Pyoos, G., MacNeil, M., Scholtz, M., Seshoka, M., Neser, F. (2026) Plasticity of feed intake of crossbred cattle during the postweaning period, *Proceedings 13th World Congress on Genetics Applied to Livestock Production* 23464: https://doi.org/10.31274/wcgalp.23464
©2026 Pyoos, et al. CC BY-NC-ND

Plasticity of feed intake of crossbred cattle during the postweaning period

G.M. Pyoos[1,2*], M.D. MacNeil[1,2,3], M.M. Scholtz[1,2], M.M. Seshoka[4] and F.W.C. Neser[2]

[1]ARC-Animal Production Institute, Private Bag X2, Irene, 0062, South Africa; [2]Department of Animal Sciences, UFS, P.O. Box 339, Bloemfontein, 9300, South Africa; [3]Delta G, 145 Ice Cave Rd., Miles City, Montana 59301, USA; [4]Northern Cape Department of Environment, Agricultural, Land Reform and Rural Development, Private Bag X9, Jan Kempdorp 8550, South Africa [*]Corresponding author: pyoosg@arc.agric.za

Abstract

Breed differences in feed intake and body weight have been observed in young beef cattle and these differences have been attributed to genetic effects. The past decade saw the warmest years, with the 2015/16 season being the warmest and driest recorded in South Africa. This suggests that use of heat-tolerant breeds will be an important strategy for successful efficiency in beef production. Calves were produced in a three-breed diallel cross of Afrikaner, Bonsmara and Nguni augmented with topcrosses to Angus and Simmentaler sires. Raw data was collected from a GrowSafe feeding system during a time period in which all breeds were fed concurrently. The binary indicator of heat stress (temperature humidity index > 72) had highly significant ($P < 0.01$) effects on both daily food intake (-9.69 ± 1.31 g/day) and partial body weight (48.2 ± 2.1 g/day). One potential reason for animals being heavier on days when the THI was greater than 72 could be that they may have consumed more water under heat stress. Inter-day plasticity of feed intake was estimated as the within-animal variance for each animal. This variance served as the dependent variable for the Friedman non-parametric two-way analysis of variance to assess differences among breed groups in plasticity. This breed group effect was partitioned into single degree of freedom for genetic effects. Nguni, Simmentaler, Afrikaner, and Angus breed direct effects indicated greater inter-day variability in daily feed intake than the Bonsmara direct effect ($P < 0.01$). Likewise, the Nguni maternal genetic effect was greater than that of the Bonsmara ($P < 0.01$). The observation that Bonsmara was more robust (less plastic) in the feedlot may result from the policies of the breed and its being a locally adapted composite. Performance recording is compulsory in Bonsmara, and a large proportion of young bulls are evaluated under intensive feedlot conditions. Estimated heterosis effects were small and not significant ($P = 0.34$). As the environments in which livestock are reared become more variable, animal robustness becomes an increasingly valuable attribute. The challenge of food security for the increasing human population will unavoidably decrease the use of human-edible foodstuffs for feeding livestock. Including robustness in future breeding and management plans suggest being able to measure and quantify it, but no single, simple and useful measure of robustness currently exists.

Introduction

The absence of information about tolerance to heat by different breeds is regarded as a major restraint to production in sub-Saharan Africa. Measurement of adaptation is complex and difficult, and an improved understanding thereof is important and relevant. While market pressures have resulted in a tendency to use large framed fast-growing breeds, these breeds have also been rapidly displacing native breeds in developing countries (Zindove *et al.*, 2015).

Most of these breeds, however, struggle to thrive in tropical environments (Matope *et al*., 2020).
Adapted breeds may have an advantage under heat stress. In beef production, understanding and managing feed under stress is essential for optimal production (Nielsen *et al.,* 2013). Cattle not affected by heat stress are more likely to consume the amount of feed they need to attain their genetic potential for growth (Archer and Bergh, 2000). This suggests that the use of heat-tolerant breeds will be an important strategy for successful beef cattle production in the tropics and sub-tropics. Preweaning plasticity of breed direct and individual heterosis effects under extensive conditions were previously reported (Pyoos-Daniels *et al*., 2022). Plasticity refers to changes in an organism's behaviour or performance in response to a specific, sometimes unique environment (Price *et al.,* 2003). Plasticity is a way for an organism to cope with environmental variation and encompasses all types of environmentally induced changes. These changes may be temporary or permanent (Kelly *et al.,* 2021). The objective was to assess inter-day plasticity of feed intake for Afrikaner, Bonsmara and Nguni in comparison with the exotic Angus and Simmentaler from the within-animal variance for each animal, and this breed group effect was partitioned into single degree of freedom genetic effects.

