Sire breed and breed genotype of dam effects in crossbreeding beef cattle in the subtropics. 1. Birth and weaning mass of calves

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The influence of sire breed and breed genotype of dam on birth and weaning mass in calves of Afrikaner, Hereford, Simmentaler and Bonsmara cattle, as well as F_1, and two- and three-breed rotational crosses between Afrikaner, Hereford and Simmentaler were investigated. Afrikaner bulls sired calves with lower birth and weaning mass ($P \leq 0.05$) than other breeds of sire. In terms of weaning mass, all the crossbreeding systems proved superior to purebred Afrikaner and Hereford breeding, but not to purebred Simmentaler and Bonsmara breeding. Simmentaler dams produced calves of heavier ($P < 0.05$) birth mass than other purebreds. An increase in percentage Afrikaner breeding in the dam led to a reduction in birth mass, while the reverse applied to an increase in Simmentaler breeding. Cows of predominant Simmentaler breeding tended to wean heavier calves than cows of predominant Afrikaner breeding.

Die invloed van vaderras en genotipe van moeder op die geboorte- en speenmassa van Afrikaner-, Hereford-, Simmentaler- en Bonsmarakalwers, sowel as F_1, en 'n twee- en drieras-rotasiekruising tussen Afrikaner, Hereford en Simmentaler is ondersoek. Afrikanervaders het kalwers met laer geboorte- en speenmassas ($P \leq 0.05$) geproduseer as ander vaderrasse. Ten opsigte van speenmassa het al die kruisteeltstelsels beter as die suiwer Afrikaner en Hereford presteer, maar nie beter as suiwer Simmentaler en Bonsmara nie. Simmentalermoeders het kalwers met hoër ($P < 0.05$) geboortemassas as ander suiwer rasse geproduseer. 'n Toename in die persentasie Afrikanerteling het 'n afname in geboortemassa tot gevolg gehad, maar die teenoorgestelde is gevind vir 'n toename in Simmentalerteling. Koeie van oorwegend Simmentalerteling het swaarder kalwers gespeen as koeie van oorwegend Afrikanerteling.

Keywords: Birth mass, crossbreeding, dam breed genotype, sire breed, weaning mass.

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Introduction

Birth mass of beef calves has been studied thoroughly, principally because of its association with dystocia and subsequent reduction in productivity (Brinks *et al.*, 1973; Smith *et al.*, 1976; Notter *et al.*, 1978a; Smith *et al.*, 1988). Low birth mass of calves has been attributed to a lack of adaptability (Bonsma & Skinner, 1969) and can be expected to result in higher peri-natal mortality rates. The birth of a strong, healthy calf has been regarded as the single most important factor influencing efficient beef production (Smith *et al.*, 1988).

A relative high weaning mass is of importance to the overall efficiency of the beef cattle enterprise (Harwin *et al.*, 1966) and is regarded as a reliable indicator of beef cow efficiency (Marshall *et al.*, 1976; Venter *et al.*, 1980). It reflects the underlying differences in milk production by cows (Notter *et al.*, 1978b).

In various extensive ranching areas of southern Africa, beef and weaner production remains the main economic activity. Information obtained under practical ranching conditions regarding the productive potential and possible utilization of various breeds and types is thus important. With this in mind, a pure- and cross-breeding project utilizing exotic British (Hereford) and Continental (Simmentaler), indigenous *Bos indicus* [Afrikaner, which was recently more accurately classified as *Bos taurus africanus* (Meyer, 1984)] and indigenous synthetic (Bonsmara) cattle was carried out by the Department of Agriculture.

Material and Methods

Data were collected at Mara Research Station (23°09 'S, 29°34 'E; 894 m) in the Northern Transvaal from 1972 to 1984. Animals were maintained on predominant *Acacia tortillis* var. *heteracanta* veld in 35 camps of approximately 172 ha each. Controlled selective grazing was practised, with a stocking rate of 8 ha per mature livestock unit.

Animals

Purebred Afrikaner, Hereford, Bonsmara and Simmentaler herds were maintained alongside F_1, criss-cross crossbred A × H and A × S and three-breed rotational crossbred between A, H and S, at approximately 40 animals per breed genotype. Hereford and Simmentaler sires were utilized to produce the initial F_1 crossbreds. Multi-sire mating at 5% males was used. Since the same sires were simultaneously used on different dam breed genotypes within each year, the number of sires per genotype could not be estimated. Some 25% of the cows were replaced annually. Criteria for replacement were death, injury, failure to conceive two years in succession and weaning performance of progeny. The best 40 to 50% heifers were selected as replacements on the basis of postweaning gain and bred at 25 to 28 months of age. Some heifers were, however, bred at 15 to 16 months to calve at two years. Bulls were evaluated for breeding soundness prior to the start of the breeding season. This included a physical examination and semen evaluation of bulls. Breeding lasted from the beginning of January through February. With a few exceptions, all bulls were replaced annually to minimize individual sire effects.

