(Co)variance components for growth traits in the Nguni cattle breed

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Abstract
Production records for birth weight (BW), weaning weight (WW), yearling weight (YW) and eighteen-month weight (EW) of Nguni herds participating in the National Beef Cattle Improvement Scheme from 1960 to 2001 were analysed. The dataset consisted of 26677 BW, 23723 WW, 10256 YW and 7260 EW records. Direct heritability estimates for BW, WW, YW and EW obtained by single trait analyses were 0.26, 0.17, 0.13 and 0.13, respectively. Maternal heritability estimates were the same (0.10) for BW, YW and EW but slightly higher for WW (0.11). Direct genetic correlations (multivariate analyses) among the four growth traits were moderate to high (0.50 to 0.95) while the maternal genetic correlation between BW and WW (bivariate analyses) were moderate (0.49). It was concluded that selection on WW alone would be undesirable as all other weights may increase. Breeding values for production traits should be seen in conjunction with one another to prevent undesirable correlated responses.

Keywords: Nguni cattle, genetic parameters, weight

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Introduction
The deliberation of economically important traits is the first and foremost aspect to be considered before selection of the parents for the next generation takes place. The accurate estimation of genetic parameters for these economic traits are thus of utmost importance (Koch et al., 1973).

Selection for growth is complicated by the fact that traits like birth weight and weaning weight are determined by the animal’s own additive genetic merit as well as a maternal component, which can be separated further in an additive genetic and a permanent environmental component. Statistical and computational developments make it possible to separate the additive and maternal components, while determining the relationship between these two components, which is mostly negative. This is of significance, since a clearly antagonistic relationship would have consequences for the breeding program, eventually leading to the development of specialized sire and dam lines (Swalte, 1993). This may be of concern to South African indigenous cattle, since most indigenous breeds are regarded as potential dam lines.

The objective of this study was to obtain heritability estimates and genetic correlations for growth traits in the Nguni cattle breed, in an attempt to aid the prediction of direct and correlated responses when selection is based on weight at a certain age.

Materials and Methods
Records of birth weight (BW), weaning weight (WW), yearling weight (YW) and eighteen-month weight (EW) from Nguni herds participating in the National Beef Cattle Improvement Scheme (NBCIS) from 1960 to 2001 were used in the study. Incomplete records were discarded. After editing, the numbers of records for BW, WW, YW and EW were 26677, 23723, 10256 and 7260, respectively. (Co)variance components and heritability estimates were obtained through single trait analyses using the ASREML program (Gilmour et al., 1999). Log likelihood ratio tests were used to indicate the most suitable model for each trait. The models described by Meyer (1992) were extended by including the herd-year-season x sire interaction (HYSxS) as an additional random effect. This led to a significant improvement in the log likelihood for all traits. Genetic correlations were obtained through multivariate analyses where another data set was used. This data set included only herds linked with at least two other herds through sires used. The maternal genetic and maternal permanent environmental effects as well as the covariance between direct and maternal effects were excluded for YW and EW in the multivariate analyses, due to convergence problems. Since solutions from the multivariate analyses did not provide information about the covariance structure of the maternal genetic component between BW and WW, two trait analyses were carried out on the same data set. Heterogeneous variances were tested by correcting the y-value with the standard deviation of each contemporary group. However, it did not affect the outcome of the analysis.

The South African Journal of Animal Science is available online at http://www.sasas.co.za/sajas.html
Results and Discussion

The estimates from the HYSxS effect were 0.07, 0.09, 0.07 and 0.05 (BW, WW, YW and EW respectively) and seemed to be significant in all traits. Neser et al. (1996) stated that the inclusion of the HYSxS interaction will have an effect on the accuracy of the estimates. This is also supported by Meyer (1987) who reported that the exclusion of even a small genotype x environment interaction could lead to an overestimation of the accuracy of the sire’s predicted breeding value. The direct heritability estimate for BW (0.26) (Table 1) compared well with the weighted mean heritability of Koots et al. (1994) for BW (0.31), while the estimate for WW (0.17) is lower than the weighted mean value of 0.24. The estimate for YW (0.13) is lower than the weighted mean heritability reported by Koots et al. (1994) (0.33). The direct heritability estimate of 0.31 for BW obtained by Van der Westhuizen (1997), fitting a sire x year-season interaction, also compares well with this study. The present estimate for EW (0.13) also compared well with the estimate reported by Van der Westhuizen (1997) (0.16). Maternal heritability estimates were the same (0.10) for BW, YW and EW, with an estimate of 0.11 for WW. The relatively high estimates for post-weaning weights may have resulted from weighing the animals at weaning, but not separating them from their dams. Koots et al. (1994) reported m² values of 0.13 and 0.14 for BW and WW, respectively. Permanent maternal environment expressed as the proportion of the phenotypic variance was 0.02, 0.14 and 0.06 for BW, WW and YW, respectively. The estimate for WW corresponded well with results obtained by Neser et al. (1996), fitting a HYSxS interaction, single trait analysis (0.15). Meyer (1992) reported a permanent maternal environmental estimate of 0.23 and stated that WW in Hereford cattle was primarily determined by this effect, while Van der Westhuizen (1997) found this effect to be non-significant.

