SELECTION FOR LOW POSTWEANING RESIDUAL FEED INTAKE IMPROVES FEED EFFICIENCY OF STEERS IN THE FEEDLOT

R.M. Herd[1], J.A. Archer[2] and P.F. Arthur[3]
Co-operative Research Centre for Cattle and Beef Quality
[1]NSW Agriculture, Beef Industry Centre, UNE, Armidale, NSW 2351
[2]AgResearch Ltd, Invermay Agricultural Centre, Otago, New Zealand
[3]NSW Agriculture, Elizabeth Macarthur Agricultural Institute, Camden, NSW 2570

SUMMARY
This experiment investigated whether divergent selection on postweaning residual feed intake (RFI) resulted in differences in steer growth, feed intake and feed efficiency over a 70-day test period in the feedlot, and in carcass attributes at slaughter. Selection for low postweaning RFI (high efficiency line, HE) produced steer progeny that ate less per unit liveweight gain compared to steers from high RFI (low efficiency line, LE) parents, with no adverse effects on growth. The HE steers tended to have lower feed conversion ratio (feed:gain; FCR) than the LE steers (7.6 *v* 8.2 kg/kg; $P<0.1$) and had lower RFI (-0.12 *v* 0.10kg/day; $P<0.05$). Significant positive regressions of FCR and RFI with mid-parent estimated breeding value for RFI (EBV_{RFI}) provided further evidence for favourable genetic associations with postweaning RFI. Ultrasound measurement before slaughter showed that HE steers had less depth of fat over their rib and rump and a smaller cross-sectional area of the eye-muscle than LE steers (10.2 *v* 11.6mm, 13.1 *v* 14.8mm, 66.9 *v* 70.6cm^2; all $P<0.05$). The HE steers had less fat depth at the rump on the hot carcass and there was a small difference in dressing percentage (14.9 *v* 16.5mm, 52.1 *v* 52.9%; both $P<0.05$). Significant ($P<0.05$) regressions for the three subcutaneous fat measurements, eye-muscle area and dressing percentage with mid-parent EBV_{RFI} provided additional evidence of genetic association. There were no differences ($P>0.05$) between HE and LE steer progeny in hot carcass weight or in predicted retail beef yield.
Keywords: beef cattle, feed intake, feed efficiency, selection, carcass

INTRODUCTION
Feeding cattle is a major cost of beef production. Residual (or net) feed intake (RFI) has been proposed as a measure of feed efficiency that is independent of liveweight (LW) and growth rate. It is calculated as the amount of feed consumed net of that predicted based on LW and growth rate. Cattle with low RFI eat less than expected for their LW and growth rate and are therefore more efficient than cattle with high RFI. Postweaning tests of young bulls and heifers from a number of British beef breeds have shown RFI to be heritable (Arthur *et al.* 2001a) and to respond to selection (Arthur *et al.* 2001b). This experiment investigated whether divergent selection on postweaning RFI resulted in differences in steer growth, feed intake and feed efficiency in the feedlot, and in carcass attributes at slaughter.

MATERIALS AND METHODS
Cattle breeding. Cattle breeding and postweaning tests for RFI were undertaken at the NSW Agriculture Research Centre, Trangie, NSW, Australia. Briefly, RFI tests were conducted each year for Trangie-bred Angus bulls and heifers and for Angus, Shorthorn, Hereford and Poll Hereford

heifers purchased from industry herds. Details of the postweaning test procedure are given in Arthur *et al.* (2001a) and establishment of divergent selection lines by Arthur *at al.* (2001b). Male progeny of the matings of Trangie bulls to industry-bred heifers were castrated for subsequent evaluation as steers. The steers were weaned at about seven months of age and then grown on pasture and finished in a feedlot for slaughter. Progeny used in this experiment were born in 1997, 1998 and 1999 and were fed for slaughter at light, heavy and medium LW respectively. The 1997-born steers entered the CRC for Cattle & Beef Quality "Tullimba" Research Feedlot (Armidale, NSW) when they were approximately 13 months old and weighed on average 314kg. The steers born in 1998 entered the feedlot when they were approximately 24 months old and weighed 502kg. The 1999-born steers entered the feedlot at approximately 15 months of age, weighing 338kg.

