Factors affecting the pre-weaning performance of Nguni and Angus x Nguni calves in an arid environment of South Africa

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Abstract

The importance of indigenous breeds that are adapted to the anticipated warmer climate, lower nutritional value of the grazing and harsher conditions will increase as a result of climate change. South Africa has indigenous beef cattle breeds such as the Nguni that are widely recognized for its adaptive attributes. Extensive livestock production is an important agricultural activity in the Northern Cape and many other parts of South Africa. Continuous deterioration in beef cattle production environments as well as alternative grass-fed production systems necessitates the reviewing and evaluation of current production and breeding strategies. Crossbreeding between British / European and indigenous breeds may become more important to increase beef production in the near future, where management is at relatively high levels, but where conditions are harsh. The aim of this study was to evaluate the Nguni in a terminal crossbreeding system. The research was conducted over a period of four years at the Vaalharts Research Station of the Northern Cape Department of Agricultural, Land Reform and Rural Development near Jan Kempdorp. A total of 238 weaning weight records was collected (167 Nguni and 81 Angus x Nguni). The 205-day weaning weight of the Angus x Nguni calves were 177 kg and that of the pure Nguni calves 145 kg. Although the adjusted weaning weight of the Angus x Nguni calves was 32 kg higher than that of pure Nguni calves, the difference was not significant. This can be attributed to the large variation in weaning weights, with that of the pure Nguni calves ranging from 56 kg to 230 kg and that of the Angus x Nguni calves from 105 kg to 303 kg. The 205-day weight also increased with an increase in the age of the cow until five years, where after it decreased. The cow weight at weaning did not seem to have an effect on the weaning weights of the calves. If cow efficiency is expressed as kilogram calf weaned per Large Stock Unit, the cow efficiency of cows with Angus x Nguni calves improves by 22%. The results showed that crossbreeding can increase the weaning weights of crossbred calves from Nguni cows. As a result of the very large variation in the 205-day weights, some non-genetic factors affecting this weight were evaluated. It was found that in addition to the sex of the calf, 205-day weight was also affected by age of the dam, the year of weaning, month of birth, year x genotype interaction and the herd of origin of the dam. The fact that herd of origin of the cow affects the weaning weights of her calves may indicate the presence of epigenetics or large differences in genetic merit between herds.

Keywords: beef cattle, cow efficiency, crossbreeding, epigenetics, non-genetic factors
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Introduction

South Africa has indigenous beef cattle breeds such as the Nguni and Afrikaner that are widely recognized for attributes such as fertility, low maintenance inputs, ease of calving, adaptability, resistance to internal and external parasites, resistance to tick-borne diseases, potential as dam lines, sustainable economic profitability, hybrid vigour, good temperament, longevity, browsing, good walking abilities, the ability to survive side by side with game in their natural environment, cost-effective beef production and survival under harsh conditions with limited food and water (Maule, 1973; Barnard & Venter, 1983; Schoeman 1989; Scholtz *et al*., 1991; Muchenje *et al*., 2008a & 2008b). Historians estimate that these indigenous breeds developed over a period of more than 1200 years in Southern Africa. This has led to the development of breeds that are well adapted to the environmental extremes of Southern Africa (Duminy & Guest, 1989).

Under commercial farming practices with fair managerial skills, but where conditions are still harsh with relatively low levels of nutrition, terminal crossbreeding with small cows may succeed in improving the output of beef cattle farming (Calegare *et al*., 2007). This advantage follows since any system with large progeny from small breeding cows must be more efficient than one with progeny and breeders of similar size, simply because small cows eat less than large ones. This higher efficiency arises from the potential increase in weaning weight of up to 26% per cow exposed to mating, while the feed energy requirement only increases by 1% (MacNeil, 2005; MacNeil *et al*., 1991). In addition, and of particular importance to the countries of sub-Saharan Africa, is the use of locally adapted, low input maternal breeds and the improvement of the production potential of the progeny using terminal sire breeds (Scholtz, *et al.*, 1990). However, such a system will only be viable if the natural environment can support the higher production, and the managerial demands can be met.

