PRELIMINARY GENETIC PARAMETERS FOR FEED INTAKE AND EFFICIENCY IN FEEDLOT CATTLE

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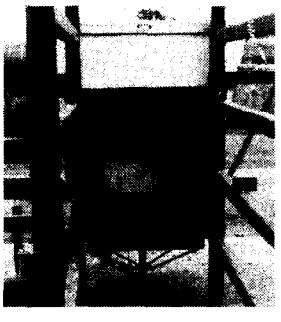
SUMMARY
Preliminary results are presented on feed efficiency of 1165 cattle with growth and feed intake measurements recorded at the Tullimba feedlot near Armidale, NSW. Feed efficiency was calculated as the residual from a regression equation relating feed intake to metabolic weight and gain, where gain was calculated (for the period intake was measured) either as the difference between start and end weights in the automatic feeder pens, or from a modelling process using random regression curves for each animal over the most or all the time animals were in the feedlot, irrespective of whether intake was being recorded. The latter measure of efficiency proved more heritable (28% vs 18%) and had lower genetic correlations with intake, rump and rib fat and intra-muscular fat (42%, 26%, 28% and 17%) than using actual gain (69%, 33%, 27% and 53%). A measure of feed efficiency derived from nutritional requirements for maintenance and weight gain was also analysed. The variance of this measure was dominated by measurement errors of weight gain, so had a heritability of 4%. Implications of these findings are discussed.

Keywords: Beef cattle, feed intake, weight gain, feed efficiency

INTRODUCTION
Because feed is a major cost in the production of grain-fed beef, measurement of feed intake and feed efficiency is an important part of the CRC research program. However, due to limited capacity of the automatic feeder (**AF**) pens, feed intake was measured on most groups of CRC animals for only 50 days. A companion paper (Robinson and Oddy 1999) describes how weight gain in the AF pens may be estimated more accurately by modelling weights for most or all of the time animals were in the feedlot. This paper provides estimates of genetic parameters for intake and growth of 1165 animals and for residual feed intake based on actual and modelled gain, confirming the benefit of basing estimates of residual feed intake on modelled gain, as discussed by Robinson and Oddy (1999). Implications in terms of selection and genetic relationships with other traits are also discussed.

MATERIALS AND METHODS


Data. The design of the Cooperative Research Centre for the Cattle and Beef Industry (**CRC**) research program was described by Robinson (1995). Feed intake measurements were available on 386 steers and 121 heifers of tropically adapted breeds and 658 steers of temperate breeds finished at the Tullimba feedlot between February 1996 and January 1999. Weaners from the tropically adapted breeds were supplied by 4 Brahman, 3 Belmont Red and 4 Santa Gertrudis herds in Queensland. After a short period at the 'Duckponds' research station in Queensland, animals were transferred south to New England where they were grown out on pasture and then finished in the Tullimba feedlot. Weaners from 10 Angus, 6 Hereford, 2 Murray Grey

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and 3 Shorthorn herds were grown out, often under three or four different grow-out nutritional regimes, at NSW Agriculture's Glen Innes Research Station, then finished at Tullimba. Animals were finished for either the domestic market (**D**; 400 kg liveweight; feedlot entry 300 kg), Korean (**K**; 520 kg liveweight; feedlot entry 400 kg) or Japanese markets (**J**; steers only; 600 kg liveweight; feedlot entry 400 kg). Domestic, Korean and Japanese market animals had feed intake measured at average weights of 390, 493 and 547 kg respectively. Table 1 of the companion paper shows numbers of animals by market, breed type and sex, as well as mean weights, intakes, weight gains and fatness measurements.