Genetic correlations among the different traits (Table 1) were all positive, ranging from moderate (0.50) to high (0.95). Estimates between WW and later weights (YW and EW) were almost similar to those reported by Groeneveld et al. (1998, Afrikaner cattle) (0.86 and 0.93) and Meyer et al. (1993) (0.88 and 0.92). Van der Westhuizen (1997) reported much lower genetic correlations of 0.20 between BW and WW, and 0.02 between BW and EW. The rest of the direct genetic correlations corresponded favourably with results reported by Groeneveld et al. (1998) and Meyer et al. (1993). However, neither of these authors fitted a HYSxS interaction.

Table 1 Direct heritability estimates (diagonal) and direct genetic correlations (off-diagonal) with the corresponding standard errors (s.e.)

<table>
<thead>
<tr>
<th>Trait</th>
<th>BW</th>
<th>WW</th>
<th>YW</th>
<th>EW</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW</td>
<td>0.26 (0.03)</td>
<td>0.53 (0.04)</td>
<td>0.51 (0.05)</td>
<td>0.50 (0.06)</td>
</tr>
<tr>
<td>WW</td>
<td></td>
<td>0.17 (0.02)</td>
<td>0.95 (0.03)</td>
<td>0.90 (0.04)</td>
</tr>
<tr>
<td>YW</td>
<td></td>
<td></td>
<td>0.13 (0.03)</td>
<td>0.92 (0.04)</td>
</tr>
<tr>
<td>EW</td>
<td></td>
<td></td>
<td></td>
<td>0.13 (0.04)</td>
</tr>
</tbody>
</table>

It is evident from the positive direct genetic correlation (0.53) between WW and BW that an increase in BW will take place when selection for WW is applied. Furthermore, selection on direct breeding values for WW will also lead to an unfavourable increase of EW as indicated by the direct genetic correlation of 0.90. The feasibility of increasing WW without increasing BW may look promising since the direct correlation is not close to unity. However, the almost unattainable result of maintaining EW while increasing WW renders such a practice impractical. Van der Westhuizen (1997) reported a correlation of 0.15 between BW and EW. Different fixed effect modelling may have contributed to the dissimilar estimates. Correlated responses in YW and EW when selecting for WW will be rapid as the relevant genetic correlations are close to unity. These results show that mostly the same genes are involved in growth up to weaning as well as in post-weaning growth. This also holds true for YW and EW. These high direct genetic correlations have several implications. The first is the inessential recording of both YW and EW, as the direct correlations between the traits show that a missing trait among one of these two will not have a significant effect on what is known about the post weaning performance of a specific animal. Although the direct correlation of WW with YW and EW is very strong, the recording of WW together with YW or EW is essential as it is necessary for accurate breeding values of the maternal component of WW.
A two trait analysis of maternally influenced traits (BW and WW) revealed that conflict might arise when selecting on maternal breeding values for WW, as this may impact adversely on the ability of the dam to inhibit the size of the foetus, thus increasing BW. This is illustrated by the positive moderate genetic correlation (0.49 ± 0.08) between the maternal components. The maternal component of WW can not be neglected as Kaps et al. (2000) stated that maternal genetic effects influence not only growth traits, but also maturing rate. Fortunately, however, the genetic correlation between these two maternal components is moderate, allowing the opportunity of maintaining BW while improving WW through the maternal component, where necessary.

Two trait analyses between BW and WW suggested a negative association between direct and maternal effects (range -0.24 to -0.71). Groeneveld et al. (1998) reported similar results in Afrikaner cattle. This shows that maternal abilities will decline when exclusive selection for growth on direct breeding values for WW is practised.

Conclusions
Results indicate that the selection of beef cattle for growth is not as simple as might be envisaged. The first opportunity where selection takes place is usually at weaning, especially in a breed considered as a dam line. However, the results of selection on WW alone will be undesirable as all other weights may increase. Alternately, increasing pre-weaning growth rate while only maintaining mature weight (EW) may prove difficult if not impossible to achieve. Maintenance of BW will be more procurable. This is also applicable when the objective is to improve the mothering ability in WW while maintaining foetal growth and thus BW. The outcome of such selection is not yet clear and future research should consider the effect of increasing WW (especially the maternal component) on fitness traits such as reproduction. The genetic correlation between the post weaning weights (YW and EW) is high and selection for one of these weights will also increase the other. No breeding value for one component or single trait associated with growth should be considered in isolation. Breeding values for production traits should be seen in conjunction with one another to accommodate undesirable effects on other traits. Future research should focus on the genetic correlation between the direct component of post weaning weights and the maternal component of maternally influenced traits. This may be best done with experimental rather than field data.

References