Recording procedure

Calving dates were recorded from 1 to 100 with September 1st being 1 and December 9th being 100. The longer calving season compared to breeding season was allowed to provide for the longer gestation period of Afrikaner cows (Bonsma & Skinner, 1969). Calving interval was calculated in days from one calving date to the next. The following data were recorded for each calf: breed of sire, breed or genotype of dam, sex, date of birth, birth mass and weaning mass. Cows and calves were weighed every 28 days on Wednesdays, and calves were weighed and weaned on the first Wednesday, 196 days (28 weeks) after birth. As a result, weaning age varied by a maximum of eight days, and was thus not corrected. Productive status was recorded as wet (a calf weaned the previous year), dry (no calf weaned the previous year) and heifer (not bred the previous year).

Statistical procedure

The GLM (General Linear Models) procedure by Statistical Analysis Systems (1985) was used to analyse the data.

All main effects (year, breed of sire, breed genotype of dam, sex of calf, age of dam, productive status of dam and day of birth) and all possible first-order interactions were included in the initial models. These models were then fitted according to a step-down procedure in which main effects and first-order interactions not making a significant ($P < 0.05$) contribution to the variance, were omitted in subsequent analyses. Higher-order interactions were, owing to complexity and the highly unbalanced nature of the dataset, not included. The final reduced model was:

$$Y_{ijlmn} = \mu + J_i + P_j + S_l + D_m + X_n + b_1B + b_2B^2 + b_1A + b_2A^2 + e_{ijlmn}$$

where μ = population mean of the appropriate trait,
J_i = effect of the i^{th} year of measurement,
P_j = effect of the j^{th} productive status of dam,
S_l = effect of the l^{th} breed of sire,
D_m = effect of the m^{th} breed genotype of dam,
X_n = effect of the n^{th} sex of calf,
b_1B and b_2B^2 = effect of the linear and quadratic regression of the appropriate deviation from the mean on day of birth within year,
b_1A and b_2A^2 = effect of the linear and quadratic regression of the appropriate deviation from the mean on age of dam and
e_{ijlmn} = random effects.

Significance of difference between least squares means was determined by Bonferroni's test (Van Ark, 1981).

Results and Discussion

All the included effects and interactions influenced birth and weaning mass of calves significantly ($P < 0.01$ or $P < 0.05$) (Table 1). Differences in birth and weaning mass as a result of productive status and sex of calf were in agreement with literature, i.e. calves born to heifers weighed less ($P < 0.05$) than those born to older cows, and male calves weighed more ($P < 0.05$) than heifers. Regression of birth and weaning mass on day of birth and age of dam followed well-established patterns, and birth and weaning mass increased with age of dam up to 8—10 years and declined thereafter. Birth mass generally increased with later calving date, while weaning mass decreased.

Table 1 Analysis of variance for birth and weaning mass of calves

	Birth mass		Weaning mass	
Source	df	F	df	F
Year	12	5.08**	12	3.89**
Sex of calf	1	168.28**	1	396.75**
Day of birth (year)	26	10.37**	13	8.04**
Dam age	2	35.51**	2	145.92**
Productive status	2	14.00**	2	5.85**
Breed of sire	3	39.58**	3	37.44**
Breed genotype of dam	14	18.86**	14	114.46**
Year × productive status	24	1.81*	24	1.79*
Year × breed of sire	36	2.69**	36	2.35**
Breed genotype of dam × sex of calf	14	3.67*	14	2.52**
Year × age of dam	–	–	24	4.02*
Error	3455		2905	
R^2 Model	39.53		64.22	

** $P < 0.01$; * $P < 0.05$.

Breed of sire

Calves born to Afrikaner sires weighed less ($P < 0.05$) at birth than calves born to other breeds of sire. Simmentaler bulls sired heavier ($P < 0.05$) calves than Hereford bulls (Table 2).

