WHEN PASTURES LIMIT GROWTH RATE OF STEERS THOSE BRED FOR LOW RESIDUAL FEED INTAKE GROW FASTER

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SUMMARY
Growth on pasture and body composition before feedlot entry was measured on Angus and Angus-cross steers born over five years from parents selected for low postweaning residual feed intake (RFI, high efficiency, 271 steers from 31 sires) or selected for high RFI (low efficiency, 250 steers from 28 sires), and 40 steers from an intermediate unselected line created in the last 2 years. After 1.5 generations of divergent selection, least-squares means for initial weight for low-RFI line and high-RFI line steers did not differ (252 *v* 250kg; P>0.05), but the low-RFI line steers grew 4.4% faster (P<0.05) than high-RFI line steers (0.66 *v* 0.64kg/day) to be 2.1% heavier (P=0.07) at the end of backgrounding (418 *v* 409kg). At that time the low-RFI line steers had less (P<0.05) subcutaneous fat over the rib and rump (3.2 *v* 4.2mm; 4.4 *v* 5.3 mm) and a trend toward slightly smaller eye-muscle area (52.1 *v* 52.6cm^2; P=0.06). Significant (P<0.05) regressions for daily growth rate, final weight and the two fat depth measurements, with midparent estimated breeding value for RFI, provided further evidence for genetic associations with postweaning RFI.
Keywords: beef cattle, growth, selection, feed efficiency, body composition

INTRODUCTION
Residual (or net) feed intake (RFI) has been proposed as a measure of feed efficiency in beef cattle that is independent of weight and average daily gain. It is calculated as the amount of feed consumed net of that predicted based on weight and gain. Cattle with low RFI eat less than expected for their weight 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*. 2001b) and to respond to selection (Arthur *et al*. 2001a). Since 2002, estimated breeding values for RFI (EBV_{RFI}) have been published for bulls of the Australian Angus and Hereford breeds. Industry guidelines for testing young bulls for RFI require that these bulls and/or their relatives have *ad libitum* access to a diet of sufficient energy density that individual differences in appetite and growth potential can be expressed. However, the steer and heifer progeny of bulls superior for RFI are usually reared on pastures that will frequently be restricted in both quantity and quality. The objective of this experiment was to investigate the effect of divergent selection for postweaning RFI on growth rate, final weight and body composition of steers during backgrounding on pasture prior to feedlot entry.

MATERIALS AND METHODS
Cattle breeding. Cattle breeding and postweaning tests for RFI were undertaken at the Agricultural Research Centre, Trangie, NSW, Australia. RFI tests were conducted each Autumn from 1993 for Trangie-bred Angus bulls and heifers (approximately 100 of each sex per test), with the heifers

entering a Spring calving herd. Angus, Shorthorn, Hereford and Poll Hereford heifers purchased from industry herds were tested in Spring from 1994 (approximately 200 per test), with the heifers entering an Autumn calving herd. Details of the postweaning test procedure are given in Arthur *et al*. (2001b). Establishment of divergent selection lines for low-RFI (high efficiency) and high-RFI (low efficiency) is described by Arthur *et al*. (2001a). In brief, from 1994 to 1997 the top and bottom 3 to 5 ranked Angus bulls tested each year were selected and mated to the top 50% and bottom 50%, respectively, of heifers ranked for RFI in each test. From 1996 to 1999 bull and heifer progeny from this first generation of selection and born in the Trangie Angus Spring calving herd were tested for postweaning RFI and selected within their selection lines to produce a second generation. A few progeny from a third generation of divergent selection were bred. Progeny born from industry heifers in the Autumn calving herd were the result of a single generation of divergent selection and were not used for further selection. Some Trangie Angus heifers and cows that failed to get pregnant in the Spring calving herd were rejoined in the Autumn calving herd and, together with the use of second and third generation selected bulls, meant some calves born in the Autumn calving herd were the result of greater than a one generation of selection. Divergent selection was relaxed after 1998, matings in 1999 and 2000 were within selection lines, with some bulls and cows from both lines being chosen for matings to create an intermediate unselected line. Five cohorts of calves born in 1997, 1998, 1999, 2000 and 2001 were used in this experiment. Those born 1997 to 1999 came from the Autumn calving herd and were predominantly the progeny of industry heifers. Those born in 2000 and 2001 came from the Spring calving herd and were progeny of Trangie Angus heifers and cows.

Management and measurements. Male progeny were castrated at three months of age and weaned at about seven months of age. Between 1 and 5 weeks after weaning, the steers were trucked to a research station on the Northern Tablelands of NSW to be backgrounded on pasture prior to feedlot entry. The steers were grown on pasture until they attained liveweight appropriate for feedlot entry and finishing for a range of markets. At that time the steers were measured for depth of subcutaneous fat at the $12/13^{th}$ rib (ribfat) and over the rump (P8 site; rumpfat), and area of the eye-muscle at the $12/13^{th}$ rib, by ultrasound scanning.

