Variance component and heritability estimates for growth traits in the Nguni cattle stud at Bartlow Combine

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Data collected from calves born at the Bartlow Combine Breeding Station were analysed to estimate direct and maternal additive genetic variances and resulting heritabilities for weight at birth, 205, 365 and 540-days of age. The estimates of direct heritability were 0.41, 0.29, 0.26 and 0.19; maternal heritability 0.16, 0.20, 0.08 and 0.003 and total heritability 0.44, 0.40, 0.34 and 0.21, respectively. The correlations between the direct and maternal components were –0.49, –0.39, –0.08 and 0.97. It is suggested that both direct and maternal breeding values be included in a selection programme for birth and 205-day weight. Because the Nguni is classified as a dam line, the improvement in the maternal component is of particular interest. The results for 365 and 540-day weights indicate that the maternal component is less important and that selection for direct additive values may well be successful in eliciting a response.

Data van kalwers wat op die Bartlow Combine Teelstasie gebore is, is ontleed om direkte en maternale additiewe genetiese variansies en gevolglike oorerflikhede van gewig op geboorte, 205-, 365- en 540-dae ouderdom, te bepaal. Die beraming van direkte oorerflikheid was 0.41, 0.29, 0.26 en 0.19; maternale oorerflikheid 0.16, 0.20, 0.08 en 0.003 en totale oorerflikheid 0.44, 0.40, 0.34 en 0.21, onderskeidelik. Die korrelasie tussen die direkte en maternale komponente was –0.49, –0.39, –0.08 en 0.97. Dit word voorgestel dat beide direkte en maternale teeltwaardes in 'n seleksieprogram vir geboorte en 205-dae gewig ingesluit word. Weens die klassifikasie as 'n moederlyn is die verbetering van die maternale komponent van spesifieke belang by die Nguni. Die resultate vir 365- en 540-dae gewig dui daarop dat die maternale komponent van minder belang is en dat seleksie gebaseer op direkte teeltwaarde, gewig op hierdie ouderdomme suksesvol kan verander.

Keywords: Growth traits, heritabilities, maternal additive variances, Nguni cattle.

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Introduction

The improvement of performance through selection is largely dependent on the effective use of additive genetic variation and therefore requires the accurate estimation of genetic parameters for the traits to be selected. Growth performance is widely used as a selection criterion in beef cattle since live weight is of economic importance and can easily be measured.

As pointed out by Kars *et al.* (1994), indigenous cattle breeds, such as the Nguni, are gaining in popularity in southern Africa because of their natural ability to produce and reproduce under local conditions without much additional managerial input or change to the environment. This ability could possibly be improved even further by using more sophisticated techniques of predicting breeding value, provided that they are used with discretion, especially as far as the traits to be considered are concerned.

Numerous variance components and heritability estimates (Table 1) of growth traits for both direct additive and maternal additive components have been reported for beef cattle (Hohenboken & Brinks, 1971; Burfening *et al.*, 1981; Bertrand & Benyshek, 1987; Cantet *et al.*, 1988; Trus & Wilton, 1988; Meyer, 1992). However, no published results are available for Nguni cattle. This is a serious limitation since these specific estimates are needed for the formulation of breeding plans and the prediction of breeding values. Investigations into the maternal additive component of the traits is of particular significance in this case. The possibility of genetic improvement in the maternal ability of the Nguni should be of interest since the breed is widely recommended as a dam line in terminal cross-breeding (Hofmeyr, 1974; Scholtz, 1988). The Bartlow Combine Nguni stud is reasonably representative of the breed and an important source of genetic material (Kars *et al.*, 1994). The objective of this study was to estimate genetic parameters in this stud for subsequent use in genetic evaluation and the formulation of breeding plans. Special reference is made to the parameters affecting possible future improvement in maternal ability.

Material and Methods

The data consisted of records collected from calves born from 1960 to 1991 for weights at birth, 205, 365 and 540-days of age in the Bartlow Combine Nguni stud according to the procedures prescribed by the National Beef Cattle Performance and Progeny Testing Scheme. The number of records for each trait is given in Table 2.

A description of the farm, history of the stud, selection, management practices and editing procedures have been reported by Kars *et al.* (1994). All sires were included.

