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Sustainable crossbreeding systems of beef cattle in the era of climate change

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Abstract

Beef cattle are unique, because they not only suffer from climate change, but they also contribute to climate change through the emission of greenhouse gases (GHG). Mitigation and adaptation strategies are therefore needed. An effective way to reduce the carbon footprint from beef cattle would be to reduce the numbers and increase the production per animal, thereby improving their productivity. Sustainable crossbreeding systems can be an effective way to reduce GHG, as it has been shown to increase production. There are a wide range of different cattle breeds in South Africa which can be optimally utilized for effective and sustainable crossbreeding. This paper reports on the effects of crossbreeding on the kilogram calf weaned per Large Stock Unit (kgC/LSU) for 29 genotypes. These genotypes were formed by crossing Afrikaner (A) cows with Brahman (B), Charolais (C), Hereford (H) and Simmentaler (S) bulls and by back-crossing the F1 cows to the sire lines. A LSU is the equivalent of an ox of 450 kg with a daily weight gain of 500 g on grass pastures with a mean digestible energy (DE) content of 55% and a requirement of 75 MJ metabolizable energy (ME). Crossbreeding with A as dam line increased the kgC/LSU on average by 8 kg (+6%) - with the CA cross producing the most kgC/LSU (+8%) above that of the AA. The BA dam in crosses with C, H and S, increased kgC/LSU on average by 26 kg (+18%) above that of the AA dam, with the H x BA cross, producing the most kgC/LSU (+21%). The BA, CA, HA and SA F1 dam lines, back-crossed to the sire line breeds, increased kgC/LSU on average by 30 kg (21%), 21 kg (15%), 19kg (13%) and 26 kg (18%) above the that of the AA, respectively. The big differences between breeds in kgC/LSU provide the opportunity to facilitate effective crossbreeding that can be useful in the era of climate change. From this study it is clear that cow productivity can be increased by up to 21% through properly designed, sustainable crossbreeding systems, thereby reducing the carbon footprint of beef production.

Keywords: Carbon footprint, cow productivity, kilogram calf, production systems
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Introduction

Livestock, and likewise beef cattle, are unique in the sense that they not only suffer from climate change, but also contribute to climate change through the emission of greenhouse gases (GHG). Livestock accounts for about 65% of the total agricultural GHG (CO_2 equivalent) of which enteric fermentation (animal digestive tract) accounts for 90%. Mitigation and adaptation strategies therefore need to be put in place if climate change that is related to animal production is to be contained within certain limits (Scholtz *et al*., 2013). An effective way to reduce the carbon footprint of beef cattle is to reduce the numbers and increase the production per animal, thereby improving their production efficiency.

Genetic improvement is a possible mitigation option whereby production efficiency can be improved (Wall *et al*., 2010). There is sufficient genetic variation in South Africa's cattle genetic resources, including indigenous genotypes, to facilitate breeding for improved production efficiency. Improved production efficiency can also be attained through effective crossbreeding systems. The benefits of effective crossbreeding have thus already been reported in a number of studies (Koch *et al*., 1978; Cundiff *et al*., 1991, Gregory *et al*., 1992; Williams *et al*., 2010).

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Materials and Methods

The least square means of cow weight (CW) and weaning weight (WW) from a crossbreeding programme using 29 genotypes as reported by Theunissen (2011) were used to estimate cow productivity. These genotypes were formed by crossing Afrikaner (A) cows with Brahman (B), Charolais (C), Hereford (H) and Simmentaler (S) bulls and by back-crossing the F1 cows to the sire line breeds.

Cow productivity was defined as kilogram calf weaned/Large Stock Unit (LSU) according to Mokolobate *et al*. (2013). Meissner *et al.* (1983) defined a LSU as the equivalent of an ox with a weight of 450 kg and a weight gain of 500 g per day on grass pastures with a mean digestible energy (DE) content of 55%, with a requirement of 75 MJ metabolizable energy (ME). The following equation, developed by Neser *et al*. (2013), was used to calculate the LSU for different weights of the lactating cows:

$$y = 0.000008x^2 - 0.0054x + 2.13$$

where y = LSU units and x = cow weight.

The weaning weights and cow weights for the 29 different genotypes are set out in Tables 1 and 2.