Terminal crossbreeding systems may be valuable for the commercialization of identified individuals within the emerging beef sector and for commercial farmers. In this case the system will rely heavily on adapted indigenous breeds (such as the Nguni and Afrikaner) as dam line (MacNeil & Matjuda, 2007). A breed such as the Angus can play an important role as the sire line. The biggest advantage of the Angus is that it starts with the market demand (quality product and branded beef).

Terminal crossbreeding, in contrast to rotational crossbreeding systems does not put any additional burden on managerial skills. All it implies is that bulls from the sire and dam lines are sequentially mated in the desired ratio to the cows. Traditionally they can even be reared together during the breeding season (Scholtz, 2007). All crossbred progeny, however should be marketed.

Extensive livestock production is an important agricultural activity in the Northern Cape and many other parts of South Africa (RMRD SA, 2012). Continuous deterioration in beef cattle production environments as well as alternative grass-fed production systems necessitates the reviewing and evaluation of current production and breeding strategies.

The importance of indigenous breeds that are adapted to the anticipated warmer climate, lower nutritional value of the grazing and harsher conditions will increase. Crossbreeding between British / European and indigenous breeds may thus become more important to increase beef production in the near future, where management is at relatively high levels, but where conditions are harsh. In this article, the performance of Angus x Nguni calves are evaluated. The results will assist commercial, emerging and communal beef producers to make better use of available beef breed resources and to capitalize on the favourable effects of heterosis.

Materials and Methods

The research was carried out at the Vaalharts Research Station of the Northern Cape Department of Agricultural, Land Reform and Rural Development near Jan Kempdorp over a period of four years, with calves weaned from 2009 until 2012. The station is located in the centre of South Africa at 27°51’ South and 24°50’ East at an altitude of 1175 meters and is in an area with sandy red soil with lime rock underneath (Laker, 2003). The veld type is mixed Tarchonanthus veld, Veld type No 16b, 4 (Acocks, 1988). The highest monthly average temperature is around 32°C and is experienced during December and January and the lowest monthly average temperature is around –0.5°C and is experienced during July. The average precipitation is around 450 millimeters per annum of which 88 percent is during the summer months from October to April in the form of thunderstorms.

The cows used in this trial were purchased at sales under the auspices of the Nguni Cattle Breeders’ Society. Single sire matings were used in the first three years. The mating season was from the beginning of December until the end of February. Twenty five to thirty five females were allocated to each bull. Initially all cows and heifers were straight bred to Nguni bulls during the first part of the breeding season. Thereafter Angus bulls replaced all the Nguni bulls. The first calves to be born would thus be purebred Nguni calves from the most fertile cows, and replacement heifers and Nguni breeding bulls could be selected from these calves. The dilemma was that much more pure Nguni than Angus x Nguni calves were born. During the last breeding season the Nguni and Angus bulls were both used in the same herd for the whole breeding season. Although there was concern that very few Angus x Nguni calves may be born, 38 crossbred and 42 pure Nguni calves were born.

The traits recorded were birth weight, actual weaning weight, age at weaning and cow weight at weaning. Although inter-calving period (ICP) was available it could not be used to compare the ICP of cows suckling pure Nguni calves with those suckling Angus x Nguni calves, due to the mating practice that was followed during the first three years, where Nguni bulls were used during the first part of the breeding season.

Commercial management practices were followed. All animals were weighed according to prescriptions of the National Beef Performance Recording and Improvement Scheme.

There was a total of 238 weaning weight records (167 Nguni and 81 Angus x Nguni). Weaning weight was adjusted to a 205-day weight as follow:

205-day weight = [(actual weaning weight – birth weight)/age at weaning] x 205 + birth weight.

