STEER GROWTH AND FEED EFFICIENCY ON PASTURE ARE FAVOURABLY ASSOCIATED WITH GENETIC VARIATION IN SIRE NET FEED INTAKE

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SUMMARY

In 1995 and 1997, growth, feed intake and feed efficiency were measured from spring to summer on Angus and Hereford weaner steer progeny of sires with known estimated breeding values for net feed intake (EBV_{NFI}). Each year, the steers were grown on 3 different pasture systems and pasture intakes were measured twice using the alkane technique. Final data analysed consisted of 77 and 50 records for steers from Years 1 and 2, respectively. They were the progeny of 42 sires (23 Hereford; 19 Angus), 3 sires having progeny in both years. Significant ($P<0.05$) regression coefficients for steer performance traits against sire EBV_{NFI} indicated that genetic variation in NFI was associated with phenotypic variation in steer performance on pasture. Initial and final liveweight of the steers, and feed intake, were not associated with variation in sire EBV_{NFI} ($P>0.05$). However, daily gain by the steers tended ($P<0.1$) toward a favourable negative association with sire EBV_{NFI} (-0.16 ± 0.10 (s.e.) kg/day per kg EBV_{NFI}). Net feed intake and feed conversion ratio (FCR) had positive associations with sire EBV_{NFI} (NFI, 2.2 ± 1.2 kg/day per kg EBV_{NFI}; FCR, 4.2 ± 2.0 kg/kg per kg EBV_{NFI}; $P<0.05$). The results show that 1 kg/day lower EBV_{NFI} of a sire produced steer progeny that grew 19% faster, with no increase in feed eaten, had a 26% lower NFI, and a 41% better FCR.

Keywords: cattle, feed efficiency, net feed intake, pasture

INTRODUCTION

Net feed intake (NFI, also called residual feed intake) is a measure of feed efficiency that is independent of liveweight and growth rate. It is calculated as the difference between actual feed intake and expected feed intake for maintenance and growth. Animals that eat less than expected have a negative NFI and are more efficient. Selecting sires genetically superior for NFI has the potential to produce steer and heifer progeny that are more feed efficient, thereby reducing the feed cost of beef production.

Industry guidelines for testing young bulls for NFI require that the animals have *ad libitum* access to a diet of sufficient energy density that individual differences in appetite and growth potential can be expressed. Genetic merit for NFI is expressed as an estimated breeding value (EBV_{NFI}) to be used together with EBV for other production traits in making selection decisions about potential sires. Since 2002, EBV_{NFI} of animals have been published for bulls of the Australian Angus and Hereford breeds.

The steer and heifer progeny of bulls superior for NFI spend most of their lives on pastures that are frequently of lower availability and/or quality than the test diets upon which their sires were evaluated. The objective of this experiment was to investigate whether growth, NFI and feed conversion ratio (FCR) of steers on pasture were favourably associated with genetic variation in NFI of their sires.

MATERIALS AND METHODS

Cattle and their management

The steers were bred by private cooperators and, after weaning, were transferred to the NSW Agriculture Research and Advisory Station, Glen Innes, in the Northern Tablelands of NSW. Steers received in autumn 1995 and autumn 1997 were used. They were grown on temperate perennial pasture systems to approximately 400 kg liveweight, before finishing on pasture or in the feedlot.

Ninty Angus and 82 Hereford steers that had been assigned to feedlot finishing for calculation of sires EBV_{NFI} were selected for measurement of pasture intake.

Growth of sub-groups each year was manipulated to provide a range of growth paths prior to finishing for slaughter. The pasture systems are described by Dicker *et al*. (2001). Briefly, in July 1995 (Year 1) the steers were allocated to 1 of 3 nutrition treatments (Figure 1a): 1) sown temperate perennial pasture only, 2) perennial pasture plus 26% crude protein pellet supplement (1.5 kg offered/head/day), and 3) perennial pasture plus ryegrass forage crop. Cattle remained on these treatments to early November 1995 after which differences in growth path were maintained with different levels of pasture biomass and green content. In Year 2 (Figure 1b), the weaners had different growth paths created from December 1997 by allocating steers to the 3 nutrition treatments used in 1995. Steers on treatment 2 were offered 1.4 kg/head/day pelleted protein concentrate. Treatments ended in January 1998 when even greater divergence in growth paths were created using different levels of pasture biomass and green content.

