GeneNOTE 10

GeneSTAR® Feed Efficiency 4
The First DNA Marker Tests for Net Feed Intake and Feed Conversion Efficiency

Key messages

- A new suite of 4 DNA markers has been released that accurately identifies an animal's genetic type for net feed intake.
- It is a new addition to the popular GeneSTAR® multi-marker test, now for Tenderness, Marbling and Feed Efficiency.
- Net Feed Intake, the difference between an animal's actual feed intake and its expected feed requirements for maintenance and growth, is the best selection criterion for genetic improvement for this trait at the bull-breeding level.
- The 4 markers have highly significant associations with both net feed intake and feed conversion ratio and will be useful tools for the seedstock and lotfeeding sectors.
- The 4 markers in the DNA test have no genetic associations to marbling, average daily gain, carcase weight and very importantly, rump fat. Unlike some other selection tools, the DNA tests have no negative associations with those traits.
- The ability to work around unfavourable associations between traits is a feature of the DNA markers that will be increasingly exploited by Catapult Genetics and the GeneSTAR® suite of tests.

Introduction

This GeneNOTE describes the background and discovery of four DNA markers for feed efficiency, the first such DNA tests ever released. The note also describes the testing of the markers to find which gave most utility and the size of their effect on feed intake of measured cattle. Release of these new tools creates an opportunity for the beef industry to save $millions in feed costs over time.

Feed efficiency and cost of production

Feed costs typically make up 60-65% of the variable costs of beef production. Lowering feed costs would have a major impact on profitability and competitiveness. Progress to improve feed efficiency (FE), the amount of beef produced per unit of feed input, or as it is often called feed conversion ratio (FCR), has been largely by non-genetic tools such as growth promoters and feed additives.

In recent years, trial Net Feed Intake EBVs from BREEDPLAN have been available for a few breeds based on actual feed intake measures on bulls using electronic in-yard measuring equipment and measures for an associated trait, IGF 1(Insulin-like Growth Factor 1) from bloodspot tests on young seedstock animals. However the number of direct feed intake measurements reported has been dropping in recent years and the high cost of identifying animals that are superior for feed efficiency has been a barrier to adoption.

Net Feed Intake (NFI)

Research in Australia in the 90's, primarily at Trangie Research Centre, New South Wales, moved the focus for a selection tool for the seedstock industry to a net feed efficiency concept and a measure called Net Feed Intake (Residual Feed Intake in USA).

NFI, defined as **actual** feed intake minus the **expected** feed intake, based on the weight of the animal and its average daily gain, has now been adopted internationally as the selection tool of preference for the breeding of cattle for improved feed efficiency.

The expected feed intake is the feed requirement for maintenance and growth and is independent of growth at the phenotypic level. It measures if an animal eats more (less efficient) or less (more efficient) than expected on the basis of its size and growth.

Genetic selection to reduce NFI will result in progeny that eat less without sacrificing growth performance. NFI in beef cattle is moderately heritable as a genetic trait (similar to growth rate).

Feed Conversion Ratio (FCR = Feed intake ÷ average daily gain) was commonly used in the past as a measure of feed efficiency but it is a gross efficiency measure that fell out of favour as a genetic selection tool because selected lines had higher weight gains but no reduction in feed intake. The lotfeeding sector however continues to use FCR to calculate cost of gain (cents per kg) for a

pen of finished animals at closeout, which is an important economic trait in lotfeeding.

Background to the release

The release was made possible by the application of the very latest genetic technologies – whole genome scans and electronically measured individual animal feed intake from cattle from the Angus, Brahman, Belmont Red, Hereford, Murray Grey, Santa Gertrudis, and Shorthorn breeds. 1472 steers and heifers were in the original discovery database. Between 75 and 300 animals each from the seven breeds made up the CRC for Cattle and Beef Quality DNA bank and database that were used.

Initially CSIRO (Commonwealth Scientific and Industry Research Organisation) conducted a survey of 10,000 markers using a whole genome scan and identified large numbers of markers with possible associations with feed efficiency. The initial markers were tested on the beef CRC animals that had been measured for NFI and subsequent analysis reduced the number of potential markers. Catapult Genetics performed additional testing and eventually four markers were deemed commercially viable for release as feed efficiency GeneSTAR® tests.