Afrikaner bulls are known to sire calves of small size at birth compared to Brahman and some *Bos taurus* breeds (Mentz *et al.*, 1975; Tawonezvi *et al.*, 1988). Sanga breeds of sire (Mashona, Nkone, Tuli) tend to do the same (Tawonezvi *et al.*, 1988). It seems, therefore, that Afrikaner bulls have a small additive effect on prenatal growth, given the longer gestation period of calves sired by Afrikaner bulls (Mentz *et al.*, 1975). The use of Simmentaler sires result in an increase in birth mass (Mentz *et al.*, 1975; Burfening *et al.*, 1978; Tawonezvi *et al.*, 1988) and a higher incidence of dystocia (Mentz *et al.*, 1975). Brahman sires show an additive effect which increase birth mass, while Brahman-sired cross-bred calves also exhibit positive heterosis for birth mass, resulting in an even further increase in birth mass (Notter *et al.*, 1978a; Roberson *et al.*, 1986; Tawonezvi *et al.*, 1988) and incidence of dystocia comparable to that of crossbred calves by Simmentaler sires (Mentz *et al.*, 1975). To minimize the risk of dystocia, sire breed effects and birth mass of sires *per se* should be considered in the planning of crossbreeding systems. These characteristics are especially important under extensive conditions.

Weaning mass of calves sired by Afrikaner bulls were less ($P < 0.05$) than that of calves by other breeds of sire (Table 2). The lower ($P < 0.05$) weaning mass attained by calves sired by Afrikaner bulls (Table 2) is in accordance with other southern African reports (Lombard, 1971; Mentz *et al.*, 1979; Tawonezvi *et al.*, 1988). Additive effects account for a larger portion of the explainable variation in weaning mass than heterosis effects (McDonald & Turner, 1972; Cundiff *et al.*, 1986) with the possible exception of Brahman (Zebu)-sired calves, where heterosis was more important than the additive

Table 2 Least squares means for birth and weaning mass of calves by breed of sire

Breed of sire	Birth mass		Weaning mass	
	n	kg ± *SE**	n	kg ± *SE**
Afrikaner	1158	35.03 ± 0.30[a]	1005	211.36 ± 1.49[b]
Hereford	972	37.24 ± 0.35[b]	823	230.59 ± 1.70[a]
Bonsmara	583	38.56 ± 0.51[bc]	491	226.53 ± 2.42[a]
Simmentaler	883	39.81 ± 0.42[c]	732	232.57 ± 2.15[a]

* Least squares means with different superscripts differ significantly ($P < 0.05$).

effect (Roberson *et al.*, 1986). Sanga type crossbred calves (Sanga sires) probably lack heterosis for birth and weaning mass. Complementarity of breeds and the sequence of their application should therefore be considered when selecting breeds for crossbreeding purposes. Considerable variation in weaning mass can be expected in rotational crossbreeding systems depending on the sequence of sire breeds (Alenda *et al.*, 1980). The negative additive effect of Sanga type and *Bos indicus* sires in rotational crossbreeding systems can thus be avoided to a large extent by the use of performance-tested part-*Bos indicus* or part-Afrikaner (e.g. Bonsmara) or even *Bos indicus*-cross sires if a certain percentage *Bos indicus* or Afrikaner breeding is desired to keep adaptability at required levels.

Breed genotype of dam

Simmentaler dams gave birth to heavier ($P < 0.5$) calves than other purebred dams (Table 3). Differences between other purebreds were non-significant. The influence of percentage Afrikaner breeding in dam on birth mass is shown in Figure 1.

Table 3 Least squares means for birth and weaning mass of calves by breed genotype of dam[1]

Breed genotype of dam	Birth mass		Weaning mass	
	n	kg ± *SE**	n	kg ± *SE**
Afrikaner	588	36.45 ± 0.31[ef]	496	208.44 ± 2.57[d]
Hereford	523	35.46 ± 0.38[f]	447	181.69 ± 1.85[e]
Bonsmara	477	36.59 ± 0.48[cdef]	387	222.28 ± 2.23[bc]
Simmentaler	491	39.00 ± 0.45[ac]	389	235.09 ± 2.36[ab]
1/2H 1/2A	160	38.72 ± 0.44[bc]	124	229.91 ± 2.23[bc]
1/2S 1/2A	491	38.59 ± 0.28[bcd]	436	236.44 ± 1.27[ab]
3/4A 1/4H	147	37.51 ± 0.50[bcde]	136	219.29 ± 2.41[c]
3/4A 1/4S	120	37.31 ± 0.59[bcdef]	105	229.09 ± 3.00[bc]
1/2H 1/4S 1/4A	151	39.41 ± 0.46[ab]	141	231.17 ± 2.24[b]
5/8H 3/8A	95	38.71 ± 0.56[abcd]	82	222.15 ± 2.84[bc]
5/8S 3/8A	116	39.87 ± 0.52[a]	108	242.69 ± 2.56[a]
5/8S 1/4H 1/8S	96	36.70 ± 0.66[bcdef]	92	235.77 ± 3.31[ab]
11/16A 5/16H	38	36.13 ± 0.83[df]	22	223.53 ± 4.94[bcd]
11/16A 5/16S	55	36.11 ± 0.78[df]	49	230.55 ± 4.05[bc]
9/16S 5/16A 1/8H	42	38.32 ± 0.81[abcde]	37	230.80 ± 3.98[bc]

[1] Sire breed of dam mentioned first in crosses.