Analyses were conducted by means of derivative-free restricted maximum likelihood (DFREML) procedure using the program of Meyer (1989; 1991) and fitting the following model:

$$y = Xb + Z_1a + Z_2m + e$$

where

y = a vector of observations,

X = a known incidence matrix relating observations to fixed effects,

Table 1 Heritability estimates for direct (a), maternal (m) and total (T) additive genetic components and correlation (r_{Gam}) between direct and maternal components

Breed	n	h^2_a	h^2_m	h^2_T	r_{Gam}	Reference
Birth weight						
Her	789	0.56	0.30	0.36	−0.58	Brown & Galvez (1969)
Ang	932	0.14	0.25	0.17	−0.37	Brown & Galvez (1969)
Her	4060	0.44	0.10	0.56	0.07	Koch (1972)
Sim	11 552		0.11		−0.24	Burfening *et al.* (1981)
Her	1 012	0.36	0.82		−0.51	Nelsen *et al.* (1984)
Lim	78 088	0.22	0.05		−0.16	Bertrand & Benyshek (1987)
Brn	20 750	0.25	0.13		−0.12	Bertrand & Benyshek (1987)
Her	4 423	0.16	0.18	−0.01	−1.03	Cantet *et al.* (1988)
Her	4 423	0.27	0.63	0.05	−0.86	Cantet *et al.* (1988)
Ang	16 345	0.37	0.13	0.32	−0.34	Trus & Wilton (1988)
Her	65 376	0.39	0.13	0.32	−0.39	Trus & Wilton (1988)
Shh	5 092	0.27	0.20	0.56	0.55	Trus & Wilton (1988)
Cha	10 048	0.42	0.17	0.35	−0.39	Trus & Wilton (1988)
Sim	23 784	0.34	0.20	0.36	−0.22	Trus & Wilton (1988)
Her	5 488	0.38	0.14	0.47	0.05	Meyer (1992)
Ang	4 036	0.34	0.10	0.47	0.27	Meyer (1992)
Weaning weight						
Bra	725	0.18	0.15	0.25	0.00	Deese & Koger (1967)
Her	2 618	0.23	0.34	0.28	−0.28	Hohenboken & Brinks (1971)
Lim	53 494	0.16	0.15		−0.30	Bertrand & Benyshek (1987)
Brn	46 661	0.28	0.20		−0.29	Bertrand & Benyshek (1987)
Her	4 423	0.31	0.33	0.10	−0.79	Cantet *et al*. (1988)
Her	4 423	0.26	0.67	0.20	−0.63	Cantet *et al.* (1988)
Her	7 003	0.14	0.46	0.14	−0.59	Meyer (1992)
Ang	3 465	0.19	0.18	0.33	0.20	Meyer (1992)

Ang = Angus; Bra = Brahman; Brn = Brangus; Cha = Charolais; Her = Hereford; Lim = Limousin; Shh = Shorthorn; Sim = Simmental

b = a vector of fixed effects consisting of year of birth, sex and the linear and quadratic regression of age of dam on year of birth,

Z_1; Z_2 = 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,

e = a random vector associated with residual errors.

The starting values for iteration were obtained from preliminary analyses using Henderson's method III (Harvey, 1988).

Other effects, such as those due to permanent environment, could also be included. This, however, increases the computational requirements and therefore only the effects of interest were included.

Results and Discussion

The estimates of variance components and heritabilities are presented in Table 2. These results allow an assessment of the relative importance of the two sources of variation. The direct additive variances (σ^2_a) and heritabilities (h^2_a) were larger than

Table 2 Estimates of variance components and heritabilities for direct additive and maternal additive components

Parameters	Weight traits (days) Birth	205	365	540
n	12 673	12 002	5 273	3 886
σ^2_a	5.559	96.298	88.310	96.376
σ^2_m	2.147	66.264	28.484	1.640
σ_{am}	−1.692	−31.049	−3.825	12.247
σ^2_e	7.596	196.332	224.760	405.363
σ^2_p	13.611	327.845	337.729	515.626
h^2_a	0.409	0.294	0.262	0.187
SE	0.057	0.032	0.047	0.040
h^2_m	0.158	0.202	0.084	.0.003
SE	0.022	0.021	0.028	0.028
h^2_T	0.442	0.401	0.335	0.214
σ_{am}/σ^2_p	−0.124	−0.095	−0.011	0.024
SE	0.016	0.024	0.029	0.026
r_{Gam}	−0.490	−0.389	−0.076	0.974

the respective maternal values (σ^2_m ; h^2_m) for all the traits under study. Similar results have been reported by Burfening *et al.* (1981), Quaas *et al.* (1985), Bertrand & Benyshek (1987), Trus & Wilton (1988) and Meyer (1992) for birth weight; Quaas *et al.* (1985), Bertrand & Benyshek (1987) and Herd (1990) for weaning weight, and Herd (1990) and Meyer (1992) for yearling weight. Larger maternal values than direct values have been reported in studies by Brown & Galvez (1969), Nelsen *et al.* (1984) and Cantet *et al.* (1988) for birth weight and Hohenboken & Brinks (1971) Cantet *et al.* (1988) and Meyer (1992) for weaning weight.

