Reducing feed costs through genetic improvement in feed efficiency

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Introduction

Feed efficiency is widely recognised as being one of the most economically important beef production traits. It is a major factor contributing to the profitability of feedlots, but is also the greatest single cost for commercial grazing enterprises. Potentially, given adequate selection across all sectors, commercial enterprises may be able to run significantly more stock on the same property, and feedlots could greatly reduce feed costs without significantly effecting performance in either sector.

Defining feed efficiency

Feed efficiency can be defined in a number of ways, but there are two ways generally considered useful to the Australian beef industry. The first of these is Feed Conversion Ratio (FCR), which as the name implies, simply refers to the kg of feed required to put one kg liveweight gain on an animal. FCR is useful for considering efficiency of cattle during growth and finishing, and is especially relevant to the feedlot where only growing animals are fed. FCR is also referred to as Gross Feed Efficiency, because it is a gross measure and does not attempt to break down feed requirements into sub-components of maintenance and gain. For this reason, FCR is not very useful for considering feed efficiency in the breeding herd, where mature females are not growing.

The second useful definition of feed efficiency is that of Net Feed Intake (NFI). Net feed intake refers to the variation in feed intake that remains after the requirements for maintenance and growth are accounted for. It is calculated as the actual feed consumed minus the feed intake which the animal was expected to eat based on its size and growth rate. Because an efficient animal is one that eats less feed compared to its body size and growth rate, efficient animals have a negative NFI while inefficient animals have a positive NFI. An example of the calculation of NFI for two bulls is given in Table 1.

Table 1. Results for two bull calves measured for feed efficiency during a 120-day test at Trangie.

Trait	High	Low Efficiency
Start weight (kg)	398	386
Growth rate (kg/day)	1.54	1.54
Expected feed intake (kg)	1668	1639
Actual feed intake (kg)	1585	1881
Net feed intake (kg)	-82	+242

Difference in feed cost = $71 over 120 days (valued at $240/ tonne)

For the purpose of making genetic comparisons of feed efficiency between animals, it is preferable to use NFI rather than FCR. This is because FCR is highly correlated with growth rate, and so higher growth animals will tend to be more efficient. However, higher growth animals also tend to have larger mature size, and so if we selected on the basis of FCR we would increase cow size and subsequent cow feed requirements. Thus, while we would have very efficient animals in the feedlot, the breeding sector would pay the penalty in terms of reduced cow numbers carried per hectare. Similar changes could be achieved by simply selecting for growth rate.

On the other hand, NFI is largely independent of the component traits, growth rate and bodyweight, so selecting for NFI will produce little change in growth and mature size, while feed intake will decrease. ***Of course in practice, breeders may select for both NFI and growth, and improve both traits simultaneously. Selecting a high growth bull with good (negative) NFI will produce animals with superior FCR as well***. However, the advantage of NFI over FCR is that it allows different breeders to place different emphasis on growth and feed efficiency. NFI also has much better statistical properties than FCR, making the use of NFI for calculating EBVs much more desirable.

Measuring feed efficiency

Feed efficiency can be measured either on young bulls (seedstock test) as done at Trangie, or on steer progeny of sires in feedlots (commercial feedlot test) as done by the Cattle and Beef Quality CRC. Either way, the principles of measurement are similar. Animals are put in front of automated feeding units that allow animals *ad libitum* access to feed, and the feed intake of the animal is recorded. Manual feeding systems are also acceptable, but are more labour intensive. The animals should be allowed 21 days to adjust to the ration and feeding system prior to the commencement of the test. Initial tests were of a duration of 120 days, but analysis of data generated indicate that tests can be reduced to 70 days without loss of accuracy. Current guidelines require a minimum 70-day test. During the test the animals should be weighed at least every fortnight to allow an accurate description of growth during the test. The data collected can then be processed to calculate NFI (or FCR) of the animal.

For industry implementation of feed efficiency testing, national standards outlining required test procedures have been developed. These standards are implemented into an accreditation program, ensuring that comparisons across tests can be made, and that data generated is acceptable for inclusion into BREEDPLAN EBVs.

Can we select for feed efficiency ?

Research by NSW Agriculture at Trangie, and by the CRC for Cattle and Beef Quality have shown that there is genetic variation in feed efficiency in the Australian cattle population. At Trangie, young bulls and heifers from Angus, Hereford, Poll Hereford and Shorthorn breeds were measured for NFI. Substantial variation between individuals was found, with the best animal eating over 550 kg less feed (over a 120-day test) than the worst animal when compared at the same level of growth performance. The heritability of NFI is calculated to be 0.39, the same as actual feed intake, and higher than feed conversion ratio (0.29) and daily gain (0.28) indicating that genetic improvement is possible through selection for NFI.

Selection for NFI has also been demonstrated to work in practice. Four groups of steer progeny of high efficiency and low efficiency parents following a single generation of selection were backgrounded on pasture from weaning to commercial feedlot entry weights, then fed in the CRC "Tullimba" feedlot. Individual feed intake, growth and efficiency were measured and recorded. Feeding was for 70 days (two groups) and 90 days (two groups) to achieve local supermarket and light export market endpoint's respectively. Results for the average daily performance and the cost of feed required to gain 100 kg liveweight for the four groups is presented in Table 2.

Steer progeny of high efficiency parents grew 5% and were 3% heavier prior to slaughter than progeny of low efficiency parents. The steers from high efficiency parents consumed 3% less per day, and because they also had a slightly higher daily gain, had an 8% superior feed conversion ratio than the steers from low efficiency parents. To gain 100 kg liveweight in the feedlot, the progeny of high efficiency parents required $19.20 less feed, that is, were 8% cheaper to feed than the progeny of low efficiency parents.