* Least squares means with at least one common superscript, do not differ significantly ($P > 0.05$).

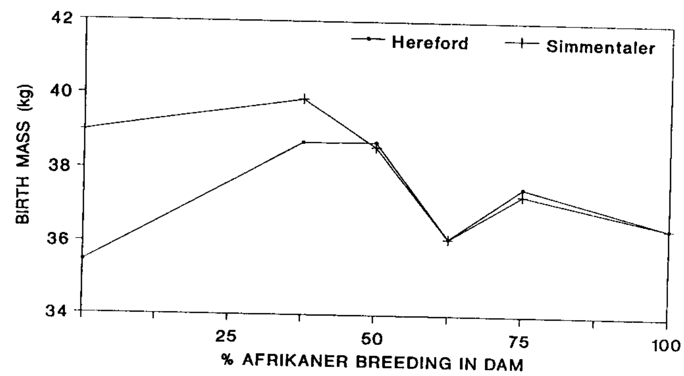

Figure 1 Influence of percentage Afrikaner breeding in dam on birth mass of calves.

Differences in birth mass of calves by cross-bred dams were generally non-significant, although a tendency for cows of predominantly Simmentaler breeding (5/8S 3/8A; 9/16S 5/16A 1/8H) to produce calves of heavier birth mass than calves from cows of predominantly Afrikaner breeding (3/4A 1/4S; 11/16A 5/16S; 5/8A 1/4H 1/8S) was noticeable (Table 3; Figure 1). Figure 2 illustrates the influence of sire breed of dam on birth mass in the criss-cross and the three-breed rotational systems. Whenever the sire breed of the dam was either Simmentaler or Hereford, calves of higher birth mass were produced compared to calves of dams with Afrikaner sires. Birth mass of calves varied with a maximum of 7.5% (2.7 kg) for H × A crosses; 10.5% (3.8 kg) and 7.4% (2.7 kg) for the three-breed rotational crossbreeding systems. Sanga and Zebu type dams restrict the birth mass of their calves (Roberson *et al.*, 1986; Comerford *et al.*, 1987; Tawonezvi *et al.*, 1988; Scholtz *et al.*, 1990), even when mated to late maturing *Bos taurus* sires with a positive additive effect on birth mass (Alenda *et al.*, 1980) by way of a large negative maternal effect (Roberson *et al.*, 1986). Maternal heterosis for birth mass is generally insignificant (McDonald & Turner, 1972; McElhenney *et al.*, 1986; Roberson *et al.*, 1986). The contention by Scholtz *et al.* (1990) that Nguni (Sanga type) dams can be successfully utilized in terminal crossbreeding systems can thus possibly be extrapolated to animals of predominant Afrikaner breeding.

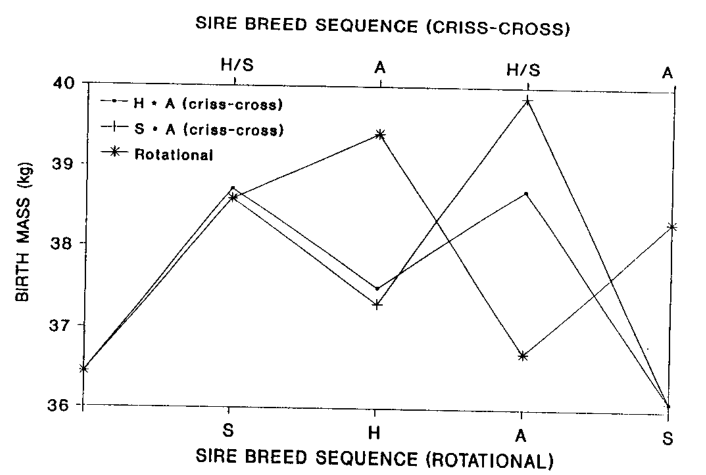

Figure 2 Variation in birth mass of calf with sire breed.