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Preliminary Results of an Investigation on Innovative Breeding Objectives to Improve Efficiency in Extensive Cow-calf Production Systems in the Bonsmara Breed.

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ABSTRACT: This study investigates kilogram calf weaned per Large Stock Unit (KgC/LSU) and weaning weight (K205), both as traits of the dam, as innovative breeding objectives to improve cow efficiency. The variance and co-variance parameters were estimated using univariate and multivariate repeatability models. The dataset was comprised of 34,884 complete cow-calf records for cow weight at weaning (DW) and pre-corrected 205-day weaning weight for parities 1, 2 and 3. The genetic correlation between K205 and DW was low (0.19), whereas that between KgC/LSU and DW was -0.83. These preliminary results indicate that selection for KgC/LSU may drastically reduce cow size. However, selection for K205 might increase cow size slightly. It is concluded that a combination of K205 and cow weight expressed in LSU's in a selection index should be investigated as a feasible option to improve cow productivity and reduce the carbon footprint.
Keywords: cow efficiency; cow weight; large stock unit

Introduction

Globally the beef cattle industry faces the challenge to maintain and improve sustainability as the global population continues to increase. Furthermore, many consumers perceive that beef has an unacceptable environmental cost. Improving beef cattle productivity will have positive sustainability implications as it will reduce resource use and greenhouse gas (GHG) emissions whilst improving economic viability (Capper (2013)). Reducing the cattle numbers and increasing the production per cow unit is an effective way to reduce the carbon and water footprint of beef, since increased productivity generates less greenhouse gas (GHG) emission per unit of beef (Scholtz et al. (2013)).

Until now, most measurements to improve production in developing countries, and in many other parts of the world, are per individual (milk production, weaning weight, calving interval, growth rate, etc.). Selection for these traits will increase production, but not necessarily productivity or efficiency of production. Measurements are thus required that express performance per constant (standardized) unit and not per animal.

Livestock agriculture is the largest user of land resources in South Africa, where 71% of the surface area is only suitable for extensive livestock farming (RMRD SA (2012)). It is therefore imperative that efficiency of extensive cow-calf production systems is measured, but this is not easy.

Estimated Breeding Values for cow maintenance requirements have been developed (Evans (2001)), but their interpretation and implementation may be a challenge (Evans et al. (2002)). Olivier et al. (2001) indicated that the reproductive performance of ewes, defined as total weight of lamb weaned per ewe joined, can be genetically improved by selection. In a comparison of between-breed averages of 30 beef and dual purpose breeds in South Africa, Mokolobate et al. (2013) found that kilogram calf weaned per Large Stock Unit (KgC/LSU) is independent of cow weight, which is contrary to the calf/cow weight ratio, which favours smaller cows.

This stimulated an investigation into the use of KgC/LSU and weaning weigh (K205), both as traits of the dam, as breeding objectives to improve efficiency in extensive cow-calf production systems. The use of the trait KgC/LSU and weaning weight as traits of the dam as breeding objectives could not be found in any literature and are therefore regarded as innovative traits worth investigating. Such breeding objectives, in the era of climate change, should be a significant consideration in extensive cow-calf production systems, where direct measurement of feed intake is almost impossible. Improved cow productivity and efficiency will have a permanent mitigating effect on the production of GHG's, as higher productivity will lead to higher gross efficiency. (Wall et al. (2010); Scholtz et al. (2011)).

Material and Methods

The Bonsmara is a composite breed that was developed in South Africa. The development of the Bonsmara started in 1940 and was based on a 5/8 Afrikaner (indigenous Sanga breed) and 3/8 Exotic (Shorthorn/Hereford) breeding admixture The breed has established itself as an easy care breed with favourable attributes such as ability to adapt to most climatic conditions, good mothering ability, high fertility, good feed efficiency and quality carcasses. It is a red, smooth coated medium sized animal with a slightly sloping rump which is common for sub-tropical breeds.

The edited dataset used by the Agricultural Research Council (ARC) for routine genetic evaluations, was used for this study. The dataset was comprised of 34,884 complete calf-cow records for parities 1, 2 and 3. To assess the influence of non-genetic factors on the different weights for inclusion in the model, an analysis of variance was done using the SAS proc GLM program (2009). A stringent significance level of $P<0.01$ was used as criterion for inclusion.

Fixed effects fitted were sex (male, female) and a concatenation of breeder, year and season. Age of dam was fitted as a linear regression. All weaning weights were pre-adjusted to 205 days to simplify the analysis. Herds with less than three years of recording as well as contemporary groups with less than 10 records and two service sires were also removed from the final data used for the analysis.

Taking into consideration both the distribution of records over a twelve month period, as well as the weaning weights of the calves, two distinct seasons were identified. The months from September to March were classified as season one, while April to August were classified as season two. The weights extracted from the dataset were cow weight at weaning (CW) and pre-adjusted 205 day weaning weight (WWT). The trait "kilogram calf weaned per Large Stock Unit" (KgC/LSU) was calculated using WWT and CW for each parity.