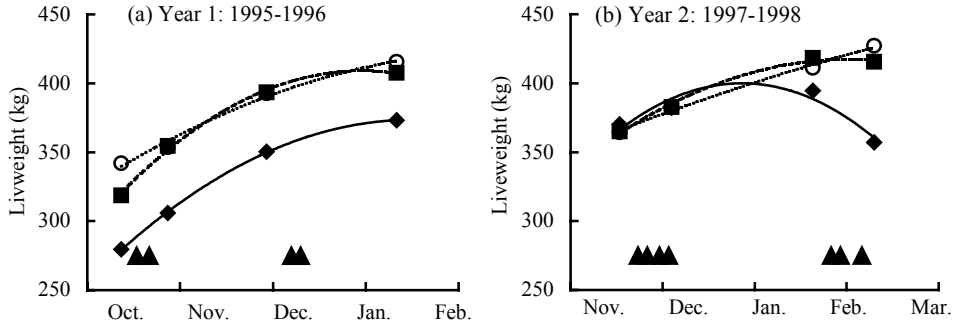

Figure 1. Liveweight of steers in (a) Year 1 and (b) Year 2 and days (=) on which pasture intake was estimated. Pasture systems are pasture only (◆), pasture plus protein pellet supplement in spring (■) and pasture plus fodder crop in spring (∗).

Measurements

Pasture intake and animal growth were measured from spring into summer in both years. The measurement periods were 18 October 1995 to 15 January 1996 (89 days) and 2 December 1997 to 23 February 1998 (83 days). Diet composition and pasture intake by individuals were measured using the alkane technique (Herd *et al.* 2002) during late spring when the cattle were on the nutrition treatments, and again in summer when on pasture only. The synthetic alkanes, C_{32} and C_{36}, were administered by intraruminal controlled-release devices (CRD; Captec Limited, New Zealand). In Year 1, the cattle were dosed on 18 October 1995 (day 0), and faecal samples were collected from the rectum of all the cattle on days 5, 9 and 13 after dosing. To determine levels of alkanes naturally present in faeces and to detect the day that excretion of synthetic alkanes ceased, faecal samples were taken from a subset (6/nutrition treatment) on days 0, 14, 15, 16, 17, 18 and 19. The cattle were again dosed on 7 December 1995, and faeces sampled on days 5, 8 and 12 for all cattle, and on days 0, 21 and 26 for a subset of cattle. In Year 2, the cattle were dosed on 2 December 1997, and faecal samples were collected from all cattle on days 6, 9 and 13 after dosing, and on days 0, 16 and 17 from a subset of cattle. The cattle were dosed again on 3 February 1998 and faecal samples taken from all cattle on days 6, 9 and 16, and days 0 and 20 from a subset. Once during each faecal collection period, pasture plants considered to have been grazed by the cattle were sampled for subsequent determination of alkane content. Pasture and faecal samples were dried at 70°C, ground and sub-sampled for determination of organic matter (OM) and alkane content using methods described by Lee (2001). Unfasted liveweight (LW) was taken mid-morning on the day of dosing, and when the last faecal sample was collected.

In spring of Year 1, individual intakes of the pellet supplement were measured on day 12 after dosing with the alkane CRD, using lithium as a marker. The increase in lithium concentration in plasma of cattle 24 h after ingestion of labelled feed was linearly related to the amount consumed (Dixon *et al*. 2003). Pellets were prepared by spraying 180 kg of pellets with 19.44 L of lithium solution (5 g $LiSO_4$/L). The pellets were fed mid-morning at the rate of 1.5 kg/head in feed troughs that allowed for 45 cm of space per animal. The cattle were observed to ensure all approached the troughs. Blood samples were taken 24 h later (K-EDTA anticoagulant), chilled, centrifuged within 3 h and the plasma

frozen. Blood from 6 other steers who had not received lithium-labelled pellets was also taken to determine natural levels present in plasma. Lithium was extracted using 2N HCl from samples of ground unlabelled and labelled supplement, then this extract and the plasma samples diluted with 6% TCA, and the lithium concentration of the supernatant determined using an inductively coupled plasma mass spectrometer (Queensland Department of Primary Industries, Brisbane).

