THE INFLUENCE OF BREED COMPOSITION ON WEANING WEIGHT PARAMETERS IN A MULTIBREED BEEF CATTLE POPULATION

S.J. Schoeman and G.F. Jordaan

Department of Animal Sciences, University of Stellenbosch, Stellenbosch, South Africa

SUMMARY
Direct and maternal components were estimated for birth weight and weaning weight in a multibreed cattle population. Data consisted of 20840 records of calves with varying levels of British (B), Charolais (C), Simmental (S) and Afrikaner (A) breeds. It included several F_1, backcrosses, threebreed and fourbreed crosses, having an approximate average composition of $^3/_8$B : $^3/_8$S : $^1/_8$C : $^1/_8$A. The number of calf, sire and dam genotypes were 122, 33 and 43, respectively. Single and two-trait analyses were conducted fitting an animal model. Direct and maternal variance components were estimated. The direct (h^2_a), and maternal (h^2_m) heritabilities and genetic correlation between direct and maternal effects (r_{am}) for weaning weight were 0.55, 0.22 and –0.53 for the single trait and 0.53, 0.20 and –0.60 for the two-trait analyses, respectively. In a subsequent analysis, where direct and maternal breed proportions as well as direct and maternal average heterosis were additionally included, corresponding estimates were 0.37, 0.18, -0.42 and 0.41, 0.18 and –0.46, respectively. Charolais had a positive direct but negative maternal effect and Simmental a negative direct but positive maternal effect. The British breeds had a positive direct but strong negative maternal effect, while the Afrikaner had a large negative direct but small positive maternal effect.
Keywords: Beef cattle, breed proportions, multibreed, variance components, weaning weight.

INTRODUCTION
Large numbers of genetic parameter estimates were already published (Koots *et al*. 1994a, b). The majority of these estimates were, however, obtained from purebred populations, while the majority of beef cattle in most countries are of multibreed composition. The genetic improvement of composite or multibreed populations is just as important as the improvement of purebreds.

In multibreed populations both direct and maternal genetic effects are composed of a fixed breed effect and a random animal effect. Failure to separate these components would result in possible biased parameter estimates. Until fairly recently analyses of multibreed data were avoided owing to the complexity thereof and difficulties such as appropriately accounting for breed composition and breed non-additive effects. However, in recent years various approaches and models have been proposed to accommodate breed composition differences (Elzo and Famula 1985; Rodiguez-Almeida *et al*. 1997). The objective of this investigation was to obtain more reliable estimates of genetic parameters and direct breed effects in an Afrikaner-British breeds-Charolais-Simmental multibreed population.

MATERIALS AND METHODS
Data. A crossbreeding project, involving two- and threebreed rotational and terminal systems, consisting of 2500 to 3000 females, was initiated at the two farms of the Johannesburg Metropolitan

Council in 1968. The main objective of the operation, where waste water was used for irrigation purposes, was to maximise output per unit of land area, though with low individual performances. Afrikaner and Hereford females were obtained from commercial farmers and were mated to sires of British breeds (B) (Hereford, Angus, South Devon), Charolais (C) and Simmental (S). In 1986 the crossbreeding project was terminated and all breed combinations were pooled. Data consisted of birth weight (BW) and weaning weight (WW) records on 20840 pure and multibreed calves born up to 1993. The number of animals in the pedigree file was 24293. In total 165 sires were used with an average of 126 calves per sire. The number of dams was 7162 with an average of 2.9 calves per dam. Heifers calved for the first time at approximately 2 years of age.

Pedigrees were traced from crossbreds back to purebreds to establish breed composition of every individual calf. Breed composition of the calves varied from pure B and A to fourbreed crosses of varying breed proportions. The average composition of the crossbred calves was approximately $^{3}/_{8}$B:$^{3}/_{8}$S:$^{1}/_{8}$C:$^{1}/_{8}$A. The number of calf, sire and dam genotypes were 122, 33 and 43, respectively. 26.8 % of calves were from B dams, 2.2 % from A dams and 71.0 % from crossbred dams.

Statistical analysis. Variance components were estimated for both BW and WW separately (unitrait) and jointly (two-trait) with a REML procedure using the VCE programme of Groeneveld (1994). Two models were fitted, firstly excluding breed proportions and direct and maternal average heterotic effects and secondly including them as fractional contributions to each individual (Dillard *et al*. 1980). Fixed effects included in the analysis were HYS (72 levels), sex of calf (2 levels) and dam age (9 levels), while weaning age was fitted as a covariate for WW. The latter model fitted was:

$$y = Xb + Z_a u_a + Z_m u_m + Z_c c + B^I g + B^M d + Hh + e$$

where

y = a vector of observations

b = a vector of fixed effects with incidence matrix X

u_a and u_m = vectors of direct and maternal genetic effects with incidence matrices Z_a and Z_m

c = a vector of random permanent environmental effects of the dam with incidence matrix Z_c.

g and d = vectors of fixed direct and maternal breed effects, respectively, with incidence matrices B^I and B^m, respectively, relating observations to the direct and maternal breed effects through the fractional contribution of each breed to each individual animal.

h = a vector of direct and maternal average heterosis effects with incidence matrix H which relates observations to heterosis through the corresponding proportions of breed heterozygosity.

e = a vector of random residual effects.

