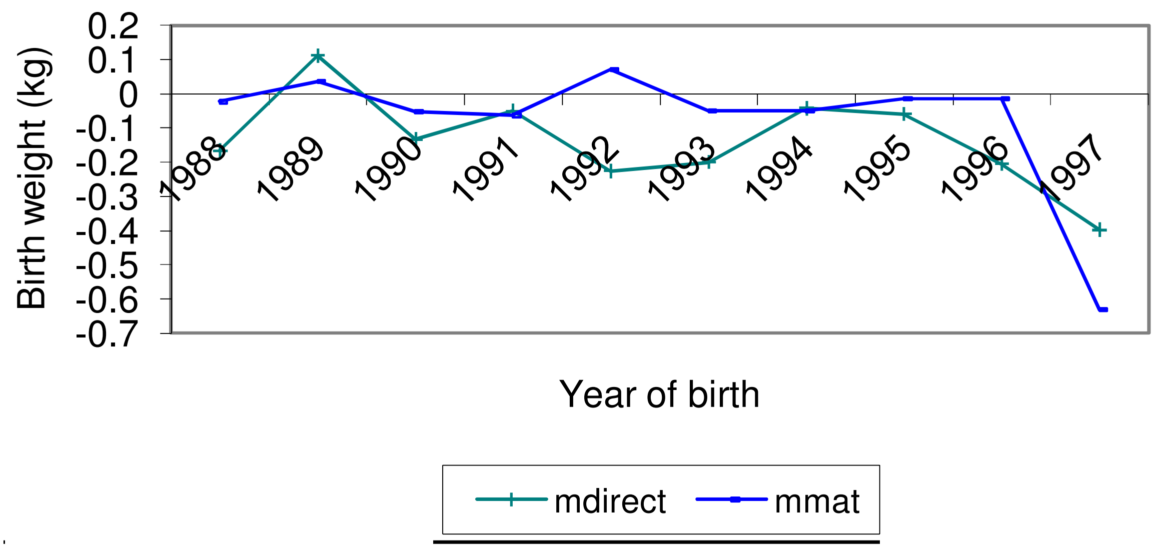

Figure 4. Direct additive and maternal additive genetic trends in male indigenous conservation Nguni cattle herd.

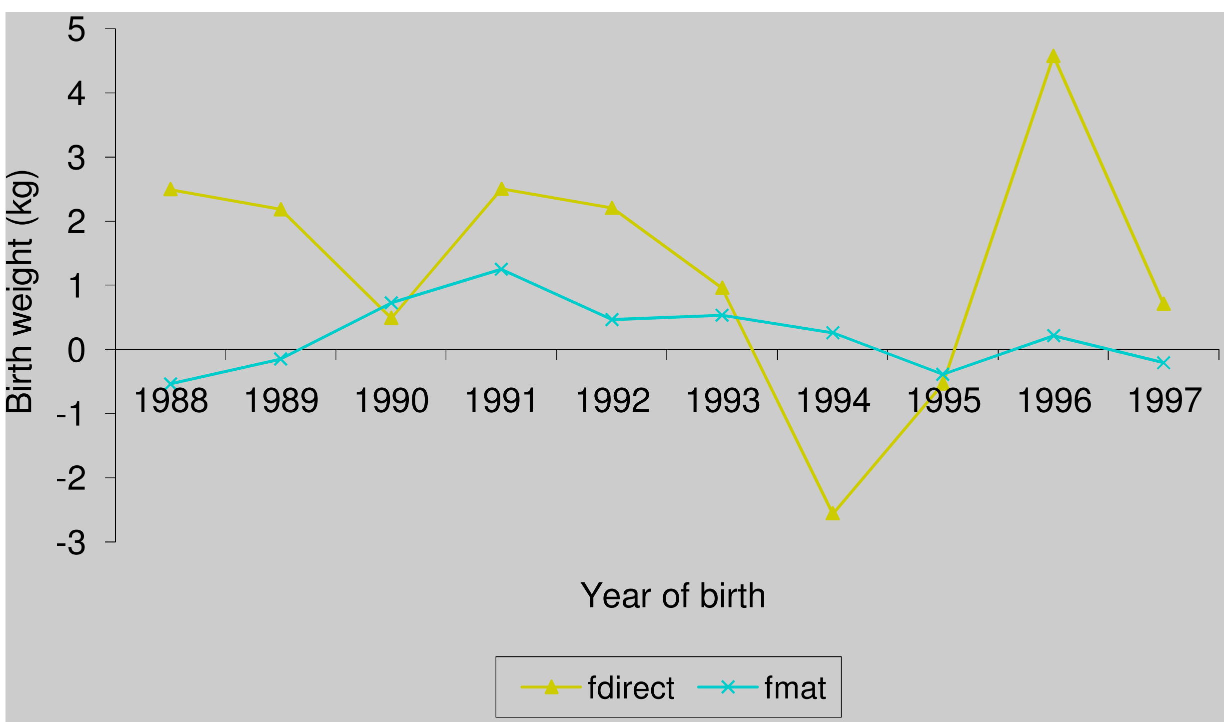

Figure 5. Direct additive and maternal additive genetic trends in female indigenous conservation Nguni cattle herd.

the structure of the data set (Maniatis and Pollot, 2003) resulting into less dam- daughter or son daughter relationships which may remove the bias on the co-variance between direct and maternal hence the low and positive correlation in the current study. In terms of non genetic influence to consider in this discussion in a possible positive covariance is that livestock indigenous to the tropics are well adapted to harsh environmental condition (Beffa, 2005). They have a high degree of tolerance to heat, are partly resistant to many of the diseases prevailing in the tropics and have the ability to survive long periods of feed and water shortage (Van Rooyen, 2007). These properties are genetic and have been acquired by natural selection over hundreds of generations and are well essential for successful animal production in the harsh semiarid tropics.