Materials & Methods

A crossbreeding trial was conducted at the Vaalharts research station in the Northern Cape Province of South Africa, in which Afrikaner, Bonsmara and Nguni cows (Sanga types) were mated with Afrikaner, Bonsmara, Nguni, and exotic Angus and Simmentaler bulls in all possible combinations (Pyoos, 2018). In total 307, 406, 431, 269 and 347 calves were sired by Afrikaner, Bonsmara, Nguni, Angus and Simmentaler sires, respectively. Afrikaner, Bonsmara and Nguni cows produced 300, 656 and 804 calves, respectively. After weaning, the bull calves were transported from Vaalharts to ARC (Agricultural Research Council) Irene, Pretoria. Upon arrival the animals were given a period of 2 weeks to adapt to the facilities and diet and were then allocated to pens with the GrowSafe (Vytelle, LLC) feeding system according to body weight in accordance with the animal ethics committee guidance (APIEC21/06). Raw data was summarized to standardize the period of data collection in each year.
Results reported here were generated using PROC MIXED of the SAS™ System for Windows (Version 8.2, ©1999-2001 by SAS Institute Inc., Cary, NC, USA). In order to examine the inter-day plasticity of feed intake, the within-animal variance was estimated for each animal. This variance served as the dependent variable for a non-parametric two-way analysis of variance (Friedman, 1940). Within each test group, the inter-day variance of feed intake for each animal was ranked. Then the ranks were subjected to two-way analysis of variance (without interaction) and the significance of the breed group effect was tested using a chi-square statistic that was calculated by multiplying the sum-of-squares for treatment by $12/((t*(t+1))$ where t is the number of breed groups. The genetic effects were calculated as linear functions of the breed group means.

Results & Discussion

The day-to-day variation in feed intake was not observed to be breed-dependent (Pyoos *et al.*, 2026). However, patterns of feed intake from day-to-day varied among animals as evidenced by the range in estimates of the serial correlation ranging from -0.60 to 0.85 (median = 0.10). Heat stress effects affected feed intake (-9.69 ± 1.31 g/day) and weight (48.2 ± 2.1 g/day). These results were interpreted to suggest that on days when there was heat stress the bulls consumed more water and less feed. These observations motivated examination of the plasticity of the breed groups.

Table 1 shows results from Friedman's test for differences between breed groups in their plasticity of feed intake. The results indicate that the breed groups differ significantly in their plasticity of feed intake.

Table 1. Friedman's analyses for plasticity of feed intake in cattle representing 15 breed groups that could be used for beef production in South Africa.

Source	Degrees of freedom	Sum of squares	Chi-square statistic	Probability of chi-square
Test group	14	9020.9	451.0	< 0.01
Breed group	14	1327.1	66.4	< 0.01

The breed group effect on plasticity of feed intake was partitioned into single degree of freedom genetic effects that are presented in Table 2. Nguni, Simmentaler, Afrikaner, and Angus breed direct effects indicated more inter-day variability in daily feed intake than the Bonsmara direct effect. Likewise, the Nguni maternal genetic effect was greater than that of the Bonsmara. The estimated heterosis effect was small and not significant, indicating that crossbred cattle would be no more variable over time in feed intake than were their straightbred counterparts. Taken together, these results indicate that Bonsmara cattle would genetically be less sensitive to changes in the temporal environment in the feedlot than the other breeds and crosses. Therefore, the daily feed intake of Bonsmara cattle would be more predictable. Performance recording is compulsory in Bonsmara, and a large proportion of young bulls are tested under intensive feedlot conditions. This may have resulted in a breed that is more tolerant (robust) of changes in conditions during the feedlot period.

Table 2. Partitioning the breed group effect on plasticity of postweaning feed intake into single degree of freedom contrast corresponding to explanatory genetic effects

Genetic effect	Sum of squares	Chi-square statistic	Estimate	Probability of chi-square
g^i AF – BN	9.22	55.32	1.35	< 0.01
g^i NG – BN	30.11	180.66	2.39	< 0.01
g^i AN – BN	4.11	24.66	0.54	< 0.01
g^i SM – BN	45.61	273.66	1.45	< 0.01
Heterosis	0.15	0.90	-0.17	0.34
g^m AF – BN	0.01	0.06	-0.06	0.81
g^m NG – BN	142.06	852.36	7.88	< 0.01