Measurements in the feedlot. The steers were fed a standard finishing ration that consisted of approximately 75% grain, 10% sorghum hay, 5% protein pellets, plus molasses and vitamin and mineral additives (fresh weight basis). To standardise feed intakes for small differences in metabolizable energy (ME) content between years, daily feed intakes were calculated as kilograms per day of a ration equivalent to 12MJ ME/kg dry matter (DM). Individual feed intakes were recorded by automated feeders (Ruddweigh, Guyra, NSW) for approximately 70 days. Start-of-test, mid-test and end-of-test LW, and average daily gain (ADG) for each steer were calculated from the linear regression of its weekly (year 1) or fortnightly (years 2 and 3) LW against time. At their final weighing the steers had subcutaneous fat depth at the rib (12/13th) and rump (P8 site), and eye-muscle area, measured using an Aloka 500 ultrasound scanner. In year 1, sufficient feedlot yards with individual feed-intake recorders were only available to accommodate the Angus portion of the steers.

Carcass measurements. The weight of the "hot" carcass and depth of fat at the P8 site was recorded before being chilled overnight. Next morning, individual weights of selected, trimmed primal cuts from the left side of each carcass were recorded for subsequent use in prediction of beef yield. Difference in the depth of fat trim by the abattoir in year1 compared to years 2 and 3 required that the predictive equation of Reverter *et al.* (1999) be used for the year 1 steers and the temperate feedlot cattle equation of Reverter *et al.* (2001) for year 2 and 3 steers.

Data analysis. The data set analysed contained 144 low-RFI (HE) line steers and 165 high-RFI (LE) line steers. They were the progeny of 14 HE sires and 15 LE sires, each of which had at least five progeny (mean 10.5 per HE sire; 11.0 per LE sire). Each year, RFI for each animal was calculated as the residual from the regression of individual feed intake on mid-test $LW^{0.75}$ and ADG. Feed conversion ratio was calculated as DM-intake:ADG. Differences in the means for the HE and LE lines were tested within a general linear model. Included in the model were the fixed effects of year, breed, age of dam and selection line, calf age at weaning as a covariate, and line-by-breed and line-by-year interactions. Preliminary analyses showed that age of dam and line-by-breed and line-by-year interactions were not significant ($P>0.05$) and they were dropped from the final model. Since the management of animals in the two selection lines was identical, any observed differences in mean performance of the lines were attributed to genetic selection. In addition, regressions were determined of traits measured on the steers on the mid-value of their sire and dam estimated breeding value for postweaning RFI (EBV_{RFI}). These EBVs were calculated for each parent based on its performance in postweaning RFI tests conducted at the Trangie Agricultural Research Centre and genetic parameters reported by Arthur *et al.* (2001a). Sire EBV_{RFI} ranged from -0.50 to +1.15kg/day and dam EBV_{RFI} from -0.63 to +0.67 kg/day. Regression coefficients were determined within a model that included year, breed, age of steer and mid-parent EBV_{RFI}. Regression coefficients significantly different from zero were presumed to provide evidence for genetic association.

RESULTS AND DISCUSSION

Performance over feedlot RFI test. Phenotypic correlations for RFI with LW (start-of test and end-of-test LW) and ADG were non-significant (P>0.05), as expected given that RFI is calculated to be independent of them. Phenotypic correlations of RFI with actual feed intake (r=0.50, P<0.001) and FCR (r=0.27, P<0.001) showed that steers with lower RFI in the feedlot also had a lower feed intake and more favourable FCR. There was no difference between HE and LE progeny in LW at the start of the RFI-test period, in ADG over the test, or in LW at the end of the test (Table 1). Daily feed intake did not differ between the selection lines. However, HE steers tended (P<0.1) to have lower FCR than the LE steers and had significantly lower RFI. A generation of divergent selection resulted in a 0.22kg DM/day difference in RFI or 6% better FCR by the HE steers, with no compromise in growth performance. Significant regressions of steer ADG, FCR and RFI on mid-parent EBV_{RFI} provided additional evidence for favourable genetic associations between postweaning RFI of the parents with the growth and efficiency of their progeny in the feedlot.

