SHOULD MEASURES OF BODY COMPOSITION BE INCLUDED IN THE MODEL FOR RESIDUAL FEED INTAKE IN BEEF CATTLE?

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SUMMARY
Data from 1783 British breed bulls and heifers born between 1993 and 1999 were used to assess the contribution of ultrasound measures of body composition to the accuracy of predicting the feed requirements used in calculating residual feed intake. Traits studied included daily feed intake (DFI), average daily gain (ADG), metabolic body weight (MWT), end of test P8 fat depth (P8), change in P8 fat depth over 70 days, end of test eye muscle area, change in eye muscle area over 70 days, feed conversion ratio and residual feed intake. The commonly used model in beef cattle to predict feed intake uses MWT and ADG. Inclusion of P8 to the model increased the R^2 by 2 to 4 percentage points. The other body composition traits had minimal effect on the R^2. Residual feed intake estimated with or without adjustment for body composition was strongly correlated (0.94-0.97). Hence re-ranking of animals based on phenotype is not expected to be high enough to warrant inclusion of body composition traits in the estimation of residual feed intake.
Keywords: beef cattle, feed intake, feed efficiency, body composition

INTRODUCTION
Providing feed for cattle is the single largest expense in most beef cattle enterprises, hence the need for genetic improvement in feed efficiency. Residual (or net) feed intake is a measure of feed efficiency and is defined as the difference between actual feed intake and the expected feed requirements for maintenance of body weight and some measure of production (eg. growth in beef cattle or milk yield in dairy cattle). Residual feed intake in beef cattle is commonly estimated using metabolic body weight and average daily gain in models to predict feed requirements (Herd and Bishop, 2000; Arthur *et al.*, 2001). In view of the results of recent studies (Basarab *et al.*, 2001; Richardson *et al.*, 2001) indicating a statistically significant, but minor, effect of carcass composition on residual feed intake, this study was conducted to assess the contribution of ultrasound measures of body composition to the accuracy of predicting the feed requirements used in calculating residual feed intake.

MATERIALS AND METHODS
Animals, management and test protocols. A total of 1783 British breed bulls and heifers born between 1993 and 1999 were tested, in nine groups (test group) for postweaning feed efficiency at the NSW Agriculture Research Centre at Trangie, NSW. Groups 1, 3, 5, 7, 8 and 9 were Angus calves born in Spring, while groups 2, 4 and 6 were Angus, Hereford or Shorthorn calves born in Autumn.

The animals were brought to the test facility 4 to 6 weeks after weaning. A pre-test adjustment period of at least 21 days was allowed for the animals to adapt to the feeding system and diet. The average age at the start of test was 268 days (± 23 days, SD). For tests groups 1 to 7, the adjustment period was followed by a 120-d test. Based on the recommendations by Archer *et al.* (1997), a 70-d test was instituted for groups 8 and 9. For this study, the efficiency test traits for all groups have been recalculated using only data from the first 70 d of the test. During the test, animals had *ad libitum* access to a pelleted diet composed of 70% alfalfa hay and 30% wheat plus monensin, vitamins, and mineral supplements. The diet had an average metabolisable energy content of 10.5 MJ/kg DM and 15% to 17% crude protein. Straw was provided at an average of 0.5 kg per animal per day. All animals were weighed weekly, and ultrasonic measurement of fat depth and eye muscle area were taken at the start and end of test. Additional information has been reported in Arthur *et al.* (2001).

Traits studied. Traits used in the study were daily feed intake (DFI), average daily gain (ADG), metabolic body weight (MWT), end of test P8 fat depth (P8), change in P8 fat depth over 70 days (CP8), end of test eye muscle area (EMA), change in eye muscle area over 70 days (CEMA) and feed conversion ratio (FCR). The growth of each animal was modelled by linear regression of weight on time (days), and the regression estimates were used to calculate ADG (the regression coefficient) and weight at start and end of test. The mean weight (WT) of an animal during the test was computed calculated as the average of the start and end of test weights. Metabolic body weight was calculated as $WT^{0.73}$. Feed intake was calculated by adding the daily energy intake of the pelleted ration and straw, and then adjusted to a common concentration of 10 MJ ME/kg dry matter. Feed conversion ratio was calculated as DFI divided by ADG. Within sex, a linear regression model of DFI on MWT and ADG, with test group as a class variable, was fitted to obtain the expected daily feed intake (EDFI) for each animal. Residual feed intake (RFI) was calculated as the actual (DFI) minus EDFI.

Statistical analyses. All analyses were conducted within sex. To evaluate the importance of the body composition traits (P8, CP8, EMA and CEMA) in the prediction of feed intake, stepwise regression analysis was run as a first step, using the PROC REG of SAS (1989). This was done to determine the order in which the body composition traits should be included in the model which already had test group, MWT and ADG. In the second step, linear models were run using the PROC GLM of SAS (1989). The base model used was $DFI = a + b_1MWT + b_2ADG + residual$, where test group was fitted as a class variable with 9 levels. Using the order obtained from the stepwise regression analysis, the linear models were progressively re-run with an additional body composition trait being added each time. The change in the coefficient of determination (R^2) as a result of inclusion of a particular trait was used to determine the relative importance of its inclusion. Based on the results, a new residual feed intake trait (RFIPLUS) was computed, where P8 was included in the model ($DFI = a + b_1MWT + b_2ADG + b_3P8 + residual$) for predicted feed intake. Phenotypic correlations among the traits were determined using PROC CORR of SAS (1989).

RESULTS AND DISCUSSION

Descriptive statistics of the traits used are presented in Table 1. The correlation between DFI and all the body composition traits were moderate, except for CEMA, where a low correlation was obtained in both sexes.