$\boldsymbol{g^i_{A-B}}$= direct genetic effect for breed A expressed as a deviation from breed B; $\boldsymbol{g^m_{A-B}}$= maternal genetic effect for breed A expressed as a deviation from breed B; $\boldsymbol{h^i}$ = individual heterosis effect; AF = Afrikaner, AN = Angus, BN = Bonsmara, NG = Nguni, SM = Simmentaler

In the tropical environment of Kenya, Oloo *et al.* (2023) indicated the viability of utilizing log-transformed variance of deviations in milk yield as an indicator of general resilience of dairy cows. In the present study, rather than using a transformation of the variance, Friedman's test was used to analyse the magnitude of the variance in feed intake across the days on test. Oloo *et al.* (2023) found the log-transformed variance of deviations in milk yield to be heritable. As the environments in which livestock are reared become more variable, animal robustness, including rates of response to and recovery from environmental perturbations, becomes an increasingly valuable attribute (Friggens *et al*., 2017). Including robustness in future breeding and management plans suggests being able to measure and quantify it, but no single, simple, useful measure of robustness currently exists. Zindove (2026) has advocated for indirect selection as a means of producing beef cattle that are resilient to harsh and fluctuating

environmental conditions. Responses in milk yield and plasma non-esterified fatty acid to imposed short-term restriction of feed intake have been suggested as alternative indicators of robustness on beef cows (De La Torre *et al*., 2022).

Conclusions

Bonsmara cattle performed more consistently in the changing environment as compared to other breed types. Concurrent measurements of feeding behaviour and growth will significantly enrich the amount of data for understanding breed differences and genetic effects amongst crossbred cattle. Future studies should also record feeding behaviour traits to better understand the variation in feed efficiency in stressful and stress-free environments. Including robustness in future breeding and management plans suggest being able to measure and quantify it, but no single, simple and useful measure of robustness currently exists.

Acknowledgements

The author would like to extend acknowledgments to the staff at the Vaalharts Research Station and technical support staff of Vytelle, LLC. Red Meat Research and Development – South Africa (RMRD-SA) is acknowledged for financial assistance.

References

Archer, J.A., and Bergh, L. (2000) Livestock Production. Science 65:47-55. https://doi.org/10.1016/s0301-6226(99)00181-5

De La Torre, A., Barreto-Mendes, L., Pires, J.A.A., *et al*. (2022) Animal 16:100556. https://doi.org/10.1016/j.animal.2022.100556

Friedman, M. (1940) The Annals of Mathematic Statistics 11:86-92. https://doi.org/10.1214/aoms/1177731944

Friggens, N.C., Blanc, F., Berry, D.P., *et al*. (2017 Animal 11:2237–2251 https://doi.org/10.1017/s175173111700088x

Kelly, D.N., Sleator, R.D., Murphy, C.P., *et al*. (2021) Journal of Animal Science 99:1-11. https://doi.org/10.1093/jas/skab285

Matope A., Zindove T.J., Dhliwayo M., *et al*. (2020) Tropical Animal Health and Production 52: 1–10. https://doi.org/10.1007/s11250-019-02020-y

Nielsen, M.K., MacNeil, M.D., Dekkers, J.C.M., *et al*. (2013) The Professional Animal Scientist 29:559–565. https://doi.org/10.15232/s1080-7446(15)30285-0

Oloo, R.D., Mrode, R., Bennewitz, J., *et al*. (2023) Frontiers in Genetics 14:1208158. https://doi.org/10.3389/fgene.2023.1208158

Price, T.D., Qvarnström, A., and Irwin, D.E. (2003) Proc. of the Royal Society of London. 270:1433–1440. https://doi.org/10.1098/rspb.2003.2372

Pyoos, G.M. 2018. Crossbreeding effects on cow efficiency and component traits. M.Sc. Dissertation. University of the Free State. South Africa.

Pyoos, G.M., Scholtz, M.M., MacNeil, M.D., *et al*. (2026) Animals (accepted).

Pyoos-Daniels, G.M., MacNeil, M.D., and Neser, F.W.C. (2022) Proc. 12th WCGALP, Rotterdam, Netherlands. 1816-1819. https://doi.org/10.3920/978-90-8686-940-4_436

Thom, E.C. (1959) The Discomfort Index. Weatherwise. 12:57-60. https://doi.org/10.1080/00431672.1959.9926960

Zindove T.J., Chimonyo M., and Nephawe K.A. (2015) Animal 9:944-995. 10.1017/S1751731114003231

Zindove, T.J. (2026) Frontiers in Animal Science 6 – 2025. https://doi.org/10.3389/fanim.2025.1637995