Table 1 Least square means for weaning weights (kg) of calves, combined in the different sire and dam breed groups

Dam breed	Sire Breed				
	Afrikaner (A)	**Brahman (B)**	**Charoloais (C)**	**Hereford (H)**	**Simmentaler (S)**
A	184 (41)	206 (29)	212 (24)	195 (31)	210 (32)
B		199 (24)			
C			222 (40)		
H				179 (44)	
S					234 (31)
BA	200 (23)	207 (17)	238 (20)	224 (21)	237 (19)
CA	216 (29)	244 (22)	235 (23)	233 (24)	241 (26)
HA	202 (21)	221 (19)	228 (16)	210 (16)	230 (26)
SA	220 (20)	237 (28)	245 (25)	230 (20)	229 (28)

( ) Number of calves in brackets

Results and Discussion

The results obtained by crossbreeding the Brahman (B), Charolais (C), Hereford (H) and Simmentaler (S) as sire line breeds with the Afrikaner (A) and F1 cow genotypes as dam lines (Theunissen, 2011), were used to estimate cow productivity. In this study kilogram calf weaned/Large Stock Unit (kgC/LSU) was used as an estimation of cow productivity. This estimated cow productivity for the different genotypes is set out in Table 3, with the percentage deviation from the Afrikaner genotype in brackets.

Table 2 Least square means for cow weights (kg) in the different sire and dam breed groups

Dam breed	Sire Breed				
	Afrikaner (A)	**Brahman (B)**	**Charolais (C)**	**Hereford (H)**	**Simmentaler (S)**
A	435	488	497	438	481
B		449			
C			502		
H				407	
S					459
BA	422	456	516	442	487
CA	460	536	508	487	509
HA	420	490	487	445	485
SA	457	507	510	457	456

Table 3 The cow productivity (kgC/LSU) for the different genotypes (percentage deviation from the Afrikaner genotype in brackets)

Dam breed	Sire Breed				
	Afrikaner (A)	**Brahman (B)**	**Charolais (C)**	**Hereford (H)**	**Simmentaler (S)**
A	142	147 (3.5%)	154 (8.5%)	150 (5.6%)	152 (7.0%)
B		151 (6.3%)			
C			155 (9.2%)		
H				142 (0.0%)	
S					175 (23.2%)
BA	157 (10.6%)	156 (9.9%)	162 (14.1%)	172 (21.1%)	170 (19.7%)
CA	161 (13.4%)	159 (12.0%)	162 (14.1%)	167 (17.6%)	166 (16.9%)
HA	160 (12.7%)	157 (10.6%)	163 (14.8%)	160 (12.7%)	165 (16.2%)
SA	165 (16.2%)	164 (15.5%)	168 (18.3%)	173 (21.8%)	172 (21.1%)

Crossbreeding with A as dam line and B, C, H, and S as sire lines, increased kgC/LSU on average by 9 kg (+6%), with the CA cross producing the most kgC/LSU with an increase of 11 kg (+8%) above that of the AA. In the case of FI cows the SA cow produced on average the most kgC/LSU (an increase of between 15.5% and 21.8%). The AB dam crossbred with the A, B, C, H and S, increased KgC/LSU on average by 21.4 kg (+15%), above that of the AA dam with the H x BA cross producing the most kgC/LSU (+21.1%) (Table 3). These results are similar to the results of the CA and HA dams, each with an average increase of 21 kg (+15 %) and 19 kg (+13%). The SA dam on average increased cow productivity by 26.4 kg (+19%). The improvement demonstrated in this study concurs with that of Schoeman (2010), which indicated that crossbreeding improves cow/calf efficiency when measured as energy requirements or input costs per kg of equivalent steer weight. Although the effect of heterosis on individual traits is normally relatively small, the cumulative effect on composite traits, such as weight of calf weaned per cow exposed are big (Gregory & Cundiff, 1980; Schoeman, 2010), which explains the superiority in kgC/LSU as a composite trait.

Effective crossbreeding also makes use of breed complementarity. Complementarity refers to the phenomena where there is an advantage for a specific crossbred over that of other crossbreds. It is generally caused by the way in which two or more traits combine or complement each other to express the net merit of the animal. Breed differences in direct and maternal effects can be used to complement each other if appropriate crosses are made (Schoeman, 2010).

Conclusions

From this study it is clear that cow productivity can be increased by up to 21% through properly designed crossbreeding systems, thereby reducing the carbon footprint of beef production. The fact that there are large differences in the kgC/LSU between certain genotypes, points to genetic differences and holds the potential for improvement through selection and the use of complementarity between breeds.

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