Data analysis. The data set contained 271 low-RFI line steers and 250 high-RFI line steers, representing an average of 1.5 generations of divergent selection, and 40 unselected steers. The steers were the progeny of 31 low-RFI sires and 28 high-RFI sires used in the respective selection lines. The unselected line steers were the progeny of 21 sires. Average daily gain in weight (ADG) from first weighing on the backgrounding property to end of backgrounding was calculated as the difference between final and initial weight, divided by the number of days. Two sets of analyses were performed. The first compared the High and Low RFI lines using general linear models (GLM). Included in the models were the fixed effects of birth year, breed, age of dam and selection line, and generations of selection and calf age (at start or end of backgrounding) as a covariate, plus all 2-way interactions, and sire within line as a random effect. Preliminary analyses showed that the interactions were not significant ($P>0.05$) and they were dropped. Selection line differences were tested against the sire-within-line mean squares. Least-squares means for the 2 selection lines at 1.5 generations of selection were calculated. Since the management of steers from the divergent selection lines was identical, any observed differences in mean performance of the lines could be attributed to genetic selection. The second set of analyses utilised data on steers from all 3 lines in regressions of each trait measured on the mid-value of the sire and dam EBV_{RFI}. These EBVs were calculated by the authors

for each parent based on its performance in postweaning RFI tests conducted at the Trangie Agricultural Research Centre. Sire EBV_{RFI} ranged from -0.92 to +1.32kg/day and dam EBV_{RFI} from -0.76 to +0.97kg/day. Regression coefficients were determined within a GLM that included birth year, breed, age of dam, age of steer and midparent EBV_{RFI}. Regression coefficients significantly different from zero were presumed to provide evidence for genetic association. Steer daily gain on pasture varied between years due to differences in backgrounding location, climatic conditions and other factors. Mean steer growth rates from start to end of backgrounding, as a measure of level of nutrition, were 0.69, 0.62, 0.52, 0.88 and 0.55kg/day for years 1 to 5. The nutritional regimes encountered by the steers were quantified by the mean growth rate, then possible interactions between selection lines with level of nutrition, for ADG, final weight and body composition traits, were tested within a GLM model containing breed, dam age, calf age and selection line as fixed effects, and level of nutrition as a continuous variable.

RESULTS AND DISCUSSION

As might be expected there were differences ($P<0.05$) between years in all traits measured at the start, during and at the end of backgrounding. There were no significant ($P>0.05$) interactions with year implying that the relative differences between the selection lines were expressed across the years of the experiment. When mean daily gain for a cohort was used as a measure of level of nutrition, there were no significant ($P>0.05$) interactions with selection line for ADG, final weight, ribfat or rumpfat, confirming the differences between the 2 selection lines in these traits persisted across the range in nutrition encountered during backgrounding in this experiment.

Table 1. Least-squares means (±se) for growth on pasture and body composition for steers divergently selected for low postweaning RFI (high efficiency) or high RFI (low efficiency), and regression coefficients with midparent EBV_{RFI}

	Selection line			Regression on
	Low RFI	High RFI	P	parental EBV_{RFI}
Midparent EBV_{RFI}	-0.31 ±0.01	0.43 ±0.01		
Number of steers	271	250		561
Initial liveweight, kg	252 ±2	250 ±3		-3.3 ±2.6
Average daily gain, kg/day	0.66 ±0.01	0.64 ±0.01	*	-0.038 ±0.013*
Final liveweight, kg	418 ±3	409 ±3	†	-11.5 ±3.5*
Fat depth over ribs, mm	3.2 ±0.1	4.2 ±0.1	*	1.1 ±0.1*
Fat depth over rump, mm	4.4 ±0.2	5.3 ±0.2	*	1.1 ±0.2*
Eye-muscle area, cm^2	52.1 ±0.5	52.6 ±0.5	†	0.7 ±0.5

* denotes significant ($P<0.05$) selection lines differences, or regression coefficient. † denotes $P<0.1$.

There was no difference between steers from the low-RFI and high-RFI lines in initial weight nor was this weight associated with genetic variation in postweaning RFI (as measured as midparent EBV_{RFI}; Table 1). Steers from the low-RFI line grew faster over the backgrounding period than steers from the high RFI-line and attained a heavier final weight ($P=0.07$). There were negative associations between ADG and final weight with genetic variation in postweaning RFI, meaning that progeny of parents with genes for lower RFI grew faster and were heavier at the end of the backgrounding period. Steers

from the low-RFI line had less subcutaneous fat at the 12/13th rib and rump sites than did steers from the high-RFI line at the end of the backgrounding, and both had a significant positive association with midparent EBV_{RFI}, providing evidence for genetic associations with postweaning RFI. There was a trend (P=0.06) toward difference in cross-sectional area of eye-muscle but no statistically-significant association with midparent EBV_{RFI}.

Across the 5 years of this experiment, and following 1.5 generations of divergent selection, the steers from parents with genes for low-RFI grew 4.4% faster from start of backgrounding to be 8.5kg (2.1%) heavier at the end of backgrounding, and differed by just over 1mm less in fat depth at the rib and rump. The calculated difference for steer progeny of parents differing in EBV_{RFI} by 1kg/day was an increase of 0.038kg/day and 11.5kg in ADG and final weight, respectively, and a corresponding 1.1mm decrease in both rib and rump fat depth. These responses in ADG and fat depths persisted during consequent growth in the feedlot by the first 3 cohorts of steers in this experiment, reported by Herd *et al.* (2003). These results may represent expression of the negative genetic correlation between 400day-direct weight, and weak positive genetic correlation for ribfat (but not with rumpfat and eye-muscle area) in yearling bulls and heifers at the end of RFI testing, with postweaning RFI reported by Arthur *et al.* (2001b).

Following divergent selection for postweaning RFI favourable changes have been demonstrated in feed intake, RFI and feed conversion ratio in bulls and heifers during postweaning RFI testing, with no change in weight or growth rate (Arthur *et al.* 2001a). Published results from three small experiments show that improvement in feed efficiency at pasture can be expected but follows predominantly from improvement in ADG, rather than by reduction in feed intake (Herd *et al.* 2004). These studies, together with results from this experiment, suggest that genes favoured by selection for low postweaning RFI appear to be accompanied by a reduction in feed intake, with little effect of growth over RFI-tests where nutrition is abundant, but on pasture where the quantity and quality of feed is typically lower, an improvement in growth rate can be expected with little change in feed intake. Genetic associations of postweaning RFI with subcutaneous fatness were expressed in steers on pasture and should be monitored to ensure compliance with market specifications.

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