Table 1. Descriptive statistics and phenotypic correlation between feed intake and the other traits

Trait	Abbre-viation	Sex	No.	Mean	SD	Correlation with DFI
Feed intake (kg/day)	DFI	Male	578	10.3	1.4	--
		Female	1205	9.2	1.2	--
Average daily gain (kg/day)	ADG	Male	578	1.48	0.24	0.36
		Female	1205	1.19	0.19	0.34
Metabolic body weight (kg)	MWT	Male	578	73.2	7.8	0.76
		Female	1205	64.3	6.6	0.74
P8 fat depth (mm)	P8	Male	577	7.0	2.5	0.48
		Female	1204	8.4	3.1	0.53
Change in P8 fat depth (cm)[A]	CP8	Male	577	3.9	2.1	0.33
		Female	1204	4.8	2.1	0.30
Eye muscle area (cm^2)	EMA	Male	576	70.5	10.6	0.54
		Female	1198	58.1	10.8	0.47
Change in eye muscle area (cm^2)[A]	CEMA	Male	576	16.6	6.9	-0.02
		Female	1198	13.4	6.0	0.14

[A]Change over a 70-day test period.

The order of inclusion of body composition traits in the model was determined to be P8, EMA, CEMA and CP8, for males and P8, CEMA, CP8 and EMA for females. The percentage of variation explained by the different models is presented in Table 2. The current model, which included MWT and ADG, explained a large percentage of the variation in DFI in both sexes. Inclusion of P8 in the model resulted in an improvement in the R^2 of 3.6 and 1.8 percentage points in males and females, respectively. The effect of the inclusion of the other three body composition traits (EMA, CP8 and CEMA) on the R^2 was minimal, with the model being improved by only 1.1 and 0.5 percentage points for males and females, respectively. Based on these results a new residual feed intake trait was developed (RFIPLUS) which was similar to RFI, but had P8 included in the regression model for predicting feed intake.

Table 2. Percentage of variation explained (R^2) by different feed intake models

Males		Females	
Model	R^2	Model	R^2
Current model (CM)[A]	70.1	Current model (CM)[A]	68.7
CM + P8	73.7	CM + P8	70.5
CM + P8 + EMA	74.5	CM + P8 + CEMA	70.8
CM + P8 + EMA + CEMA	74.8	CM + P8 + CEMA + CP8	71.0
CM + P8 + EMA + CEMA + CP8	74.8	CM + P8 + CEMA + CP8 + EMA	71.0

[A]$DFI = a + b_1MWT + b_2ADG + residual$.

The correlations between the two residual feed intake traits and the other traits are presented in Table 3. As expected, the residual feed intake traits were independent of their component traits (MWT and ADG for RFI, and MWT, ADG and P8 for RFIPLUS). For both sexes, RFI and RFIPLUS were strongly correlated. The magnitude of the correlation coefficients between RFI and the other traits and between RFIPLUS and the other traits was also similar. These results are similar to those reported by Jensen *et al.* (1992), who estimated residual feed intake with and without carcass composition traits.

Table 3. Phenotypic correlations between different measures of residual feed intake and growth and body composition traits

Trait[A]	Sex	RFIPLUS	DFI	ADG	MWT	FCR	P8	EMA
RFI	Male	0.94	0.55	0.00*ns*	0.00*ns*	0.41	0.27	0.09
	Female	0.97	0.56	0.00*ns*	0.00*ns*	0.43	0.17	0.04*ns*
RFIPLUS	Male	--	0.51	0.00*ns*	0.00*ns*	0.39	0.00*ns*	0.09
	Female	--	0.54	0.00*ns*	0.00*ns*	0.42	0.00*ns*	0.04*ns*

[A]RFI = residual feed intake; RFIPLUS = residual feed intake with P8 fat depth in the model. See Table 1 for the definitions of other traits.
ns, indicates that the correlation coefficient is not significantly (P>0.05) different from zero.

CONCLUSION

Residual feed intake estimated with adjustment for body composition was strongly correlated with that estimated without adjustment for body composition. Re-ranking of animals based on phenotype is not expected to be of sufficient magnitude to warrant inclusion of body composition traits in the estimation of residual feed intake.

ACKNOWLEDGMENTS

This work was funded by NSW Agriculture, Meat and Livestock Australia and the CRC for Cattle and Beef Quality. The assistance by staff of the NSW Agriculture Trangie Research Centre is gratefully acknowledged.

REFERENCES

Archer, J.A., Arthur, P.F., Herd, R.M., Parnell, P.F. and Pitchford, W.S. (1997) *J. Anim. Sci.* **75**:2024.

Arthur, P.F., Archer, J.A., Johnston, D.J., Herd, R.M., Richardson, E.C. and Parnell, P.F. (2001) *J. Anim. Sci.* **79**:2805.

Basarab, J.A., Price, M.A., Aalhus, J.L., Okine, E.K., Snelling, W.M. and Lyle, K.L. (2001) *Can. J. Anim. Sci. (Abst.)* **81**:614.

Jensen, J., Mao, I.L., Bech Andersen, B. and Madsen, P. (1992) *J. Anim. Sci.* **70**:386.

Herd, R.M. and Bishop, S.C. (2000) *Livest. Prod. Sci.* **63**:111.

Richardson, E.C., Herd, R.M., Oddy, V.H., Thompson, J.M., Archer, J.A. and Arthur, P.F. (2001) *Aust. J. Exp. Agric.* **41**:1065.

SAS Institute, Inc. (1989) "SAS/STAT Users Guide" Version 6, 4th ed. SAS Institute Inc., Cary.