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RESPONSE TO SELECTION FOR NET FEED INTAKE IN BEEF CATTLE

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SUMMARY
Direct and correlated responses in postweaning feed efficiency and growth traits resulting from 5 years of divergent selection for net feed intake (NFI) in beef cattle were evaluated. Approximately two generations of selection were achieved in both the high and low feed efficiency selection lines. Direct selection response (high minus low line) in NFI per year was 0.249 kg/day. Correlated responses in yearling weight and average daily gain were not significant. However, annual correlated responses in feed intake (0.24 kg/day) and feed conversion ratio (0.24) were significant ($P<0.05$).
Keywords: Cattle, feed efficiency, growth, selection.

INTRODUCTION
Profitability of beef production is dependent on both inputs and outputs. In the past, genetic improvement has been aimed mainly at output traits such as fertility and liveweight, and more recently carcass and meat quality traits. Little direct emphasis has been placed on reducing inputs to improve efficiency of production. Providing feed to cattle is the single largest expense in most commercial beef production enterprises, thus any effort at improving the efficiency of feed utilisation by animals should help reduce input costs. In beef cattle, attempts at genetic improvement of feed utilisation in the past have been based on feed conversion ratio (FCR), which is the amount of feed consumed divided by liveweight gain. Recent interest in feed efficiency in livestock have centred around net (residual) feed intake (NFI), which unlike FCR, is a linear index and is phenotypically independent of growth. NFI is the difference between actual feed intake and the expected feed requirements for maintenance and growth.

In 1993, a research project was started at the Agricultural Research Centre, Trangie, NSW, Australia to investigate the potential for genetic improvement in postweaning feed efficiency as a means of improving whole beef production system efficiency. Details of the design of the project have been reported by Arthur *et al*. (1996). This study is one of the components of the main project, and it evaluates the responses to divergent selection for net feed intake in young cattle.

MATERIALS AND METHODS
Starting with the 1993 born animals at Trangie, a feed intake and efficiency test was conducted each year using an automated feeding system which delivers and records individual animal feed intake. This study commenced in 1994 with the establishment of High and Low feed efficiency selection lines. The 1993 born and 1994 born animals formed the foundation herd for this study. Starting with the 1993 born animals, the females were allocated to the High efficiency line (High line) and the Low efficiency line (Low line), based on their individual NFI values. Females with low NFI values are more efficient (consumes less feed than that predicted for growth and maintenance) and were allocated to the

High efficiency line, and those with high NFI values were allocated to the Low efficiency line. The three most efficient bulls born in 1993 were allocated to the High line and the three least efficient bulls to the Low line. Throughout the study, the sole selection criterion for all replacement bulls and heifers in the High line and Low line was individual NFI. This design was chosen to provide a rapid divergence in NFI between the High and Low selection lines.

Only 200 animals can be tested in the feed intake and efficiency facility at any one time, and for this study a maximum of 100 males and 100 females were tested per year. Therefore, there was very little selection in the females due to limited numbers. In the males however, three to six bulls were selected per line each year, depending on the number of females available to be mated. Throughout the project bulls and heifers were mated at 14 months of age, and bulls were used for only one mating season except for the 1997 and 1998 mating seasons where, for each selection line, one bull from the previous year was used again. Animals from each selection line were grazed together throughout the year, except during mating. Allocation of mates within selection line was completely random, except for the avoidance of half-sib and son-dam matings. All matings were by natural service. The first progeny of selected parents were born in 1995 and the last in 1999. Calves were nursed by their dams until weaning, and the breeding herd was on pasture all year round, with supplementary feed (lucerne hay and wheat) offered during times of limited pasture growth. The animals were brought to the testing facility a few weeks (generally 4 to 6 weeks) after weaning. At the testing facility, a pre-test adjustment period of at least 21 days was allowed for the animals to adapt to the feeding system and diet, followed by a 70-day test as recommended by Archer *et al*. (1997). The average age at the start of test was 268 days. During the test animals had *ad libitum* access to a pelleted ration of approximately 10.5 MJ/kg dry matter and 16% crude protein. Records taken during the test were used to calculate NFI for each animal.

The growth of each animal during the test was modelled by linear regression of weight on time (days), and the regression coefficient represented average daily gain (ADG). The mean weight (MWT) of an animal during the test was computed as the average of the start and end of test weights. Metabolic body weight (MMWT) was calculated as $MWT^{.73}$. Feed intake (FI) was standardised to a concentration of 10 MJ ME/kg dry matter. FCR was calculated as FI divided by ADG. A linear regression model of FI on MMWT and ADG, with test group and sex included as class variables, was fitted to the data. The regression coefficients from this model were used to obtain expected feed intake of all animals based on ADG and MMWT. NFI was calculated as the actual (measured) FI minus that predicted using the regression equation.

