A novel breeding objective to improve beef cow efficiency and reduce the environmental impact in extensive systems

M.C. Mokolobate[1,2], M.M Scholtz[1,2] , F.J Jordaan[1] & F.W.C. Neser[2]

[1] *ARC-Animal Production Institute, Private Bag X2, Irene, 0062, South Africa*
MokolobateM@arc.agric.za (Corresponding Author)
[2] *Department of Animal, Wildlife and Grassland Sciences, University of the Free State, Bloemfontein, 9300, South Africa.*

Summary

It is worrying that most measurements to improve production in livestock are still per individual animal (milk production, weaning weight, growth rate, etc.). The chances are that selection for these traits may increase production, but not necessarily efficiency of production. A breeding objective to improve cow-calf efficiency may be defined as kg calf weaned per Large Stock Unit (KgC/LSU). The LSU is linked to daily feed requirements. The trait, kg calf weaned per Large Stock Unit (KgC/LSU) was investigated as a novelty trait to improve cow-calf efficiency. Heritability estimates for the trait varied between the diverse breeds used, viz. Afrikaner (0.52), Angus (0.24), Bonsmara (0.26) and Charolais (0.21). Very high negative genetic correlations (from -0.09 to -0.83) between KgC/LSU and dam weight suggests that direct selection for KgC/LSU will decrease dam weight, which is not always desirable. It therefore seems that selection for KgC/LSU will have the same defects as other ratio traits. A more effective alternative will be a "cow efficiency index" which include dam weight (DW) and calf weight, but with a restriction on DW. A restricted selection index will therefore restrict increases in DW, and implicitly LSU or feed requirements.

Keywords: Production, Selection Index, Large Stock Unit

Introduction

It is somewhat surprising that until this day measurements for production efficiency of the cow-calf production to date is still a challenge as most measurements to aid improvement are still per individual animal (milk production, weaning weight, calving interval, growth rate, etc.). The chances are that selection for these traits may increase production, but not necessarily efficiency of production. A measurement is thus required that expresses output per constant (standardized) unit, such as Large Stock Unit (LSU), which may be a useful breeding objective/goal to increase production efficiency. It may also reduce the carbon footprint of extensive cow-calf production systems. Since a LSU is linked to specific metabolizable energy requirements, it should be possible to eventually "link" this breeding objective with the carbon footprint of weaner calf production. Selection for productivity and efficiency, for instance, will have a permanent mitigating effect on the production of greenhouse gases (GHG), as higher productivity will lead to higher gross efficiency as a result of diluting the maintenance cost of animals (Wall *et al*, 2010 & Scholtz et al., 2011). Proper trait definition is therefore imperative. The trait, Kilogram Calf Weaned (KgC) per Large Stock Unit, was thus investigated as a measure of efficiency. This trait has not been found in any literature, hence the novelty. In addition its correlation with weaning weight as trait of the dam was estimated.

Material and methods

The edited dataset, as used by the Agricultural Research Council (ARC) for routine genetic evaluations, was used for this study. Herds with less than three years of recording, as well as contemporary groups with less than 10 cow records and two service sires in the first parity, as well as animals with unknown parents were removed from the final dataset used for the analysis The final datasets comprised of 34 884, 6 104, 7 581 and 2 291 complete calf-cow records for parities 1, 2 and 3, for the Bonsmara, Afrikaner, Angus and Charolais breeds, respectively. The data used in this study included pre-corrected 205 day weaning weight and dam weight (DW). This information was used to calculate weaning weight as trait of the dam (K205) and cow efficiency. Charolais had the least number of records followed by the Afrikaner, Angus and Bonsmara with the most records in this case.

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 Metabolizable Energy (ME) is required (Meissner *et al.,* 1983). The following frame size specific specific equations developed by Mokolobate (2015) for beef cows with calves were used:

Small frame: $Y = 0.2871428571 + 0.0025542857x - 0.0000005714x^2$

Medium frame: $Y = 0.220714286 + 0.0030978571x - 0.0000010714x^2$

Large Frame: $Y = 0.3239285714 + 0.0036535717x - 0.0000015\ x^2$

Where Y = LSU and x = cow weight

These equations were used to determine the relevant LSU to estimate cow efficiency.

Cow efficiency was correspondingly estimated as the kilogram of calf weaned per Large Stock Unit (KgC/LSU).

ASReml 3.0 (Gilmour *et al.,* 2009) was used to estimate the (co)variance components.