RESULTS AND DISCUSSION

Direct effects. Direct heritabilities (h^2_a) (Table 1) tend to be higher than the mean estimates reported in the literature (Koots *et al*. 1994a). In both the uni- and two-trait analyses there were considerable reductions in estimates in the models where the breed proportions and direct and maternal heterosis effects were included. Higher heritabilities arising from large genetic variances due to multibreed composition could be expected. Higher mean heritabilities were also obtained by Meyer *et al*. (1993) in a multibreed population ($h^2 = 0.52$) compared to the estimates in a Hereford population ($h^2 = 0.19$). Likewise, Bennett and Gregory (1996) obtained a h^2_a of 0.37 in composite lines compared to a mean

h^2_a of 0.29 in the foundation breeds. Both direct and maternal genetic effects are composed of fixed breed group and random animal effects. In both the unitrait and two-trait analyses estimates were reduced since breed group effects and non-additive breed effects were accounted for.

Table 1. Heritability estimates (h^2_a, h^2_m), permanent environmental effects (c^2) and direct-maternal genetic correlations (r_{am}) for BW and WW with or without the inclusion of direct breed proportions and direct and maternal average heterosis

Parameters	Unitrait analysis				Two-trait analysis			
	Proportions excluded		Proportions included		Proportions excluded		Proportions included	
	BW	WW	BW	WW	BW	WW	BW	WW
h^2_a	0.62	0.55	0.40	0.37	0.57	0.53	0.38	0.41
h^2_m	0.09	0.22	0.06	0.18	0.08	0.20	0.05	0.18
c^2	0.10	0.13	0.09	0.15	0.10	0.13	0.08	0.14
r_{am}	-0.37	-0.53	-0.01	-0.42	-0.31	-0.60	0.03	-0.46

Direct breed effects (Table 2) were relatively small when compared to those reported elsewhere (Schoeman *et al*. 1993; Rodriguez-Almeida *et al*. 1997). This may be related to the relatively unfavourable environment. Direct estimates for Afrikaner and Simmental were negative, while they were positive for the British breeds. The negative estimates for Simmental were unexpected. Large positive direct effects for Simmental were obtained by Schoeman *et al*. (1993) also involving Afrikaner and Hereford. Likewise, Rodriguez-Almeida *et al*. (1997) obtained a large negative direct effect for Simmental in one data set, but a positive one in another data set.

Table 2. Estimates of direct, maternal and total breed effects

Breeds	Traits					
	BW			WW		
	Direct	Maternal	Total	Direct	Maternal	Total
Afrikaner	-0.82	-0.14	-0.96	-6.72	1.96	-4.76
British	0.70	0.02	0.72	4.95	-7.67	-2.72
Charolais	-0.52	-0.38	-0.90	2.12	-7.30	-5.18
Simmental	-0.09	0.25	0.16	-4.07	9.20	5.13

Maternal effects. Direct maternal heritabilities (h^2_m) (Table 1) were low for WW and correspond to most reported estimates (Koots *et al*. 1994a). Higher estimates for WW were obtained for Herefords by Meyer *et al*. (1993). Maternal heritabilities were only marginally reduced by the inclusion of the breed proportions and direct and maternal average heterosis in the model. Estimates of the maternal permanent environmental effect (c^2) also agree well with most estimates reported elsewhere (Meyer *et al*. 1993; Meyer 1994; Tosh *et al*. 1999). One could have expected a larger c^2 estimate as a large proportion of the heifers were raised by two-year old dams and these dams could have impeded growth performances. Maternal estimates (h^2_m, c^2) were less affected by the inclusion of breed proportions and direct and maternal average heterotic components, as would have been expected.

Maternal breed effects (Table 2) were also small and for WW negative for the British breeds and the Charolais, while it was positive for the Simmental. The larger positive maternal breed effect for Simmental and the negative estimate for the British breeds, could therefore be expected. Large positive maternal effects for the Simmental were obtained in several other similar studies (Cunningham and Magee 1988; Schoeman *et al*. 1993; Rodriguez-Almeida *et al*. 1997).

For all four breeds, direct breed and maternal breed effects tended to be in different directions. This, together with some of the unexpected results, may be an indication of large sampling variances or some confounding between direct and maternal effects (Rodriguez-Almeida *et al*. 1997). The results suggested that for high WW crossbred dams with high Simmental proportions should be used, while use of sires with high British breed proportions would be preferred.

Direct-maternal genetic correlations. Genetic correlations between direct and maternal effects (r_{am}) were mostly negative (Table 1) and agree with literature estimates (Meyer 1992; Koots *et al*. 1994b). This may not reflect a true adverse relationship between direct and maternal effects, but management practices, environmentally-induced negative dam-offspring covariances or sire x year interactions (Robinson 1996). In the model with breed proportions and direct and maternal mean heterosis were included, r_{am} for WW were considerably reduced in both the unitrait and two-trait analyses.

Genetic parameter estimates obtained in this study pertain to a relatively small population. These animals are regarded as being sampled from a single population with a mean genetic value of zero and common variances, which is evidently not the case. Base animals consisted of purebred British breeds, Afrikaner and sire breeds varying in mature size and other traits (e.g. Hereford *vs* Charolais). The population then consists of various sub-populations having different means and possibly also different variances. Including breed group proportions and breed non-additive effects in the model, accounts for expected bias caused by these differences.

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