POTENTIAL TO REDUCE GREENHOUSE GAS EMISSIONS FROM BEEF PRODUCTION BY SELECTION FOR REDUCED RESIDUAL FEED INTAKE

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INTRODUCTION

The agricultural sector is a major source of greenhouse gas emissions worldwide. Within this sector, livestock are the main source of emissions. In Australia, livestock emissions contributes 67% of all agricultural emissions and 13% of total national emissions (NGGI, 2000). There are currently few practical strategies to reduce greenhouse gas emissions from livestock without reducing stock numbers. The urgent need for development of emission abatement strategies for livestock has already been identified (Hegarty, 2001).

In recent years there has been interest in genetic improvement of the efficiency of feed utilisation by cattle, using residual feed intake (RFI). The existence of genetic variation in beef cattle for RFI has been confirmed in a review by Archer *et al*. (1999). The progeny of animals selected against RFI are expected to have reduced feed intake but similar performance to unselected progeny. This paper uses feed intake and production data from cattle divergently selected for residual feed intake (RFI) to examine the potential to reduce greenhouse gas emissions by selection for reduced RFI.

MATERIALS AND METHODS

Animals and data. Starting with the 1993 born cohort, Angus weaners were tested each year for postweaning RFI at the Agricultural Research Centre, Trangie, Australia. After a 21-day adjustment period, these animals were fed *ad libitum* for 70 days a pelleted diet consisting of 70% lucerne hay and 30% wheat, with metabolisable energy (ME) concentration of 10 to 10.5 MJ/kg dry matter and 15 to 17% crude protein. Individual feed intake was recorded for each animal. In addition, 0.5 kg/head of oaten straw (containing 6.7 MJ ME/kg dry matter) was fed in open troughs. Animals were weighed weekly during the test. The growth of each animal during the test was modelled by linear regression of weight on time (days), and the regression estimates were used to calculate average daily gain (ADG) and mid-test weight (MWT). Feed intake was calculated by adding the daily energy intake of the pelleted ration and straw, and then adjusted to a concentration of 10 MJ ME/kg dry matter. Feed conversion ratio was calculated as dry matter intake (DMI) divided by ADG. Metabolic body weight (MMWT) was calculated as $MWT^{0.73}$. A linear regression model of feed intake on MMWT and ADG, with test group and sex included as class variables, was fitted to data for all test animals up to the 1996-born group. The regression coefficients from this model were used to predict feed intake of all animals, based on ADG and MMWT. Residual feed intake was calculated as the actual (measured) feed intake minus that predicted using the regression equation. Animals with low

RFI values consume less feed than that predicted for growth and maintenance and are more efficient. Details of the RFI test has been provided by Arthur *et al*. (2001).

The establishment of the divergent RFI selection lines started in 1994. Starting with the 1993 born animals, the females were allocated to the Low RFI line and the High RFI line, based on their postweaning individual RFI values. The three bulls with the lowest RFI values in the 1993-born group were allocated to the Low RFI line and the three bulls with the highest RFI values to the High RFI line. Throughout the study, the sole selection criterion for all replacement bulls and heifers was individual RFI. Data on the 1999 born animals were used in this study. Approximately 2 generations of selection had been achieved by 1999.

Estimation of greenhouse gas emissions. Metabolisable energy required for maintenance (MEM) and ME-intake (MEI) relative to maintenance (L) need to be known to calculate greenhouse gas emissions. Variation in DMI due to MMWT, ADG over the test period, sex (bull or heifer) and body composition (as measured by subcutaneous rib fat thickness, RIBFAT) was modelled using the general liner model (GLM) procedure of SAS (2001). No intercept was fitted on the assumption that DMI should be zero when MMWT, ADG and RIBFAT are zero. Kilograms of DMI required for no change in ADG was then predicted for each animal using the parameter estimates from the GLM, provided by the 'solution' option in the SAS (2001) procedure. From this it was apparent that approximately two-thirds of DMI was predicted to be required for maintenance, and one-third for ADG. Differences in RFI may result from differences in the efficiency of feed use for maintenance and for gain. It was assumed that two-thirds of RFI was due to variation in maintenance requirement and one-third to variation in requirement for gain. To calculate kilograms of DMI for maintenance for each animal, two-thirds of its RFI was added to its DMI for no change in ADG. Kilograms of DMI for maintenance was converted to MEM (MJ per day). MEM relative to maintenance (L) was calculated as (DMI x 10)/MEM.