The four markers for release were selected initially as part of the subset based on their association with NFI. However other key criteria were considered in marker selection as follows: -

- strongest predicted effect on NFI, both their individual effect as well as their contribution to a multi-marker test
- gene frequency (of the favourable allele);
- the degree of genetic dominance such that the expression of the 1-STAR lies intermediate between the 2-STAR and the 0-STAR;
- consistency of effect across breeds; and
- the absence of any negative associated effects on other commercially important traits e.g. average daily gain, rump fat or marbling.

Details of research methods

The markers were tested and evaluated on two DNA databanks and databases. Direct and associated effects were examined as well as gene frequencies by breed. The principal information that was evaluated and analysed came from the CRC for Cattle and Beef Quality (1472 animals), plus one of Genetic Solution's datasets for 250-day grain-fed (953) steers.

The NFI measurements on the animals were taken during the final phase of grain-based finishing for different domestic and export market endpoints. Across steers and heifers, for different markets, the average gross intake was 12.30 kg/day, average daily gain of 1.36 kg/day, and a feed conversion ratio of 9.62. Carcase results were also available on the CRC cattle for carcase weight, P8 (rump) fat, and IMF%.

For more details on the cattle in the CRC, see the published paper of Robinson and Oddy (2004).

Analysis of Effects

Genotype Frequencies

The frequency of the favourable alleles (STARs) by breed is shown in Table 1 for seven breeds.

Table 1. Frequency (%) of the favourable forms of the markers (STARs) based on 1255 net feed intake records from 7 breeds*

Breed	STARs						
	2	**3**	**4**	**5**	**6**	**7**	**8**
Angus	2	6	15	22	31	17	7
Brahman	0	1	0	4	9	46	40
Belmont Red	1	3	6	18	31	29	12
Hereford	1	3	9	28	36	17	6
Murray Grey	1	17	33	19	22	4	3
Santa Gertrudis	0	1	3	10	31	30	25
Shorthorn	0	4	9	17	29	25	15

N.B. there were no 0 or 1 STAR animals in this group

It can be seen that the Brahman and Santa Gertrudis breeds showed a higher frequency of more STARs with 86% of Brahman animals either 7 or 8-STAR for the 4 markers. The British breeds showed similar frequencies across the 2 to 8-STAR range with peak frequencies between 5 and 7 STARs but with a lower frequency of 7 and 8 STARs compared to Brahman.

STAR effects on key feed efficiency measures

An analysis was conducted to examine the combined direct effects of the four selected markers on NFI, Gross Feed Intake (GFI) and FCR. The combined effect of STARs for the 4 markers on NFI, FCR, GFI and ADG are shown below in Table 2.

Table 2. The effect of STARs on NFI (kg/day) and FCR (kg of feed eaten/kg gain), Gross Feed Intake (GFI kg/day) and Average Daily Gain (ADG kg/day) by STAR for 1060 steers and heifers in the finishing phase.

STARs	**n**	**NFI**	**FCR**	**GFI**	**ADG**
<3	8	1.121	10.31	13.53	1.305
3	41	0.533	9.90	13.19	1.392

4	95	0.135	9.43	12.65	1.350
5	178	0.102	9.09	12.69	1.381
6	307	-0.025	9.01	12.45	1.363
7	268	-0.092	9.09	12.14	1.332
8	163	-0.145	8.93	12.19	1.352

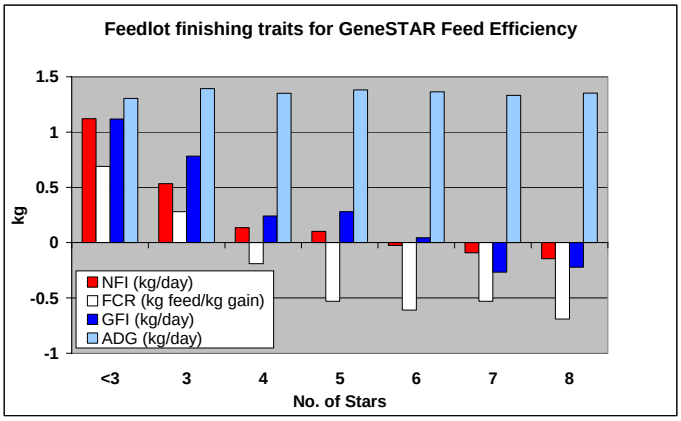
Overall, STARs showed a highly significant association with both feed efficiency measures (NFI and FCR). They also showed an association with feed eaten (GFI) though there was no association with average daily gain (ADG).