Calculations

Pasture intake and faecal output. If the C_{36} concentration in faeces of an animal failed to stabilise above 100 mg/kg OM from day 5 or 6 after dosing, it was assumed that the CRD in that animal had malfunctioned. Results for 8 steers in October 1995, and 6 steers in December 1995, were discarded for this reason, leaving 77 steers with valid feed intake records for Year 1. The nominal daily alkane release rate of the CRDs was 345 mg of each of C_{32} and C_{36} for at least 17 days in Year 1, and 230 mg/day of C_{32} and 220 mg/day of C_{36} for at least 17 days in Year 2. In October and December of Year 1, 24 and 21% of steers had low concentrations of C_{36} in faeces by day 13 after dosing. This may indicate that their CRDs had expired early, and if so, the dose rate used in calculations was lower than the actual dose rate and resulted in underestimation of actual pasture intake and faecal output. Therefore, only faecal samples from day 5 and 8 or 9 were used in calculations. No such problem was apparent in Year 2, and faecal samples from days 6 to 16 were used. The concentration of C_{36} in faeces of steers on treatment 1 in February 1998 did not plateau. These animals were losing weight, and feed intakes were presumably low, and may have been declining over the sampling period. Under these conditions performance of CRDs can deviate from expectation (K. Ellis, *pers. comm*.). Results for these steers were not used, leaving 55 steers with valid feed intake records for Year 2. Diet composition, pasture intake from the ratio of C_{31}:C_{32} in faeces, faecal output from the concentration of C_{36} in faeces and digestibility of OM (DOM) were calculated day by day as described by Herd *et al.* (2002). They were then averaged within each of the 4 collection periods.

Supplement intake. Pellet intake was calculated by dividing the load of lithium within the body of each steer by the total lithium load consumed by all the steers, and then multiplying the total weight of pellets consumed by this fraction. Mean intake was 1.4 ± 1.3 (s.d.) kg OM/day (range: 0 to 5.1). It was assumed that this single estimate of pellet intake was representative of daily intake across the collection period and added to each animal's estimated pasture intake. In Year 2, pellet intake was taken to be 1.2 kg OM/head/day. The large range in pellet intake observed in Year 1, together with lack of additional estimates of pellet intake by individual animal in both years, may have contributed to error of an unknown magnitude in the feed intakes (pasture + pellets) used in calculating NFI.

Net feed intake. Feed intake in each period was multiplied by DOM to calculate DOM intake, which was then multiplied by 0.16 to calculate metabolisable energy (ME) intake (MJ/day; SCA 1990). This was divided by 10 to convert feed intake to kg of 10 MJ ME/kg DM/day, the same units as used for EBV_{NFI}. Feed intake each year was then calculated as the average for the spring and summer collection periods. Net feed intake was calculated as the residual from the regression of feed intake on average $LW^{0.75}$ (mean of 4 measurements) and ADG (final LW minus initial LW/length of test).

Data analysis

The EBV_{NFI} for sires were calculated separately for Angus and Hereford animals. The EBV_{NFI} for 2 sires that produced 5 steers used in Year 2 were not available and their records were not used. Records were available for 77 and 50 steers from Year 1 and 2, respectively, being the progeny of 42 sires (23 Hereford, 19 Angus), 3 having progeny in both years. The mean number of progeny per sire was 3.0 ± 1.7 (s.d.; range 1 to 9) and mean EBV_{NFI} of the sires was 0.00 ± 0.25 kg/day (range -0.77 to 0.46). Significant ($P<0.05$) regression coefficients for steer performance traits against sire EBV_{NFI} were taken as evidence that genetic variation in NFI was associated with phenotypic variation in steer performance on pasture. The regression coefficients were determined in a general linear model (GLM). The initial GLM model included the fixed effects of year, breed and pasture treatment, sire EBV_{NFI} as continuous variable nested within breed, and their interactions. The interactions were not significant ($P>0.05$) and were dropped from the final model.

