

SELECTION FOR RESIDUAL FEED INTAKE IMPROVES FEED CONVERSION IN STEERS ON PASTURE

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SUMMARY

The aim of this experiment was to determine whether divergent selection of parents on post-weaning residual feed intake (RFI) was accompanied by differences in feed efficiency in steer progeny on pasture. The Angus steers were the progeny of approximately one generation of divergent selection for low RFI (high efficiency; HE) or high RFI (low efficiency; LE). Pasture intake by 22 HE-line and 31 LE-line steers was measured during Spring using the alkane technique. The two groups of steers were of similar age (mean 15.5 months) at the start of the pasture-intake measurement period. Comparison of alkane profiles of pasture species and in faeces indicated that the steers were consuming predominately perennial ryegrass (*Lolium perenne*) and some tall fescue (*Festuca arundinacea*), with a trend ($P < 0.1$) for the steer progeny of HE parents to have a higher proportion of ryegrass in their diet. Digestibility of dry matter (DM) in the diet consumed was not associated with genetic variation in RFI ($P > 0.1$). Steers from the HE-line tended to grow faster than steers from the LE-line (0.50 v 0.42 kg/day; $P < 0.1$), consistent with the negative regression coefficient for ADG with mid-parent Estimated Breeding Value (EBV) for RFI (-0.11 ; $P < 0.05$). The difference in daily feed intake between the selection lines was not significant (3.04 v 3.23 kg DM/day; $P > 0.1$), nor was the regression coefficient with mid-parent EBV for RFI ($P > 0.1$). Feed conversion ratio (FCR) was 6.36 ± 0.35 (se) for HE-line steers and 8.51 ± 0.74 for LE-line steers but this difference was only significant at $P = 0.1$. The positive regression coefficient for FCR with mid-parent EBV for RFI (2.9 ; $P < 0.1$) provided further evidence for low RFI in the parents being genetically associated with superior efficiency of feed conversion on pasture of the steer progeny.

Keywords: steers, residual feed intake, selection, pasture intake, alkanes

INTRODUCTION

Feed is a major cost of beef production. Residual feed intake (RFI) measures variation in feed intake that is independent of body size and growth rate. It is calculated as the amount of feed consumed by an animal less its expected requirements for maintenance and production. Animals considered to be the more efficient are those that eat less than expected for their size and growth rate, and have lower RFI. Post-weaning results from British breed cattle fed a medium quality ration have demonstrated that variation in RFI exists, and that the trait is moderately heritable (Arthur *et al.* 2001). Selection against post-weaning RFI has been shown to improve the feed efficiency of bull and heifer progeny in post-weaning tests for RFI (Herd *et al.* 1997) and of steer progeny when fed in a feedlot (Richardson *et al.* 1998). There is also evidence for a favourable phenotypic association between post-weaning RFI and cow/calf efficiency on pasture (Herd *et al.* 1998). The aim of this experiment was to determine whether divergent selection of parents on post-weaning RFI was accompanied by differences in feed efficiency in steer progeny on pasture.

MATERIALS AND METHODS

Experimental animals

The Angus steers were born in July/August 1997 at the NSW Agriculture Research Centre, Trangie NSW, of high efficiency (HE) or low efficiency (LE) parents selected on postweaning RFI (details of selection procedure described in Herd *et al.* 1997). The steers represented the result of approximately one generation of divergent selection for RFI. The steers were weaned in March 1998 and then trucked to the NSW Agriculture Research Station "Shannonvale", near Glen Innes in northern NSW. They were grown on improved pastures. Pasture intake by 23 HE-line and 31 LE-line steers was measured during December (Spring) 1998 using the alkane technique previously described by Herd *et*

al. (1998). The two groups of steers were of similar age (mean 15.5 months) at the start of the pasture-intake measurement period.

Procedures

The steers were weighed off pasture (no fasting) 19 days before dosing with synthetic alkanes, then again on the day of dosing (day 0), 14 days later (day 14) and 65 days after dosing. Average daily gain in LW (ADG) by each steer over this period was calculated by linear regression of its LW on date of weighing. Mid-test LW was taken as the average of LW on day 0 and day 14. On day 0 faecal samples were taken from eight steers to determine natural levels of alkanes in faeces. Each steer was dosed with an intra-ruminal controlled-release device (CRD). The CRDs were manufactured by K. Ellis (CSIRO, Chiswick, NSW; batch number 950118-2) to contain 4 g of each of C32 and C36 and were expected to release 200mg/day of each alkane over 20 days. Pasture species were sampled for subsequent determination of their alkane content. Samples were cut to be representative of the plant parts observed to be eaten by the steers. On days 7, 9, 11 and 14 faecal samples were taken from all the steers. Ten steers were sampled again on days 18, 21 and 22 for the purpose of using the alkane profiles in their faeces to confirm expiration of the CRDs. Faecal samples were taken mid-morning. Samples of pasture plants and faeces were oven-dried (70°C), ground (1mm sieve) and analysed for their alkane content using previously described methods (Hegarty *et al.* 2000).