It can be seen in Table 2 that daily NFI decreased as the number of STARS increased with 7 and 8 STAR animals showing -0.092kg/day and -0.145 kg/day respectively compared to animals with <3 STARS that had a NFI of +1.121 kg/day. The effect of STAR on NFI is also shown in Figure 1.

The difference between animals with 3 or less STARs (less efficient) and those with 7 or 8 STARs (more efficient) was 1kg less feed eaten daily in terms of NFI or the feed needed to produce the same weight gain.

The effect of a STAR on FCR is shown in Table 2 and Figure 1. It can be seen that the effect of STARs increased FCR up to 5-STAR. There was a difference of 13-15% FCR between animals with 3 STARs or less compared to animals with 5-8 STARs.

Figure 1 shows the average effect of STARs for GeneSTAR® FE 4 on feedlot finishing traits.



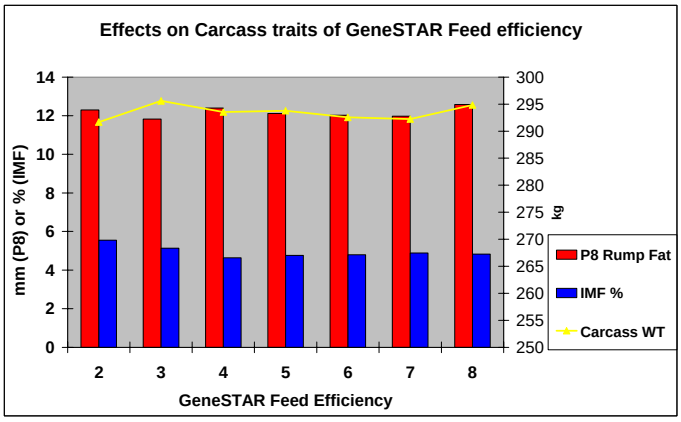
The markers allow us to select specifically for animals that have more favourable NFI. The effect of the selection for NFI using these particular markers is that the animals also have more favourable FCR. This allows selection for both seedstock and commercial cattle using the markers.

Associations with carcase traits

When selecting animals for a trait it is important to know if that selection pressure could adversely affect another biological trait.

The association between STAR and P8 (rump) fat, average carcase weight (Cwt) and intra-muscular fat (IMF)% is shown in figure 2. It can be seen that there are no significant trends and STAR is independent of the three carcase traits.

Figure 2 shows the associated effect of STAR score on carcase traits, Cwt, P8 fat and IMF%.



A recent review (Arthur and Herd 2006) of the genetic associations between NFI and other traits showed that with the exception of sub-cutaneous fat, there are only weak associations with carcase traits.

To date no effect on maternal productivity has been found but more information is required on maternal performance.

Implications from this research

The results demonstrate that the 4 NFI markers in GeneSTAR® FE 4 have a significant effect on NFI and FCR without any associated effects on carcase traits examined. They provide an important tool to breed for improved feed efficiency and as a feedlot tool to select more profitable cattle.

The lack of an association between the four markers and P8 (rump) fat is very important because previous studies with NFI and with these same trial animals from the CRC (Robinson and Oddy 2004) showed a relationship between NFI and fat, where selection for low NFI would strongly reduce fat on animals. Based on other research, lowering fat levels in females can reduce female reproductive performance (Johnston and Graser 1998). With the GeneSTAR® FE 4 test reduced fat levels should not be a concern to users.

The ability to work around unfavourable associations between traits is a feature of the DNA markers that will be increasingly exploited by Catapult Genetics in future selection of markers.