RESULTS AND DISCUSSION

The LW of the steers at the start and end of the experiment were not associated with genetic variation in their sires EBV_{NFI} ($P>0.05$; Table 1). However, daily gain by the steers tended ($P<0.1$) toward a

favourable negative association with sire EBV_{NFI}, such that progeny of sires with lower EBV_{NFI} grew faster. The advantage in growth rate was about 0.16 kg/day for a 1 kg difference in sire EBV_{NFI}.

Table 1. Mean initial and final liveweight (LW), average daily gain (ADG), feed intake, net feed intake (NFI) and feed conversion ratio (FCR) of Angus and Hereford steers on pasture in Spring to Summer of 1995 and 1997, and regression coefficients with sire estimated breeding value for NFI (EBV_{NFI}). Results are for 127 steers from 42 sires.

	Mean (±s.e.)	Regression coefficient (±s.e.)	Change for 1 kg EBV_{NFI} as % of mean
Start LW (kg)	338 ± 5	-9 ± 25	2.6%
ADG (kg/day)	0.84 ± 0.02	-0.16 ± 0.10[†]	19%
Final LW (kg)	411 ± 4	-23 ± 26	5.5%
Feed intake (kg/day)[A]	8.5 ± 0.3	1.3 ± 1.1	15%
NFI (kg/day)	0.00 ± 0.27	2.2 ± 1.2*	26%[B]
FCR (kg intake/kg gain)	10.4 ± 0.4	4.2 ± 2.0*	41%

Probabilities for regression coefficient differing from zero: [†] <0.1; * <0.05.
[A] kg 10 MJ ME/dry matter. [B] As a % mean daily feed intake.

Feed intake by the steers was not (P>0.05) associated with sire EBV_{NFI} (Table 1). Growth of the steers was well below their genetic potential and is evidence that they were not able to eat to their genetic potential. It may have been that others factors, such as pasture characteristics, were regulating feed intake. Net feed intake by steers at pasture had a favourable positive association with sire EBV_{NFI} (P<0.05). Feed conversion ratio had a favourable positive association with EBV_{NFI} (P<0.05). A 1 kg difference in sire EBV_{NFI} was associated with no significant change in feed intake and an approximate 1 kg/day difference in NFI and 4-unit difference in FCR.

The significant regression coefficient for steer NFI on pasture with sire EBV_{NFI} is evidence for genetic correlation between the 2 traits. If the genetic correlation was unity, ie. NFI on pasture and on higher-energy test diets were the same trait, then the regression coefficient should be 0.5 (since half the genes comes from the sire). That it was greater than 0.5, although not significantly so, may be evidence for greater variation in NFI on pasture. The improvement in growth rate and FCR in steers of sires with lower EBV_{NFI} was evidence for other, favourable ways of expression of genes for superior NFI inherited from the sire.

This experiment demonstrated that improvement in growth rate, NFI and FCR by steers on pasture treatments similar to those in this experiment can be expected if sires with superior (lower) EBV_{NFI} are used in the breeding program. These results predict that a 1 kg/day lower EBV_{NFI} of a sire can produce steer progeny that grow 19% faster, with no increase in feed eaten, a 26% lower NFI, and a 41% better FCR. These results are in agreement with similar improvement in growth and FCR on pasture by steers from parents selected for low NFI reported by Herd *et al*. (2002). These experiments confirm that there are favourable underlying genetic relationships for NFI of breeding animals with growth and feed efficiency of steers on pastures typical of many regions of southern Australia. Using low EBV_{NFI} (high efficiency) sires can be expected to deliver considerable economic benefit to pasture-based beef production.

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