Quite obvious that the potential for milk production is poorly developed in most of the livestock indigenous to the tropics (Muchenje et al., 2007). In view of the above facts, it may be reasonable to speculate that cattle breeds in the harsh semi-arid tropics could have developed over time an efficient biological mechanism to perfect their priority to either maternal ability or direct growth in order to minimize or totally remove the antagonism tendency between direct and maternal genetic effects, which makes observation of low and positive covariance possible as in the current study. This may be however in contrary with previous reports by Swalve (1993) who compared results from different studies of correlation of direct and maternal genetic effects on beef cattle, and argued that a less sufficient environment may impose a negative correlation between direct and maternal effects. It should be assumed that different herds or populations are at a different stage of perfecting this biological process (priority to either the maternal ability or the direct growth) hence variation within region on co-variances between direct and maternal effects may be expected. Reasonably to suggest that breeds at an advanced stage of adaptation in the harsh environmental condition may experience a positive covariance between direct and maternal effects in line with reports in literature (Hertzel et al., 1990) who reported that estimate of genetic parameters in the semi-arid and sub tropics may be different from those in temperate environment.. Most work on cattle by Meyer (1992, 1993a) and Meyer et al. (1993) were not typically good examples of harsh environmental conditions as found in semi arid sub Saharan Africa and the definition of less sufficient environment need to consider a lot of non genetic factors which affect animal production in different regions of the world so that it becomes clear to breeders. It is not however until great scale investigations on factors and their relationship which affect the size and direction of genetic correlation between direct and maternal effects, it would be difficult to make recommendation on use of a single value covariance in breed evaluation taking into cognizance diverse breed use under typically of harsh semi-arid tropics. Much seems to have been done on genetic parameters in the breeds found in the temperate region which has tended scientist or breeders from these regions assume that the same findings may apply to others despite a variety of differences. Zhang et al. (1991) reported genetic trend of 0.02 kg/yr for birth for a Hereford herd maintained in a nutritionally stressful environment and selected by visual appraisal in the USA. The only correlation of biological importance was that of average male breeding values with its corresponding male maternal breeding value, 0.66 which indicates less antagonistic behavior in males for these effects. It was interesting to note the negative correlation of average male direct breeding values with average female direct breeding values this may be expected due differences in selection intensity in males and females. In contrary the association of average direct breeding values with average maternal breeding values in females was low and positive. The correlation between maternal genetic effects between males and females were small and positive which indicates that birth weight in both sexes is influenced by maternal effects in cattle. Haile-Mariam and Philipson (1995) reported correlations of estimated breeding values between direct and maternal effects of -0.54 for birth, which showed not quite similar trend in the present study that direct and maternal correlations were negative for early weights and tend to be positive in later ages (Meyer, 1992).

The environmental trends were non-significant for both male and female birth weight, as indicated by the low (R^2) of 11% and 5% for males and females, respectively. However, environmental values were fluctuating below zero for females and maintained a slightly positive trend for males. Phenotypic trends for birth weight for both male and female roughly followed a similar pattern, however indicating that males were heavier than females. The male phenotypic trend was significant which may suggest differences in weight at birth of males and females.

Implication

The cause of the relatively low negative correlation between male direct breeding values and female direct breeding values for birth weight may be an indication of the selection policy, which was against high birth to reduce dystocia in this herd. The results of this study indicates that birth weight should be given some consideration in selection in view of the fact that there is comparatively high genetic variability in females which can be exploited to improve weight traits by mass selection by local farmers. The dam had a considerable maternal influence on birth weight in females therefore greater care should be taken in selection of dams and in the evaluation of their influence in progeny tests of sires. It is likely that an increase in birth weight would be desirable and that under weight calves may be more serious problem than over weight. As a result taking advantage of the positive co-variances of direct and maternal breeding values may not be difficult to establish an appropriate selection index to fit in birth weight.

However, future studies should focus towards implementation of a selection program based on comprehensive multi trait objectives, which can produce reliable estimates of genetic parameters and particularly genetic correlation of birth with further live weights to totally avoid the introduction of detrimental effects of dystocia in the long term. In order to arrive at a valid conclusion for this population more detailed study on the association of birth with further live weights may be necessary in order to develop an appropriate selection index which may optimize total productivity. The potential exist for increasing the genetic merit for growth with minimal birth problems as indicated by the magnitude of trends and positive genetic covariance in males and females. The birth weight should elevate to an intermediate optimum weight with excessively large calves liable to dystocia and excessively small calves at risk of death due to other causes. The environmental conditions are not however reliable and the negative effects on birth weight are no means unique in drought stricken southern part of Zimbabwe. The maternal genetic trend indicates a decline in maternal ability for birth weight and since the indigenous Nguni cattle breed is widely suggested as dam line, an opportunity exists to improve the maternal ability for birth weight by selection on maternal additive breeding values as the new selection criteria and emphasis should be put on selecting animals on the basis for their estimated breeding values rather than on phenotypic performance taking into cognizance the existence of weak positive environmental effects which may not strongly support the expression of genetic differences in males and females hence do not warrant partitioning of data for genetic evaluation.

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