Emissions of methane and nitrous oxide for the cattle and manure were calculated using the equations in the Australian National Greenhouse Gas Inventory (AGO 1998). Methane from enteric fermentation as a percentage of gross energy intake and methane production per day were based on the equation of Blaxter and Clapperton (1965) as described in AGO (1998; diet gross energy of 18.4MJ). Methane from faeces is formed from fermentation of the organic fraction of the faeces. The rate of production was calculated using Eqns.27 and 28 of AGO (1998) and factors recommended therewithin. Nitrous oxide emission was calculated from total nitrogen excretion (faeces plus urine) multiplied by the nitrous oxide emission factor: a value of 0.02 for 'drylot' being used (AGO 1998). Nitrogen excreted in faeces was calculated using Eqn.47 of AGO (1998). Calculation of nitrogen from urine first requires calculation of nitrogen retained (Eqn. 48: AGO 1998), based on MMT and standard reference weights of 770kg for bulls and 550kg for heifers. Nitrogen excreted was calculated using Eqn.49 of AGO (1998). Nitrous oxide emissions from the animals themselves are very small (AGO 1998) and not considered. Methane and nitrous oxide productions were converted into carbon dioxide equivalents assuming factors of 21 times for methane and 310 for nitrous oxide (NGGI 2000) and totalled to give kg CO_2 per head per day.

Statistical analysis. The data were analysed using generalised linear models procedures, fitting a model which included the fixed effects of sex, age of dam, generation of selection and selection line. Least squares means were computed for each line at generation 2, using the 'estimate' statement option within the SAS (2001) GLM procedure.

RESULTS AND DISCUSSION

Least squares means for production traits and greenhouse gas emissions for cattle selected for low RFI (more efficient in feed utilisation) and high RFI are presented in Table 1. The differences in liveweight and growth of cattle from the two selection lines were not significant, although cattle from the Low RFI line consume 15% less (P<0.001) feed.

Table 1. Least squares means (± standard errors) for production traits and greenhouse gas emissions from progeny of cattle selected for high and low residual feed intake

Trait	Selection line		Sig.[A]
	Low RFI	High RFI	
Number of animals	62	73	
Animal production			
Metabolic mid-weight ($kg^{0.73}$)	67.8 ± 1.8	69.1±1.6	*ns*
Average daily gain (ADG; kg/day)	1.36 ± 0.07	1.35 ± 0.06	*ns*
Feed intake (DMI; kg/day)	9.06 ± 0.49	10.60 ± 0.44	*
Gross energy intake (GEI; (MJ/day)	167 ± 9	195 ± 8	*
Metabolisable energy intake (MJ/day)	90.6 ± 4.9	106.0 ± 4.4	*
Residual feed intake (kg/day)	-0.55 ± 0.32	0.86 ± 0.28	*
Feed conversion ratio	6.72 ± 0.34	7.94 ± 0.30	*
Animal requirements			
Metabolisable energy for maintenance (MJ/day)	59.9 ± 3.5	71.9 ± 3.1	*
Feed intake relative to maintenance requirement	1.55 ± 0.03	1.47 ± 0.03	*
Greenhouse gas emissions			
Enteric methane (MJ, as % GEI)	7.28 ± 0.03	7.34 ± 0.02	*
Enteric methane (g/day)	219 ± 12	259 ± 11	*
Faecal methane (g/day)	4.7 ± 0.2	5.5 ± 0.2	*
Faecal nitrous oxide (g/day)	3.5 ± 0.2	4.2 ± 0.2	*
Carbon dioxide (kg/day)	5.79 ± 0.33	6.85 ± 0.29	*
Carbon dioxide (g/kg DMI)	638 ± 3	647 ± 2	*
Carbon dioxide (kg/kg ADG)	4.30 ± 0.23	5.14 ± 0.22	*

[A]Significant (P<0.001) selection line difference denoted by *; non significant (P>0.05) selection line difference denoted by *ns*.

Cattle selected for low RFI produced 15% less enteric methane per day than those selected for high RFI (Table 1). This is a consequence of the Low RFI cattle having lower daily gross energy intake as well as lower methane production per MJ of gross energy intake. Methane and nitrous oxide production from fermentation of faeces of Low RFI cattle was estimated to be lower by 15% and 17%, respectively, than those of High RFI cattle. The lower methane and nitrous oxide production by Low RFI cattle resulted in a 16% lower emission of carbon dioxide equivalents in comparison to High RFI cattle. The difference in emission per unit of feed intake was small (1.3%) but difference in amount per unit of liveweight gained was large (16%). These results are similar to those obtained by Okine *et al*. (2001) who estimated greenhouse gas emissions from phenotypically low, medium and high RFI feeder steers.

CONCLUSION

The results of this study indicates that selection for low RFI (more efficient cattle) in beef cattle should be accompanied by a significant reduction in greenhouse gas emissions per day and per unit of liveweight produced, largely as a consequence of the reduction in daily feed intake. This is achieved without compromise in growth performance.

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