Model, used for bivariate analysis:

$Y = X\beta + Z_1a + Z_2c + \varepsilon$

Where: -

Y = vector of observations, KgC/LSU, K205, and DW

β = vector of fixed effects (HYS, Sex, Damage, Parity) influencing KgC/LSU, K205, and DW

a = vector of direct additive effects,

c = vector of additional random permanent environmental effects (Animal),

ε = vector of residuals and where

X, Z_1 and Z_2 were incidence matrices relating observations to their respective fixed and random effects

Results and Discussion

The variance components for the traits K205, DW and KgC/LSU of the different breeds are presented in Table 1 and the heritability estimates (h^2) in the same table for the different single trait analyses. There is a vast difference in the heritability estimates between the breeds for the same trait as is evident from Table 1. Heritability estimates of weaning weight as trait of the dam (K205) for the four breeds ranged from 0.11 to 0.40. Since no similar trait could be found in the literature these values had to be compared with the heritabilities of related traits. Wright *et al*. (1987) reported heritabilities of 0.12 and 0.09 for direct and maternal weaning weight respectively, while van der Westhuizen *et al.* (2010) reported heritabilities of 0.22 and 0.12 and Neser *et al*. (1996) reported heritabilities of 0.13-0.28 and 0.14-0.29 for the same traits, respectively.

Table 1 *(Co)variance components estimates genetic parameters for KgC/LSU, DW and K205 of, Afrikaner, Angus, Bonsmara, and Charolais*

Breed	Parameters	Trait		
		KgC/LSU	DW	K205
Afrikaner	h^2	0.52±0.06	0.48±0.05	0.40±0.05
	Ratio PE	0.32±0.05	0.39±0.05	0.32±0.05
	δ^2_A	169.3	682.7	682.7
	δ^2_e	53.2	193.1	193.1
	δ^2_{PE}	105.4	558.7	558.7
	δ^2_P	327.2	1435.3	1435.3
Angus	h^2	0.24±0.03	0.56±0.03	0.17±0.03
	Ratio PE	0.28±0.03	0.16±0.03	0.19±0.03
	δ^2_A	81.8	1330.4	94.3
	δ^2_e	169.9	667.8	352.7
	δ^2_{PE}	95.4	378.3	105.7
	δ^2_P	347.2	2378	552.7
Bonsmara	h^2	0.26±0.02	0.45±0.02	0.11±0.01
	Ratio PE	0.18±0.02	0.22±0.02	0.1±0.01
	δ^2_A	35	950	67
	δ^2_e	77	697	483
	δ^2_{PE}	24	476	61
	δ^2_P	136	2124	610
Charolais	h^2	0.21±0.04	0.67±0.02	0.13±0.08
	Ratio PE	0.17±0.08	0.22±0.1	0.16±0.08
	δ^2_A	48.7	2505.7	79.3
	δ^2_e	186.9	1202.4	447.1
	δ^2_{PE}	38.3	764	101.7
	δ^2_P	235	3708.	628.1

[1] Heritability estimate (h^2), phenotypic variance ($\delta\ ^2{}_A$), error variance ($\delta\ ^2{}_e$), additive variance ($\delta\ ^2{}_A$), permanent environmental variance ($\delta\ ^2{}_{PE}$), permanent environmental variance and Ratio (Ratio PE)

Table 2 demonstrates a low and moderate but positive relationship between dam weight (DW) and K205 of 0.43 in both Angus and Charolais, and 0.17 in the Bonsmara breed. However, in the case of the Charolais it is not significant due to the large SE. Since K205 is a novel trait it could not be compared with any estimates from the literature, but it is similar to those between cow weight and weaning weight that are reported by Koots *et al.* (1994) and the 0.44 reported by van der Westhuizen *et al.* (2010) between mature weight and weaning weight direct.

There is however, a major difference in the nature of the relationship between KgC/LSU and K205 between the Angus and the Charolais, the latter indicated a strong negative relationship (-0.75) and the Angus a strong positive relationship (+0.84), compared to that of the Bonsmara (+0.39). At this stage it is not clear to what this difference can be attributed to, possibly due to the small number of records. The genetic correlation between KgC/LSU and DW was not estimable in the case of the Charolais and was -0.75 in the case of the Angus, which is of the same magnitude as the -0.83 in the case of the Bonsmara.