Large Stock Units (LSU) was calculated by using the following equation developed by Mokolobate *et al.,* (2015):

$$LSU = 0.220714286 + 0.0030978571*X - 0.0000010714*X^2$$

Where:

X = cow weight at weaning

The official definition of LSU in South Africa, according to Meissner *et al.* (1983) is an equivalent of an ox with a live weight of 450 kg, which gains 500 g per day on grass pasture, that has a mean digestible energy of 55%, and to maintain this 75MJ per day is required.

All the traits were analyzed using generalized linear model procedure of SAS (v 9.3; SAS Inst., Inc., Cary, NC) using the following model:

$$Y_{ijklm} = \mu + B_i + S_j + Y_k + M_l + D_m + (S \times Y)_{jk} + \beta DW + \varepsilon_{ijklm}$$

Where:

Y_{ijklm} = performance trait (e.g. 205-day weight)
B_i = fixed effects of the i^{th} breed
S_j = fixed effects of the sex of a calf
Y_k = fixed effects of the k^{th} birth year of a calf
M_l = fixed effects of the l^{th} birth month of a calf
D_m= fixed effects of the m^{th} age group of the dam
$(S \times Y)_{jk}$ = calf sex and calf year of birth interaction
β = partial linear regression coefficient of the dependent variable on dam weight
ε_{ijklm} = residual error distributed as N $(0, I\sigma_e^2)$

Mean separation was performed using the Tukey's procedure of SAS (v 9.3; SAS Inst., Inc., Cary, NC).

Results and Discussion

The performance of both purebred Nguni (Table 1) and Angus x Nguni (Table 2) male (M) and female (F) calves for the four years (2009 until 2012) that the project has been running is summarized below. The performance include 205-day weight, cow weight at weaning and the kilogram calf weaned (205-day weight) per LSU.

Table 1 Performance of purebred Nguni calves in respect of 205-day weight, cow weight at weaning and the kilogram calf weaned per LSU.

Year	Sex	Trait	N	Mean (Kg)	Std Dev (Kg)	Minimum (Kg)	Maximum (Kg)
1	F	205-day weight	18	155	14.9	126	174
		Cow weight at weaning	18	348	55.0	250	496
		Kilogram calf weaned per LSU	18	125	12.1	103	141
	M	205-day weight	28	151	21.0	110	198
		Cow weight at weaning	28	342	68.4	222	516
		Kilogram calf weaned per LSU	28	120	17.2	89	157
2	F	205-day weight	15	141	17.2	102	171
		Cow weight at weaning	15	353	38.2	296	431
		Kilogram calf weaned per LSU	15	115	14.2	82	140
	M	205-day weight	18	155	14.5	133	179
		Cow weight at weaning	18	360	48.3	312	508
		Kilogram calf weaned per LSU	18	125	13.0	102	147
3	F	205-day weight	25	158	27.2	95	208
		Cow weight at weaning	25	366	51.9	294	514
		Kilogram calf weaned per LSU	25	128	23.1	65	170
	M	205-day weight	21	189	27.2	136	230
		Cow weight at weaning	21	372	57.6	300	566
		Kilogram calf weaned per LSU	21	151	23.6	93	181
4	F	205-day weight	19	107	23.5	56	150
		Cow weight at weaning	19	343	32.5	278	408
		Kilogram calf weaned per LSU	19	87	16.5	45	122
	M	205-day weight	23	113	15.8	84	141
		Cow weight at weaning	23	356	34.3	313	432
		Kilogram calf weaned per LSU	23	92	14.6	69	116

Table 2 Performance of Angus x Nguni calves in respect of 205-day weight, cow weight at weaning and the kilogram calf weaned per LSU.