Table 2. Average feedlot performance following a single generation of selection for Net Feed Intake

Trait	High-efficiency parents	Low-efficiency parents	High *v* Low efficiency
Average daily gain (kg)	1.39	1.32	+5%
Final liveweight (kg)	462	450	+3%
Average daily feed intake (kg fresh wt.)	11.1	11.4	-3%
Feed conversion ratio (kg feed/kg gain)	8.0	8.6	-8%
Cost of feed to gain 100kg (at $300 per tonne)	$240	$259	-8%

What are the consequences of selection for feed efficiency on other traits?

Following postweaning testing each year, females were allocated to either the High efficiency line, or the Low efficiency line, based solely on their individual NFI values. The High efficiency line were joined to the highest efficiency bulls tested each year, and the Low efficiency line were joined to the lowest efficiency bulls each year, to create divergent selection lines for NFI. This design meant that there was little selection of females each year, but three to six bulls were selected per line per year depending on the number of females to be joined.

Differences between selection line means for animals born in 1999 are consistent with the premise that NFI is phenotypically independent of liveweight and growth, as there was no correlated response in either yearling weight or average daily gain. Results are shown in Table 3. Correlated responses with feed intake, feed conversion ratio and subcutaneous fat depth were significant. Following two generations of selection for NFI, the average NFI divergence between lines was 1.25 kg/day.

Of possible concern to some sectors of the industry is the relationship between NFI and subcutaneous fat depth, with more efficient animals tending to be leaner. It should be emphasised that the relationship is not strong, and there is ample scope to select animals, which are superior for NFI and also meet fat requirements for most markets.

Table 3. Performance of progeny of high NFI and low NFI bulls and heifers following two generations of selection.

Trait	**High-efficiency progeny**	**Low-efficiency progeny**	**Difference is significant**[1]
365-day liveweight (kg)	384.3	380.7	No
Average daily gain (kg/day)	1.44	1.40	No
Actual feed intake (kg/day)	9.4	10.6	Yes
Net feed intake (kg/day)	-0.54	+0.71	Yes
Feed conversion ratio	6.6	7.8	Yes
Rump (P8) fat depth (mm)	6.7	8.0	Yes

[1]*Difference between groups is statistically significant ($P<0.05$)*

The consequences of selection for feed efficiency on other traits are the subject of on-going research or further analysis. The current evidence suggests that NFI is unrelated to scrotal circumference (an indicator of fertility), and eye-muscle area (an indicator of muscularity). Genetic correlations between NFI and other traits measured are shown in Table 4. *(Bear in mind, that selecting for "improved" NFI is a more negative value, and so a negative correlation means an increase in the correlated trait, while a positive correlation means a decrease in the correlated trait).* Data is still being collected on the relationships between NFI and performance characteristics of the breeding herd, such as cow intake, fertility and maternal ability.

Table 4. Genetic correlations between NFI and other postweaning traits.

Trait	**Correlation**
Average daily gain (kg/day)	-.04
Actual feed intake (kg/day)	.69
Feed conversion ratio	.66
Scrotal circumference (cm)	-.03
12/13th rib fat (mm)	.17
P8 rump fat (mm)	.06
Eye muscle area (cm^2)	.09

Relationships of NFI on steers measured in feedlots are undergoing further research and analysis, but in general are similar to those for NFI on seedstock animals. Animals which deposit excessive quantities of sub-cutaneous fat tend to be less efficient. Preliminary evidence indicates that there is an antagonistic relationship between feed efficiency of steers and marbling ability, but the correlation is not particularly strong, and there is adequate potential to select animals with negative NFI and positive IMF. Genetic correlations between NFI and other feedlot and carcase traits are shown in Table 5.

Table 5. Genetic correlations between NFI and other feedlot and carcase traits.

Trait	Correlation
Pre-slaughter scan P8 fat	0.42
Pre-slaughter scan EMA	-0.28
Carcase weight	-0.30
Carcase IMF%	0.21
Carcase P8 fat	0.48
Carcase RBY%	-0.77

How will producers implement selection to improve feed efficiency ?

Information on feed intake and efficiency forms the basis of the new Trial BREEDPLAN EBV for NFI. At this stage only three breeds - Angus and Hereford/Poll Hereford have sufficient, well-linked data, to have their data analysed by the Animal Genetics and Breeding Unit (AGBU) to produce across herd EBVs. These are published in these Breeds' Sire summaries and websites. As other breeds accumulate data, they will also be able to publish EBVs

NFI EBVs are reported as kg of feed eaten per day. The lower (more negative), the less feed eaten and the more efficient. For example, two bulls with these EBVs:

Bull A: + 0.6 kg/day Bull B: – 0.8kg/day

A simple interpretation, is that *Bull B* (having more -ve NFI EBVs) would be expected to breed "more efficient" progeny than *Bull A*. If the two bulls had similar EBVs for growth and were joined to average cows, progeny of *Bull B* would gain the same, but eat 0.7 kg less per day than the progeny of *Bull A* (half the difference of 1.4 kg between the Sire EBV, as the cows contribute half the genes).

This EBV will be used in exactly the same way that existing BREEDPLAN EBVs are currently used, with commercial producers wishing to place emphasis on improving efficiency within their herd able to consider the EBV for NFI along with the EBVs for all other relevant traits when purchasing bulls. These breeders will then be able to provide feeder steers with significantly lower feed intake without affecting potential feedlot performance.

References

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