In South Africa, a LSU is defined as the equivalent of an ox with a weight of 450 kg and a weight gain of 500 g per day on grass pasture with a mean Digestible Energy (DE) concentration of 55%. To maintain this, 75 MJ Metabolisable Energy (ME) is required (Meissner (1983)). This is similar to the Animal Unit used in North America (Thorn et al. (2007)). There following equation of Neser and Scholtz (2013) was used to estimate LSU:

$$y = -0.0000010714x^2 + 0.003978571x + 0.220714286$$

Where y = LSU and x = dam weight

Three different models were tested for all traits analyzed. The (co)variance components for the traits DW, KgC/LSU and calf weaning weight (K205), the latter two as traits of the dam, were estimated using repeatability models in ASReml 3.0 (Gilmore et al. (2009)). The Log likelihood ratio test (Swalve (1993)) was used to obtain the most suitable model for the analysis. Only the final models used are presented.

Model used for the single trait analysis:

$$\mathbf{Y = X\beta + Z_1a + Z_2c + \varepsilon}$$

Where: -
Y = vector of observations,
β = vector of fixed effects influencing KgC/LSU, K205, and DW
a = vector of direct additive effects,
c = vector of additional random permanent environmental effects,
ε = vector of residuals and where
X, Z_1 and Z_2 are incidence matrices relating observations to their respective fixed and random effects.

Model used for the multivariate analysis:

$$\mathbf{Y = X\beta + Z_1a + \varepsilon}$$

Where:
Y = vector of observations,
β = vector of fixed effects influencing KgC/LSU, K205, and DW
a = vector of direct additive effects,
ε = vector of residuals and where
X and Z_1 are incidence matrices relating observations to their respective fixed and random effects.

Results and Discussion

One of the models tested used service sire as an additional random effect, but since it was not significant it was omitted from the final model used. It is somewhat surprising that service sire had no effect on KgC/LSU and K205 and the reason for this might be attributed to the dam effect over shadowing all other effects, a speculation that calls for further investigation.

Unfortunately the heritability estimates for dam weight when using the multivariate analysis were unrealistically high. It was therefore decided to only present heritabilities from the single trait analysis (Table 1). The heritability estimates using the single trait analysis for K205 was relatively low (0.16), while the estimate for KgC/LSU was moderate (0.26) and that of DW high (0.45). Of interest was the high permanent environmental variance estimates for all three traits (Table 1), indicating a large carry over effect from one parity to the next.

Table1. Heritabilities (h^2) (± SE) and variance components from the single trait analysis for K205, KgC\LSU and DW

Parameter	Trait		
	K205	DW	KgC/LSU
h^2	0.16±0.02	0.45±0.02	0.26±0.02
Ratio PE	0.12±0.02	0.22±0.02	0.18±0.02
Direct additive variance	66.9	950.4	35.1
Error variance	299.5	697.5	76.5
Permanent environ. variance	47.9	476.6	24.1
Phenotypic variance	414.4	2124.5	135.72

Table 2. Genetic correlations (± SE) as obtained from the multivariate analysis

Trait	K205	KgC/LSU
DW	0.19±0.02	-.83±0.006
KgC/LSU	0.38±0.02	

The very high negative genetic correlation (-0.83) between KgC/LSU and DW suggests that direct selection for KgC/LSU will decrease dam weight. On the contrary, selection for K205 will result in a slight increase in DW, since the correlation between the two is only +0.19. Of interest is the moderate positive correlation between K205 and KgC/LSU of +0.38, indicating that selection for weaning weight as trait of the dam may increase cow efficiency, albeit that cow weight will possibly show a small increase.

The results demonstrate that, although the use of ratios to adjust one correlated trait for another has been fairly commonplace, it may not be the most feasible approach. The statistical arguments that restrict the use of ratios to certain circumstances are well documented (Weil (1962)). The use of the ratio of calf weaning weight to cow weight as a selection criterion, for example, has theoretical defects and places inconsistent emphasis on the component traits resulting in variable responses to selection (MacNeil, (2007)). It seems that selection or KgC/LSU will have the same defects.

Conclusion

A trait that expresses performance (calf weaning weight) per constant unit, viz. per Large Stock Unit (KgC/LSU) may be a useful breeding objective/goal to increase production efficiency, which may reduce the carbon footprint of extensive cow-calf production systems. Since a LSU unit is linked to specific metabolisable energy requirements it should be possible to eventually “link” this breeding objective with the carbon footprint of weaner calf production

The next step must therefore be to identify possible selection criteria that can be used to increase the weaning weight of calves in relation to a cow LSU unit (75 MJ Metabolisable Energy need per day) in extensive beef production systems. The combination of calf weight as a trait of the dam and dam weight expressed in LSU units in a selection index will probably be the most feasible option and such a selection index should be investigated. Normally, the traits in a selection index are weighed with their economic value. However, in this case the traits can even be assigned weights that can be linked to carbon footprints or credits (sequestration,) and not only economic weights.

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