Table 2 (Co) variance components estimates genetic parameters for K205, KgC/LSU of, Afrikaner, Angus Bonsmara, and Charolais

Breed		Trait		
		K205	KgC/LSU	DW
	K205	0.17±0.03	0.84± 0.01	0.43±0.05
Angus	KgC/LSU		0.24±0.03	-0.75±0.03
	DW			0.56±0.03
	K205	0.13±0.08	-0.75±0.01	0.43±0.24
Charolais	KgC/LSU		0.21±0.04	NE
	DW			0.67±0.02
	K205	0.40±0.05	NE	NE
Afrikaner	KgC/LSU		0.52±0.06	NE
	DW			0.48±0.05
	K205	0.11±0.01	0.39±0.03	0.17±0.02
Bonsmara	KgC/LSU		0.26±0.01	-0.83±0.01
	DW			0.45±0.01

[1] Kilogram Calf Weaned per LSU (KgC/LSU), Weaning Weight as trait of dam (K205) and Dam Weight (DW).

Conclusions

A trait that expresses performance (calf weaning weight) per constant unit, viz. per Large Stock Unit (KgC/LSU) would 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 is linked to specific metabolisable energy requirements, and thus daily feed consumption, it should be possible to eventually "link" this breeding objective with the carbon footprint of weaner calf production.

However, the results in this study support the complexities encountered when selecting for a ratio such as KgC/LSU. The use of the ratio of calf weaning weight to cow LSU as a selection criterion, for example, has theoretical defects, since it places inconsistent emphasis on the component traits resulting in variable responses to selection (MacNeil, 2007). It seems that selection for KgC/LSU will have the same defects. A "Cow Efficiency index" could therefore be a more effective alternative, with minimal to no defects. Such a "cow efficiency index" should include DW and K205 but with a restriction on DW. A restricted selection index will therefore restrict increases in DW (and implicitly LSU) which will happen as a consequence of improving K205, thus limiting or restricting the increase in DW which is also associated with high maintenance cost (Burrow et al., 1991; Schoeman & Jordaan, 1999).

Acknowledgement

This work is based on research supported in part by Red Meat Research and Development South Africa and the National Research Foundation of South Africa (NRF), under grants UID 75123. The Grant-holder acknowledges that opinions, findings and conclusions or recommendations expressed in any publication generated by the NRF-supported research are that of the authors and that the NRF accepts no liability whatsoever in this regard.

List of References

Burrow, H.M., Seifert, G.W. & Hetzel, D.J.S., 1991. Consequences of selection for weaning weight in Zebu, Bos Taurus and Zebu x Bos Taurus cattle in the tropics. Aust. J. Agric. Res. 42, 295-307.

Gilmour, A.R., Cullis, B.R. & Welham, S.J., 2009. ASREML Reference Manual.

Koots, K.R., Gibson, J.P., Smith, C. & Wilton, J.W., 1994. Analyses of published genetic parameter estimates for beef production traits. 1. Heritability. Anim. Breed. Abstr. 62: 309-338.

MacNeil, M.D., 2007. Retrospective analysis of selection applied to a ratio. Amer. Soc. Anim. Sci. 58: 85-88.

Meissner, H.H., Hofmeyr, H.S., Van Rensburg, W.J.J. & Pienaar, J.P., 1983. Classification of livestock for realistic prediction of substitution values in terms of a biologically defined Large Stock Unit. Tech.Comm. No. 175. Department of Agriculture, Pretoria

Neser, F.W.C., Konstantinov, K.V. & Erasmus, G.J., 1996. The inclusion of herd-year-season by sire interaction in the estimation of genetic parameters in Bonsmara cattle. S. Afr. J. Anim. Sci. 26: 75-78.

Schoeman, S.J. & Jordaan, G.F., 1999. Multi-trait estimation of direct and maternal (co)variances for growth and efficiency traits in a multibreed beef cattle herd. S. Afr. J. Anim. Sci. 29, 124-136.

Scholtz, M.M., McManus, C., Okeyo, A.M. & Theunissen, A., 2011. Opportunities for beef production in developing countries of the southern hemisphere. Livest. Sci. 142: 195- 202.

Van der Westhuizen, R.R., Theron, H.E., Van der Westhuizen, J., Maiwaishe, A. & Jordaan, F., 2010. Newsletter Nat. Beef Record. Impr. Scheme, 99: 39.

Wall, E., Simm, G. & Moran, D., 2010. Developing breeding schemes to assist mitigation of greenhouse gas emissions. Animal 4(3): 66-376.

Wright, H.B., Pollak, E.J. & Quaas, R.L., 1987. Estimation of variance and covariance components to determine heritabilities and repeatability of weaning weight in American Simmental cattle. J. Anim. Sci. 65: 975-981.