Year	Sex	Trait	N	Mean (Kg)	Std Dev (Kg)	Minimum (Kg)	Maximum (Kg)
1	F	205-day weight	12	161	23.5	114	192
		Cow weight at weaning	12	344	44.7	286	425
		Kilogram calf weaned per LSU	12	131	18.4	93	155
	M	205-day weight	7	151	26.6	105	173
		Cow weight at weaning	7	320	45.6	250	385
		Kilogram calf weaned per LSU	7	123	23.1	84	142
2	F	205-day weight	5	187	15.9	168	212
		Cow weight at weaning	5	345	50.7	309	432
		Kilogram calf weaned per LSU	5	152	15.6	130	174
	M	205-day weight	6	176	29.7	129	218
		Cow weight at weaning	6	347	62.9	302	470
		Kilogram calf weaned per LSU	6	141	23.2	105	179
3	F	205-day weight	7	180	38.2	118	241
		Cow weight at weaning	7	378	51.5	319	452
		Kilogram calf weaned per LSU	7	143	27.7	96	182
	M	205-day weight	6	176	29.7	129	218
		Cow weight at weaning	6	347	62.9	302	470
		Kilogram calf weaned per LSU	6	141	23.2	105	179
4	F	205-day weight	20	190	25.6	138	226
		Cow weight at weaning	20	356	42.8	299	492
		Kilogram calf weaned per LSU	20	154	20.6	112	184
	M	205-dayweight	18	199	32.7	138	303*
		Cow weight at weaning	18	341	37.9	270	400
		Kilogram calf weaned per LSU	18	162	34.8	113	249

*There was concern that this calf was weighed wrongly or that there was a writing error. However, it was confirmed that the weaning weight was indeed correct. The weight of the dam was only 337 kg at weaning, giving a calf/cow ratio of 90%.

The number of observations, least square mean (LSM), standard deviations (Std Dev), minimum and maximum values for 205-day weight, cow weight at weaning of the calf and kilogram calf weaned per LSU is presented in Table 3.

Table 3 Summary statistics of 205-day weight, cow weight at weaning of the calf and kilogram calf weaned per LSU

Trait / genotype	N	LSM (Kg)	Std Dev (Kg)	Minimum (Kg)	Maximum (Kg)
205-day weight					
Nguni	167	145	35.4	56	230
Angus x Nguni	81	177	36.8	105	303
Cow weight					
Nguni	167	365	65.4	222	566
Angus x Nguni	81	355	53.2	250	492
Kg calf / LSU					
Nguni	167	116	29.5	45	181
Angus x Nguni	81	142	30.1	84	249

Some non-genetic factors affecting 205-day were evaluated. The non-genetic factors that may influence 205-day weight that were included in the study were breed, sex, year of birth, month of birth, age group of the dam, herd of origin, sex x year interaction and breed x year interaction and the results are summarized in Table 4.

Table 4 Non-genetic factors affecting 205-day weight of Nguni and Angus x Nguni calves

Trait	205-day weight
Breed	NS
Sex	***
Year of Weaning	***
Month of Birth	**
Age group of dam	**
Herd of origin	*
Sex x year	***
Breed x year	*

***p** < 0.10; **p < 0.05; ***p < 0.01

The average 205-day weight of the Angus x Nguni calves was 177 kg and that of the pure Nguni calves 145 kg (Table 3). Although the 205-day weight of the Angus x Nguni calves was 32 kg (22%) higher than that of pure Nguni calves, the difference was not significant (Table 4). This can be attributed to the large variation in weaning weights, with that of the pure Nguni calves ranging from 56 to 230 kg and that of the Angus x Nguni calves from 105 to 303 kg.

If cow efficiency is expressed as kilogram calf weaned per LSU, the cow efficiency of cows with Angus x Nguni calves improved by 26 kg or 22.4% (Table 3). It should also be noted that the cow weight of cows suckling Angus x Nguni bull calves were 10 kg or 2.7% lighter than cows suckling pure Nguni bull calves, indicating that the crossbred calf may be putting an additional drain on the cow.

The results in Table 4 indicate that 205-day weight of the calves is affected by factors like the sex of a calf, age of the dam, year of weaning and month of birth of a calf and the herd of origin of the dam. There was also a significant interaction of sex and breed, with year. This phenomenon will require further investigation, since this may be the result of Type I errors, which is controlled by choosing the significance level. A 5% level means that on average 1/20 comparisons will be "significant" when they are just due to sampling variation (Faul, 2007).