Feed efficiency. Net or residual feed intake (**RFI;** kg/day) was calculated by fitting the model: Intake = metabolic weight + weight gain + RFI (1) to each group of animals tested. In this equation, intake and weight gain were measured in kg/day; metabolic weight was calculated as mean test weight to the power of 0.73. Estimated RFI is the residual or error term from fitting this equation. To compare the efficacy of using modelled vs actual weight gains in this equation, and determine whether the first two weeks, in which animals learn to use the AF feeders and adapt to AF pens, should be considered atypical, four different estimates of RFI were calculated. **RFA2** and **RFM2** were based on intake and actual or modelled weight gains (**GNA2, GNM2**) for all but the first two weeks in the AF pens; **RFA** and **RFM** covered the entire time in the AF pens. The stability of the regression coefficients across markets was investigated by fitting equation (1) to all tropical and all temperate breeds, but allowing additional random terms for market, breed, herd, nutrition (if applied) and additional random regression coefficients for the interactions of market and test group with metabolic weight and weight gain using ASREML (Gilmour 1998) as well as genetic effects using a full pedigree animal model. A fifth measure of residual feed intake (**RFIT**) was calculated as the residual from published nutritional requirements for maintenance and actual weight gain (see Appendix).

RESULTS

The mean correlation between metabolic weight and feed intake was 0.80 for tropical breeds. Figure 2 shows the relationship between feed intake and metabolic weight for three groups of heifers with raw correlations of 0.92 (circles; market D), 0.52 (triangles; D) and 0.80 (crosses; K). Within many test groups, intake was closely related to weight. However, the relationship does not hold across different markets, where animals differ in age as well as weight. For example, temperate breed steers for the Japanese market averaged 564 kg and ate on average 12.8 kg/day, less than the 13.1 or 13.3 kg/day for Korean and Domestic market steers, averaging 496 and 407 kg respectively (see Table 1 of the companion paper). In temperate breeds, the ASREML analyses identified moderately large breed and market effects, as well as test group effects within markets, and some differences in partial regression coefficients for gain for different market and intake groups. For tropical breeds, there were differences in the partial regression coefficients for gain for Domestic, Korean and Japanese Markets

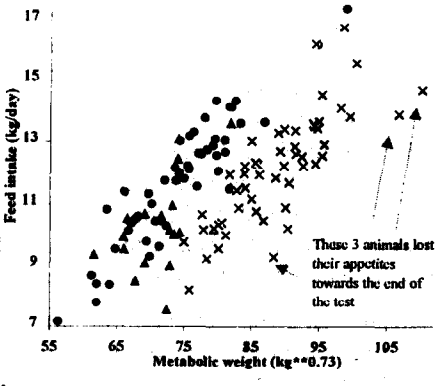

Figure 2. Relationship between feed intake & metabolic weight.

(see Table 2 of the companion paper), but variation of coefficients within markets was not significant. When breed effects were fitted in addition to the terms in equation (1) for each intake group of temperate breeds, residual variances were marginally lower than for tropical breeds. Examination of outliers for both breed types showed that, in some cases, eg the three animals arrowed in Figure 2, departures from the expected relationship may be due to loss of appetite, rather than true feed efficiency.

Preliminary estimates of heritabilities and genetic correlations calculated using VCE4 (Groeneveld and Garcia-Cortes 1998) are shown in Table 1. Residual feed efficiency (RFA2, RFM2) was calculated by fitting the regression relationship separately for each group of animals tested. For RFA and RFM, based on intake and growth for all weeks in the AF pens, estimated heritability was 18% for both traits, lower than for RFM2, which excluded the first two weeks. For brevity, results presented in Table 1 are therefore based on intake measurements and gains excluding the first two weeks in the AF pens. The estimated genetic correlation of RFM2 with weight (4%) was negligible but not with GNA2 (74%). Further investigations of the data and error structures are needed to shed some light on these results. However as a precautionary principle, both weight and gain criteria should be considered in any selection for reduced residual feed intake, to avoid any undesired changes in these traits. The positive genetic correlations between residual feed intake and fatness measures is probably a consequence of the fact that deposition of fat requires more energy than deposition of muscle. Thus reducing residual feed intake will also result in leaner animals. If animals are being feedlot finished specifically to meet marbling criteria for export markets, identification of superior genetic stock will require scanning for marbling as well as measurement of feed efficiency.