All genetic and statistical analyses were done using standard procedures for selection experiments, similar to those used by Parnell *et al*. (1997). Variance components used for estimating breeding values for NFI were from Arthur *et al*. (2001). Selection line means for 1999 born animals were obtained using linear mixed models procedures in ASREML (Gilmour *et al*. 1996), and fitting selection line and sex as fixed effects and sire as a random effect, with age of dam and age of animal as covariates.

RESULTS AND DISCUSSION

A summary of the population parameters and the selection differentials for each selection line is presented in Table 1. The population parameters were similar between the two selection lines.

Selection line means for NFI and other feed efficiency and growth traits are presented in Table 2. There was significant (P<0.05) divergence between the two selection lines for the selected trait (NFI). This translated into an annual realised direct selection response of 0.249 kg/day. Figure 1 shows the trends in average estimated breeding values (EBVs) for NFI. The differences in average EBVs over time reflected trends in realised genetic differences between the selection lines. Mean EBVs for NFI for the 1993 foundation animals were used as the zero base, and by 1999 the mean NFI EBVs were –0.508 for the high efficiency and 0.562 for the low efficiency selection line.

Table 1. Summary of population parameters and selection differentials in high and low feed efficiency selection lines

Item	High efficiency line	Low efficiency line
Generations of selection	1.73	1.96
Generation interval (year)	2.5	2.5
Effective population size per generation	42	43
Average selection differential per year (kg/day)	-0.318	0.387

Differences in selection line means for the 1999 born animals indicate that after 5 years of selection for NFI, there was no realised correlated response in either yearling weight or average daily gain (Table 2). This result is consistent with the fact that, theoretically, NFI should be phenotypically independent of test period liveweight and growth. Significant (P<0.05) realised correlated responses in feed intake and feed conversion ratio were obtained. Animals in the high efficiency line consumed less feed and had lower values (more efficient) for feed conversion ratio than those in the low efficiency line.

Table 2. Least squares means (± standard errors) for 1999 born calves, and response to selection in growth and feed efficiency traits after 5 years of selection for net feed intake

	Selection line mean		Correlated response[1]	
Trait	High Efficiency	Low efficiency	Total (5 yr)	Per yr
Number of animals	62	73		
Net feed intake (kg/day)	-0.540 ± 0.176[a]	0.707 ± 0.172[b]	1.247	0.249
Yearling weight (kg)	384.3 ± 6.9	380.7 ± 6.7	3.6	0.72
Average daily gain (kg/day)	1.443 ± 0.034	1.400 ± 0.033	0.043	0.009
Feed intake (kg/day)	9.4 ± 0.3[a]	10.6 ± 0.3[b]	1.2	0.24
Feed conversion ratio	6.6 ± 0.2[a]	7.8 ± 0.2[b]	1.2	0.24

[1]Absolute mean difference between High and Low Efficiency selection lines.
[a,b]Selection line means with different superscripts differ significantly (P<0.05).

These results show that selection for NFI results in improvement in postweaning efficiency of feed utilisation with minimal effect on growth. Given the feed cost of $200 per 1000 kg at Trangie, the divergence of 1.247 kg/day between the lines in 1999, represents savings of $27 in feed costs per animal over a 100 day feeding period.

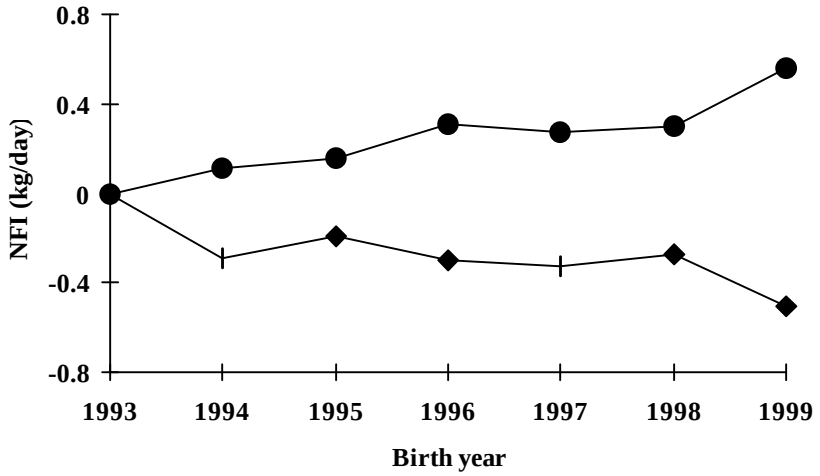

Figure 1. Trends in estimated breeding values for net feed intake (NFI) for High (◆) and Low (●) feed efficiency selection lines

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