Preliminary examination of the alkane present in faeces found one HE-line steer had faecal concentrations of C36 that never exceeded 11 mg/kg DM which indicated that either the steer had spat up its CRD or that the CRD failed to release alkane. Results for this steer were not used. The profile of alkanes in faeces (Figure 1) showed that levels of C32 and C36 had returned to natural levels by day 18 indicating that the CRDs had expired earlier than the expected 20 days. By day 14, 10 of the 53 steers (19%) had faecal C36 concentrations of less than 100 mg/kg DM suggesting that their alkane cores had begun expiring the previous day. It was therefore assumed that the CRDs had released alkane over only 13 days and the expected daily dose rate for each of C32 and C36 was revised upward to 308 mg/day. Pasture intake by steers in this experiment was calculated based on faecal samples collected on days 7, 9 and 11 after dosing with CRDs.

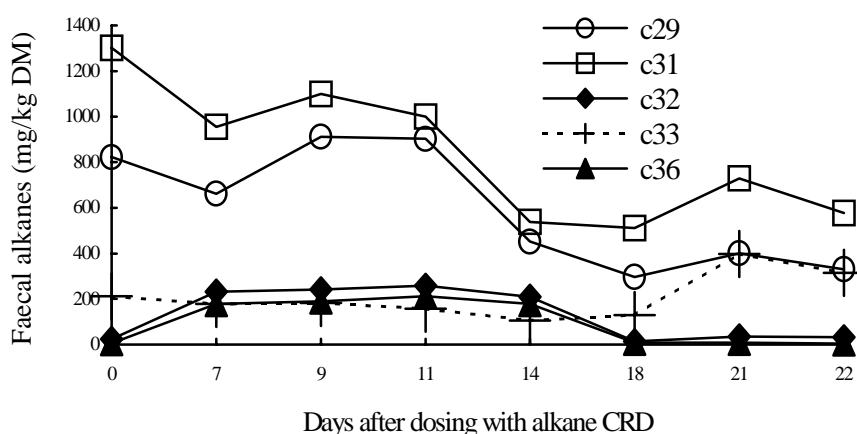


Figure 1. Alkane profiles of faeces sampled at time of dosing with synthetic C32 and C36 alkanes contained in controlled-release intra-ruminal devices (Day 0) and on days subsequently

The diet of each steer on days 7, 9 and 11 was computed by comparing the profile of alkanes in faeces with that of the pasture species considered to be eaten by the steers. For this purpose only alkanes naturally present at concentrations above 10 mg/kg dry matter (DM) in pasture were used in calculations. The pasture species considered to be on offer to the steers are given in Table 1. Rat's tail fescue and soft brome had very similar alkane profiles and were considered together as "annual grasses". Diet estimation required upward adjustment of alkane concentrations in faeces to compensate for their imperfect recovery in faeces. Recovery values used were the means of published values for naturally occurring alkanes in cattle faeces summarised by Lee (2001). They were for C27 0.64, C28 0.70, C29 0.74, C30 0.75, C31 0.78 and C33 0.82. Diet composition was calculated by non-negative least-squares regression. For each steer, the concentration of each alkane in faeces was regressed against the concentration that alkane in each pasture species and the regression coefficient

for each species restricted to being greater than or equal to zero. The regression coefficients are the weight of DM for each pasture species eaten to produce the alkanes contained in one kilogram of faeces DM: their sum is the weight of DM consumed to produce one kilogram of faeces DM. Digestibility of the diet (DMD_{diet}) was calculated as (DM_{consumed} - 1)/DM_{consumed}. Means over days 7, 9 and 11 for diet composition and DMD_{diet} were then calculated for each steer.

Table 1. Alkane profiles of major pasture species available to be eaten by the steers

Pasture species	Alkane content (mg/kg dry matter)							
	C27	C28	C29	C30	C31	C32	C33	C36
Tall fescue (<i>Festuca arundinacea</i>)	75	8	331	25	520	11	117	0
Perennial ryegrass (<i>Lolium perenne</i>)	165	27	490	31	578	9	39	0
Sorrel (<i>Rumex acetosella</i>)	200	38	832	15	138	2	30	3
Brome (<i>Bromus molliformis</i>)	68	21	477	19	353	9	59	0
Rat's tail fescue (<i>Vulpia myuros</i>)	109	18	441	30	264	10	27	0

Intake of dry matter and faecal output by each steer on day 7, 9 and 11 were calculated using published formula (Herd *et al.* 1998), based on the C31:C32 ratio and C36 levels respectively, and after adjusting faecal alkane concentrations for assumed differences in recovery. The recovery value used for C32 was 95%; being midway between the recovery values of 94% and 96% for C32 previously reported in other studies using similar CRDs (Herd *et al.* 1996; Dicker *et al.* 1996). It is apparent from Figure 1 that the recovery in faeces of dosed C36 was lower than for dosed C32 as both were released from the CRD in equal amounts. Lower recovery of C36 compared to C32 from these CRDs has been previously observed (Herd *et al.* 1996; Herd *et al.* 2002). A recovery value for C36 of 82% was adopted because it produced an adjusted concentration of C36 in faeces over days 7 to 11 that was equal to the difference between C32 and C36 in faeces on days 0, 18, 21 and 22 when synthetic alkanes were not present. Average daily feed DM intake (ADFI) and faecal output (ADFO) for days 7, 9 and 11 were calculated for each steer. Digestibility was also determined from the difference between feed intake and faecal output (DMD_{FI}). Means over days 7, 9 and 11 for ADFI, ADFO and DMD_{FI} were then calculated for each steer. Feed conversion ratio (FCR) was calculated as ADFI/ADG.