The estimated heritability of mean test weight was 67%. One reason for this unusually high value is that measurement error of this trait, calculated as the mean of all recorded weights while the animal was in the AF pens, is much lower than for a single weighing. Modelled gain had an estimated heritability of 16% and a genetic correlation of 71% with mean test weight. GNA2 had a lower heritability of 12%, a very low estimated correlation with mean test weight but high estimated genetic correlation with RFA2, suggesting that the partial regression coefficient to adjust for gain when calculating RFA2 is too low. Estimated correlations based on only 1165 animals are likely to have high sampling variances. There is no reason in principle to believe that the genetic correlation between weight and gain should be any different for actual vs modelled gain. However, the low heritability for GNA2, may result in increased errors of estimating genetic correlations. Despite its higher heritability, estimated genetic variation for modelled gain, GNM2, was lower than for actual gain. As discussed in the companion paper, the modelling process may cause some shrinkage of variation. This will change the magnitude of the partial regression coefficient. However, genetic progress depends on the heritability of the trait and true genetic variation, not the shrunken estimate.

Residual feed efficiency based on nutritional requirements for maintenance and weight gain, RFIT had an estimated heritability of only 4%. The low heritability can be partly explained by the high measurement error of gain, though it is somewhat surprising that the heritability estimate, (probably by chance), was less than for GNA2. Estimated genetic correlations of RFIT with weight and fatness were very high, but are not listed in Table 1 because of the low heritability and consequent errors likely to be associated with this trait.

Table 1. Estimated heritabilities, genetic variances and genetic correlations

	Intake	Wt	GNM2	GNA2	RFM2	RFA2	P8 fat	Rib fat	IMF[1]
Genetic variation	0.97	1250	0.008	0.016	0.28	0.17	4.1	3.3	1.3
Heritability(%)	38	67	16	12	28	18	46	49	49
Genetic correlations (%)									
Feed intake (kg/d)		78	73	55	42	69	44	42	51
Mean test wt (kg)			71	-4	4	16	42	48	42
Modelled gain - GNM2				74	-23	50	10	-17	24
Actual gain - GNA2					74	94	-18	-45	-20
Resid. feed intake - RFM2						88	26	28	17
Resid. feed intake - RFA2							33	27	53
P8 Rump fat (mm)								98	48
Rib fat (mm)									48

[1]Intra-muscular fat (%)

Use of a relatively short test period was essential in the case of CRC cattle to enable all animals to be tested and hence obtain the most accurate estimates of genetic parameters. A test of this length should not be used to identify individual animals but rather the genetic potential of their sires, based on the performance of several of their offspring. A longer testing period, or perhaps use of automatic weighing equipment, would be required to draw any conclusions about the performance on an individual animal.

ACKNOWLEDGEMENT

This work would not have been possible without the expert assistance of Reid Geddes, Stuart Murphy, and Colin Crampton at the Tullimba feedlot, as well as Diana Perry, Matt Wolcott and Paul Reynolds of the Meat Science Program plus the many co-operating breeders who have been involved in the Core Breeding Program of the CRC for the Cattle and Beef Industry.

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APPENDIX - EQUATIONS USED TO ESTIMATE RFIT

From: Standing Committee on Agriculture - Ruminants Subcommittee. Feeding Standards for Australian Livestock. CSIRO, Australia, 1990.

Energy required for maintenance (MJ/day) = C*MWt / 0.7 + 0.09*(MJ eaten), where
MWt = metabolic weight = Ebwt**0.75; Ebwt = Empty body wt = 0.92*Mean_wt
C=0.312 for tropical and 0.364 for temperate breeds.
Energy required for gain (MJ/day) = (Ebg)*2.5*(6.7 + R + (20.3-R)/(1+exp(2.4-6P)), where
Ebg = empty body gain = 0.92*measured gain (kg/day); R=250*Ebg/(SRW**0.75); P=Ebwt/SRW
SRW = standard reference weight = 550 for heifers and 660 for steers.
Energy requirements were converted into kg of feed based on the energy value of 10.8 MJ/kg for the feed used. Residual feed intake (RFIT) for each animal was the difference between feed eaten per day in kg and predicted values for maintenance and gain according to these equations.