The covariance and genetic correlation between direct and maternal components for weight at birth, 205 and 365-days of age were found to be negative, reducing the total heritability. The antagonism between these components appears to be common in beef cattle for pre-weaning growth traits (Hohenboken & Brinks, 1971; Van Vleck *et al.*, 1977) and also occurs in yearling weight (Mavrogenis *et al.*, 1978; Meyer, 1992). However, positive correlations have been reported by Koch (1972), Trus & Wilton (1988) and Meyer (1992) for birth weight and Deese & Koger (1967) and Meyer (1992) for weaning weight. Van Vleck *et al.* (1977) illustrated that genetic improvement would be difficult with a large negative covariance as an increase in one component could result in a decline in the other.

Koch (1972) reported that the total maternally related variance is likely to account for 15 – 20% of the phenotypic variance in birth weight. This study estimated the proportion of σ^2_m and σ_{am} to be roughly 16% and 12%, respectively. The correlation between direct and maternal effects is in close agreement with the literature averages by Koch (1972) and Baker (1980). The estimates of direct, maternal and total heritability for birth weight are in general agreement with the literature.

The proportion of maternal additive variance and covariance to the phenotypic variance was 20% and 10%, respectively, for 205-day weight which corresponds well with the estimates for σ_{am}/σ^2_p of 8% by Hohenboken & Brinks (1971) and Meyer (1992) in Hereford cattle. The estimate of direct heritability is supported by Preston & Willis (1974) and Woldehawariat *et al.* (1977), while the maternal heritability is considerably lower than the values reported by Koch (1972) and Baker (1980). The r_{Gam} for the 205-day weight is lower than the mean values of –0.55, –0.72 and –0.65 calculated by Koch (1972), Baker (1980) and Cantet *et al.* (1988), respectively. Hohenboken & Brinks (1971) and Bertrand & Benyshek (1987) reported correlations in the order of –0.29.

The estimates of total heritability and the genetic correlation between the direct and maternal components for birth and 205-day weight suggest that a response to selection can be obtained if both direct and maternal breeding values are considered in a selection program. This is of particular interest since the selection for maternal ability creates the opportunity for developing dam lines. The expected progress in maternal ability would, however, be slow owing to the relatively low maternal heritabilities of these traits.

Little information exists in the literature on maternal additive genetic components for post-weaning traits. Meyer (1992) found the maternal component to be significant in yearling and final weight of Hereford and Zebu-cross cattle. In this study, the maternal variance contributed 8.4% and 0.3% to the phenotypic variance of 365 and 540-day weight, respectively, indicating that the maternal component is of less importance in these traits. The estimate of direct heritability for 365-day weight is considerably lower than the mean values calculated by Preston & Willis (1974) and Petty & Cartwright (1966) which are in the order of 0.50. The genetic correlation between the direct and maternal components for 365-day weight suggests that there is little association between them, while Meyer (1992) reported an average of –0.41.

The proportion of covariance between direct and maternal genetic components for 365 and 540-day weight suggests that genetic progress can be achieved, although the response to 540-day weight may be slow owing to a low direct heritability. There would be little value in selecting for maternal ability because maternal heritability of these traits is low.

Conclusions

The results of this study indicate that early growth traits in the Nguni can be improved by selection using both the direct and maternal additive components of genetic variance. However, the negative covariance between these components poses some limitations on the total response expected. Best Linear Unbiased Prediction (BLUP) of direct and maternal breeding values, using the parameters obtained in this study and the model specified by Kars *et al.* (1994), can be used as a basis for future selection.

Later growth traits will be more difficult to improve by selection. In practical terms, this should not be viewed as an unwelcome result, since it is doubtful whether these traits need 'improvement' in this breed. Increasing mature body weight would simply lead to increased maintenance requirements.

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