Conclusions

GeneSTAR® Feed Efficiency 4 heralds a new era in selection of cattle for improved feed efficiency. Seedstock breeders can use it to select animals of high efficiency (low feed intake), without reducing fat levels which could be a concern in breeding terms.

Lotfeeders can use the test to sort cattle for FCR. Selecting the 5-8 STAR cattle & drafting off the animals with less than 5 STARs could improve pen FCR and reduce cost of gain in that pen. Done in combination with the GeneSTAR® Marbling & Tenderness tests an opportunity exists to select cattle with higher meat quality at a lower cost of gain.

To incorporate the information into an EBV will require additional work to link this NFI based on the feedlot phase with other information collected post-weaning and projects are underway to achieve this in the future.

Industry now has a robust tool that can allow selection of seedstock animals for NFI at a young age and at a low cost as part of a multi-marker test that also gives genetic information on tenderness and marbling.

Australian and Canadian researchers have suggested that by selecting for NFI it could also reduce the amount of methane and manure released into the environment. In the longer term those effects could reduce the impact of beef production on the environment.

The Trangie and subsequent Beef CRC research (Herd et al 2003) has shown that those that are more efficient as heifer weaners are also efficient as mature cows and will eat less without compromising maternal performance, however the trial done was not a replication of what happens in normal production. Selection for lower NFI will lead to a decrease in feed intake by cows in a lot-feeding situation, with no increase in cow size. So it may be possible to keep all the economic traits that make up growth and maternal performance equal while lowering feed requirements, however much more information on maternal performance is needed before conclusions can be drawn.

The same researchers demonstrated that parents selected for low and high feed efficiency produced steer progeny that had a favourable response in growth and feed efficiency on pasture. There was no significant difference in daily pasture intake between the selection lines, however the more feed efficient animals grew faster.

Selecting sires with more favourable NFI information will result in producing progeny that are more efficient in the feedlot and on pasture.

Current GeneSTAR® Multi-Marker Test

GeneSTAR® Feed Efficiency 4 is sold as a part of a 12-marker test that also tests for 4 markers for Marbling and 4 markers for Tenderness, so from one sample of DNA, 12 results are provided on important genetic and production information.

Testing Commercial and Feedlot Cattle

With the addition of a fourth marbling marker and the four marker Feed Efficiency test as a new trait to the GeneSTAR® suite of tests, the ability to effectively sort long fed cattle for the higher marbling markets has been greatly enhanced. The commercial and feedlot test reports total STAR ratings for each trait, which provides a simple tool for making effective selection and drafting decisions.

A typical set of over 850 steers fed for 250 days were evaluated using GeneSTAR Marbling 4 and GeneSTAR Feed Efficiency 4. If these steers had been tested prior to feedlot entry and sorted into high marbling/high feed efficiency and low marbling/low feed efficiency groups there would have been a major difference in performance. The high marbling/high feed efficient group averaged 1 Marble score greater and would have eaten on average 1 kg less feed per day.

A major advantage of the multi-marker test is that it allows more accurate drafting lines to be identified between high and low performers, therefore getting a higher percentage of high performing cattle in the favourable group. In this set of animals the high marbling/high feed efficient group included 62% of the steers from the total group.

References:

Arthur, P.F. and Herd, R.M. (2006) 8th World Congress on Genetics applied to Livestock Production, August 13-18, 2006, Belo Horizonte, MG, Brazil.

Herd, R.M, Archer, J.A. and Arthur, P.F. (2003) Reducing the cost of beef production through genetic improvement in residual feed intake: Opportunity and challenges to application. J. Anim. Sci, 81:E9-E17

Johnston, D.J. and Graser, H-U. (1998) Proceedings of the 6th World Congress on Genetics applied to Livestock Production, Armidale, NSW, Australia pp 157-160.

Robinson, D.C. and Oddy, V.H. (2004) Livestock Production Science Vol. 90, Issues 2-3, November, pp 255-270.

For more information on the GeneSTAR® suite of DNA tests for Marbling, Tenderness and Feed Efficiency, please contact Catapult

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