Body composition and carcass traits. There were significant differences between HE and LE steers in the body composition traits measured by ultrasound before slaughter. The HE steers had less depth of fat over their rib and rump and a smaller cross-sectional area of eye-muscle than LE steers. There was no difference between the HE and LE steers in hot carcass weight. The HE steers had less fat depth at the rump site on the hot carcass and there was a small difference in dressing percentage. There was no difference between HE and LE steers in predicted retail beef yield. There were significant regressions of the three subcutaneous fat measurements, eye-muscle area and dressing percentage on mid-parent $EBV_{RFI,}$ providing evidence for genetic associations.

Reduced fatness accompanying selection for low RFI might be expected from the small but significant genetic correlations reported at the end of postweaning tests (Arthur *et al.* 2001a). Phenotypic correlations for the scanned and carcass measurements with RFI in the feedlot were not significant (P>0.05) indicating that these measurements of body composition were not associated with variation in RFI in this experiment. Richardson *et al.* (2001) found that variation in body composition explained only a very small portion of variation in RFI in beef steers.

Selection for low RFI produced steers that ate less per unit gain, with no adverse effects on growth and retail beef yield. Feeding low-RFI steers for slaughter should therefore be more profitable than feeding high-RFI steers. The genetic correlations of postweaning RFI with feedlot RFI and FCR are at present unknown but the regressions reported above indicate that both will be non-zero and positive. The genetic associations of RFI with subcutaneous fatness, eye-muscle area and dressing percentage suggest these traits should be monitored in association with on-going selection for RFI.

Table 1. Feedlot performance and carcass charcteristics of steer progeny from parents selected for low postweaning residual feed intake (RFI: high efficiency) or high RFI (low efficiency), and regression coefficients with mid-parent EBV for postweaning RFI

	Selection line[A]			Regression on parental EBV_{RFI}
	High efficiency	Low efficiency	P	
Feedlot performance				
Number of animals	144	165		
Start of test weight, kg	480 ± 9	490 ± 9		-7.5 ± 7.4
Average daily gain, kg/day	1.53 ± 0.03	1.49 ± 0.02		-0.09 ± 0.05*
End of test weight, kg	586 ±10	593 ± 10		-14 ± 9
Daily feed intake, kg DM/day[A]	12.3 ± 0.2	12.5 ± 0.1		0.04 ± 0.26
Feed conversion ratio, kg/kg[A]	7.6 ± 0.2	8.2 ± 0.2	†	0.59 ± 0.33†
Residual feed intake, kg DM/day[A]	-0.12 ± 0.08	0.10 ± 0.07	*	0.42 ± 0.16*
Preslaughter fat depth over ribs, mm	10.2 ± 0.3	11.6 ± 0.3	*	1.8 ± 0.5*
Preslaughter fat depth over rump, mm	13.1 ± 0.4	14.8 ± 0.4	*	2.4 ± 0.7*
Preslaughter eye-muscle area, cm^2	66.9 ± 0.9	70.6 ± 0.9	*	3.6 ± 1.0*
Carcass				
Hot carcass weight, kg	306 ± 6	314 ± 6		-1.1 ± 5.0
Dressing percentage	52.1 ± 0.3	52.9 ± 0.2	*	1.3 ± 0.5*
Rump fat depth on hot carcass, mm	14.9 ± 0.5	16.5 ± 0.5	*	1.5 ± 0.7*
Predicted retail beef yield, %	67.5 ± 0.3	67.3 ± 0.2		-.27 ± 0.51

P: Probability values: †<0.1; *<0.05. Values are means and regression coefficients ±standard error for Angus and Angus-crossbred steers born in 1987, 1998 and 1999.
[A]Individual feed intakes were recorded on 102 high and 130 low efficiency line steers.

ACKNOWLEDGEMENTS

This work was funded by NSW Agriculture, Meat and Livestock Australia and the CRC for Cattle and Beef Quality. The assistance by R. Woodgate, R. Geddes, M. Wolcott, C. Smith, P. Reynolds, A. Blakely and NSW Agriculture staff at Trangie and Glen Innes is gratefully acknowledged.

REFERENCES

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

Arthur, P. F., Archer, J.A., Herd, R.M. and Melville, G.J. (2001b) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **14**:135.

Reverter, A., Johnston, D.J., Stephens, E. and Perry, D. (1999) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **13**:381.

Reverter, A., Johnston, D.J., Graser, H.-U. and Perry, D. (2001) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **14**:469.

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.