Statistical analyses

Differences in performance between HE-line and LE-line steers were analysed in a mixed model analysis of variance with selection line fitted as a fixed effect and sire-within-line as a random effect. Selection line differences were tested against the sire-within-line mean squares. The low number of animals in this experiment meant that this approach lacked the power to detect all but large differences between selection lines. An alternate approach was used to detect whether there was evidence for a genetic association of parental RFI with variation in traits measured on their progeny. Estimated Breeding Values (EBVs) for RFI for the sires and dams of steers in this experiment had been previously calculated using a best linear unbiased prediction animal model and genetic parameter estimates from progeny tests for postweaning RFI reported by Arthur *et al.* (2001). Mid-parent EBVs for RFI ranged from -0.52 to +0.61 kg/day (mean 0.08, sd 0.34 kg/day). Statistically significant regression coefficients were presumed evidence for a genetic association.

RESULTS AND DISCUSSION

Alkane profiles in faeces indicated that steers from the RFI selection lines were consuming a similar diet of predominately perennial ryegrass and some tall fescue (Table 2). The slopes of the regressions for proportion of ryegrass and fescue in diet against mid-parent EBV for RFI were negative and positive, respectively (P<0.1). This meant that there was trend for the steer progeny of parents with EBVs for low RFI to have a higher proportion of ryegrass, and less fescue, in their diet than progeny from parents with EBVs for high RFI, even though the magnitude of the differences between the means for the selection lines was not statistically significant. Digestibility of DM calculated using the patterns of naturally-occurring alkanes in pasture and faeces (DMD_{diet}), and from the difference between ADFI and ADFO measured using dosed synthetic alkanes (DMD_{fi}), was very similar: about

56% and 54% respectively, and gives some credence to the recovery values used in the calculations. There was no evidence that the digestibility of the DM in the diet eaten differed between the selection line progeny groups or varied in association with mid-parent EBV for RFI.

Table 2. Diet selected, growth, feed intake and feed efficiency of Angus steer progeny of parents selected for low RFI (high efficiency) or high RFI (low efficiency). Results are presented as selection line means \pm se and as regressions coefficients with mid-parent EBV for RFI

Trait	Low RFI	High RFI	Signif.	Regression
Number of steers	22	31		
Diet DM digestibility (DMD _{diet} ; %)	55.4 \pm 1.0	56.0 \pm 0.5	ns	0.01 ^{ns}
Ryegrass in diet (%)	83.5 \pm 2.0	78.0 \pm 1.8	ns	-0.07 [†]
Fescue in diet (%)	16.5 \pm 2.0	22.0 \pm 1.8	ns	0.07 [†]
Average daily gain (kg/day)	0.496 \pm 0.023	0.415 \pm 0.019	†	-0.11*
Mid-period liveweight (kg)	387 \pm 7	380 \pm 6	ns	-3.5 ^{ns}
Average daily feed intake (kg DM/day)	3.04 \pm 0.11	3.23 \pm 0.14	ns	0.28 ^{ns}
Feed conversion ratio	6.36 \pm 0.35	8.51 \pm 0.74	ns	2.94 [†]

ns P>0.1; † P<0.1; * P<0.05.

There was no difference between the selection lines in LW, nor evidence of association with parental EBV for RFI. Steers from the low RFI selection line tended to grow faster than those from the high RFI line (Table 2), consistent with the negative regression coefficient for ADG with mid-parent EBV for RFI. The difference in ADFI between the selection lines was not significant nor was the regression coefficient with mid-parent EBV for RFI. Feed intake relative to growth (FCR) appeared to be two-units lower (better) in the low RFI selection line steers but this difference was only significant at P=0.1. The positive regression coefficient for FCR with mid-parent EBV for RFI provided further evidence for low RFI in the parents being genetically associated with superior efficiency of feed conversion on pasture of the steer progeny.

Selection against post-weaning RFI has been shown to improve the feed efficiency of progeny in post-weaning tests for RFI (Herd *et al.* 1997) and when fed in a feedlot (Richardson *et al.* 1998). There is also evidence for a favourable phenotypic association between post-weaning RFI and cow/calf efficiency on pasture (Herd *et al.* 1998). This experiment has demonstrated a favourable response in growth and feed efficiency of steers on pasture following selection of their parents for low post-weaning RFI. Together these results suggest that it is possible to genetically reduce the amount of feed required by beef cattle without compromise to production (ie. to size and growth rate): an improvement in the profitability of beef production should follow.

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