The 205-day weight increased as the age of the cow increased until cows were 5 years, then it decreased. Male calves were heavier compared to the females. The cow weight at weaning did not have an effect on the 205-day weights of the calves.

The Least Square Means for the non-genetic factors affecting 205-day weight of Nguni and Angus x Nguni calves are given in Table 5. Calves weaned in 2011 had the highest 205-day weight of 180 kg, whereas those weaned in 2012 had a 205-day weight of only 152 kg, a difference of 18.4%. This demonstrates the large effect of year on weaning weight and it may be more pronounced in arid areas with variable rainfall.

Month of birth had an even bigger effect on 205-day weight, with calves born in December having a much higher 205-day weight than those born in September, namely 182 kg versus 145 kg or a difference of 25.5%. The fact that month of birth has such a big effect on 205-day weight is suggesting that the mating season must be planned so that the most calves are born in the more "favourable" months. It may also suggest that the breeding season should be moved backwards so that most calves are born in November and December in the case of a breed such as the Nguni for this environment.

Table 5 Least Square Means (LSM) for non-genetic factors affecting 205-day weight of Nguni and Angus x Nguni calves

	Sex		**Year of weaning**				**Month of birth**			
	M	**F**	**2009**	**2010**	**2011**	**2012**	**Dec**	**Nov**	**Oct**	**Sep**
LSM (Kg)	169	160	154	160	180	152	182	176	153	145
Std Dev(Kg)	3.37	3.37	4.41	4.43	3.68	4.17	6.07	5.52	5.20	6.62

In order to get a better understanding of possible differences in genetic merit between cows, their estimated breeding values (EBV's) at the start of the trial are summarized and presented in Table 6.

Table 6 Estimated breeding values (EBV's) of the Nguni cows at the start of the trial

EBV	**Breed**	**Herd**	**Highest**	**Lowest**	**Difference**
Wean Direct	-0.3	-0.4	+7.6	-6.6	14.2 kg
Wean maternal	+0.2	+0.3	+6.7	-6.6	13.3 kg
18 month weight	+1.1	+1.3	+25.4	-28.4	53.8 kg
Mature cow weight	+3	+3	+28.0	-30.0	58.0 kg

Despite the fact that all the cows were purchased at sales under the auspices of the Nguni Cattle Breeders' Society, there was a very large difference in EBV's, and thus genetic merit, between the cows. This big variation in EBV's may partly explain the variation in actual weaning weights and cow weights.

The fact that herd of origin of the cow affects the weaning weights of her calves may be due to differences in genetic merit. However, the concept of epigenetics cannot be ignored entirely. Epigenetics is associated with gene expression and the expression of different phenotypes (appearance). These modifications are influenced by environmental factors and can be transferred to the progeny of complex organisms, including livestock (Tollefsbol, 2004).

Conclusion

The results showed that crossbreeding can increase the weaning weights of crossbred calves from Nguni cows. Crossbred calves from Nguni cows weighed 32 kg more than purebred Nguni calves. However, there was a large variation in the weaning weight of the crossbred calves. Similarly, cow efficiency defined as kilogram calf weaned per LSU was 22% higher with crossbred calves.

The fact that pre-weaning performance traits are affected by many non-genetic factors indicates that there is a great need to make adjustments for them when estimating genetic parameters. Furthermore, the data also shows that crossbreeding can increase the weaning weights of crossbred calves from Nguni cows. However, there is a need to investigate the reason(s) for the large variation in weaning weight of the calves from Nguni cows. This may include an in depth study of the differences between farms from which the dams originate, cow weight, genetic merit and epigenetics.

Epigenetics can be described as the study of molecular mechanisms by which the environment controls genetic activity and provides a means of understanding how environmental factors may result in heritable changes in gene expression. A modern definition of epigenetics is "Collective heritable changes in phenotype that arise independent of genotype" (Tollefsbol, 2011). Epigenetic mechanisms play a major role in phenotypic diversity in response to environmental conditions.

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