

DNA profiling helps unlock the economic potential of feed efficiency traits.

Feed (dietary energy) accounts for approximately 70 percent of total production costs in the beef industry — and is the single largest variable cost in beef production systems.¹ But, 70 percent to 75 percent of the total dietary energy consumed in a beef production system is used for maintenance.^{2,3} In fact, only 5 percent of the total energy intake in beef cattle is converted into deposited protein — compared with 14 percent and 22 percent for swine and poultry, respectively.^{2,3}

This combination of factors makes the beef industry especially sensitive to recent increases in feed input costs — and well positioned to benefit from increases in feed efficiency in production animals.

DNA TECHNOLOGY PLAYS A CRITICAL ROLE IN IDENTIFYING AND ANALYZING FEED EFFICIENCY TRAITS.

Genetic variation in feed efficiency has long been recognized — but the prohibitive cost of measuring individual feed intake has been an obstacle for routinely conducting classic genetic evaluations for feed efficiency. Publication of the bovine genome and subsequent investigation of economically important traits have made the potential for using DNA markers for the selection and management of feed efficiency in beef cattle a viable option for all producers.

Studies have confirmed that cattle with the genetic potential to be more efficient are more profitable — *at all stages of*

production.^{2,3} Utilizing DNA profiling to help make selection decisions provides the practical key to improved feed efficiency, which would lead to better economic returns for both cow/calf and feedyard operations.⁴

MEASURING AND COMPARING FEED EFFICIENCY IN BEEF CATTLE.

There is a considerable amount of animal-to-animal variation in feed intake independent of requirements for maintenance and growth.⁵ Several traits are used for identifying and comparing feed efficiency potential among individual animals. Some of the most common and useful traits are:

- Residual feed intake (RFI), also called net feed intake, describes an animal's energy requirements for maintenance and growth, partitioned and evaluated separately.⁶ Low RFI is more desirable than high RFI, because a low-RFI animal either:
 - Eats less with the same gains
 - Gains more from the same amount of feed
- Average daily gain (ADG) is a gross measure of daily gain, regardless of the amount of feed intake, which means that animals with the same ADG often have different RFI. While not an optimal tool for predicting feed efficiency, ADG combined with RFI helps you to find the most profitable animals — those that grow quickly and efficiently.

See the following pages for research that evaluates the impact of feed efficiency analyses available from IGENITY®.



RESEARCH SUPPORTS THE IMPACT OF RFI ANALYSES INCLUDED IN THE IGENITY PROFILE.

Feed efficiency as measured by RFI is a very important trait for beef cattle production, especially in light of the relative importance of feed costs in a beef production system. RFI is a moderately heritable trait that is difficult and expensive to measure by traditional means, but DNA technology can make selection for RFI practical for any producer.

A modified whole genome scan was used to generate a set of DNA markers that were shown to be significantly associated with RFI in beef cattle. The markers were subsequently validated in multiple groups of unrelated cattle prior to being made commercially available. Use of the analyses from IGENITY to help select efficient breeding stock is an important new way for cattle producers to produce progeny of above-average efficiency.

FEED EFFICIENCY AND GROWTH TRAITS ANALYZED IN THE IGENITY® PROFILE.

IGENITY offers third-party-validated analyses for DNA markers related to RFI and ADG.

Selecting for RFI has great potential to reduce feed requirements without compromising growth or carcass merit.^{4,5,7} Most efficient animals have negative RFI because they eat less than would be expected, based on their body weight and growth rate.

RESULTS HOLD SIGNIFICANCE FOR CATTLE IN ALL SEGMENTS.

- Analyses for RFI from IGENITY have been validated in studies in North America and Australia.
- Analyses have been validated by the NBCEC for all types of cattle.
- Lifetime value is demonstrated by correlation of feed efficiency in young cattle with older cattle.^{2,3}
- Research has shown no adverse impact on carcass traits when selecting for feed efficiency with IGENITY.
- There also is no adverse impact on fertility when selecting for feed efficiency with IGENITY.

The IGENITY profile is designed so each trait analysis represents a range and each point on the profile represents an added value. For example, the *Bos indicus* RFI analysis from IGENITY, the difference between the least and most efficient animals is 5.5 pounds of feed per day at midpoint weights — and each point difference on the 1-to-10 scale represents approximately 0.6 pound of feed intake per day. In the *Bos taurus* analysis for RFI from IGENITY, the difference between the least and most efficient animals is 4.21 pounds of feed per day at midpoint weights — and each point difference on the 1-to-10 scale represents approximately 0.45 pound of feed intake per day.

SIGNIFICANCE OF OFFERING INDIVIDUAL ANALYSES FOR *BOS INDICUS* AND *BOS TAURUS* CATTLE FOR RFI FROM IGENITY®.

Bos indicus and *indicus*-influenced cattle are phylogenetically and biologically different from *Bos taurus* breeds of cattle. This means that molecular and physiological effects of certain genes for complex traits like RFI, can be slightly different in the different cattle types — even when the same genes are involved in controlling similar biological processes.

Resource populations used for marker validation must closely match the commercial populations for which the results are going to be applied — and producers should be aware of this. The new markers added to the analyses for RFI from IGENITY were tested in both *Bos indicus* and *Bos taurus* cattle. DNA markers are only used in analyses from IGENITY for across-breed use if they are proven to predict performance in both types of cattle.

RESEARCH CONFIRMS MARKER PROFILES FOR FEED EFFICIENCY IN *BOS INDICUS* CATTLE.

Population and results

- The first *Bos indicus* study involved 464 head of Brangus cattle, averaging 597 pounds at the start and 752 pounds at the finish of intake data collection.
- ADG average for the group was 2.23 lb/day.
- Dry matter intake (DMI) average for the group was 20.83 lb/day.
- Phenotypic RFI, adjusted for contemporary group effects, growth and metabolic body weight, ranged from -3.95 lb/day to 2.06 lb/day with a standard deviation of 1.43 lb/day.
- RFI in these cattle was genetically and phenotypically independent of growth and body weight, but was also strongly correlated with both feed conversion ratio (FCR) and DMI as expected. In contrast, FCR had strong negative genetic and phenotypic correlations with ADG but weak corresponding correlations with DMI.
- These results demonstrate that RFI is potentially the best index for improving feed efficiency and reducing feed consumption without compromising growth performance.^{4,5,8}
- The relationship between each animal's phenotype and its corresponding genetic profile for RFI was significantly different from zero ($P=5.7 \times 10^{-13}$).

IMPLICATIONS

- RFI genetic effects ranged from -2.23 lb/day to 2.38 lb/day with a standard deviation of 0.66 lb/day.
- The genetic effects for RFI were significantly correlated to phenotypes for RFI, FCR and DMI, but were phenotypically unrelated to ADG, final body weight, metabolic body weight and ultrasound measures of intramuscular fat and ribeye area; however, they had a weak positive correlation with backfat thickness (Table 1).
- Selection using the RFI analysis from IGENITY is therefore expected to reduce feed intake, improve feed conversion and reduce backfat thickness, with no impact on growth performance, body weight, ribeye

area or marbling score. Based on the current data, a 1 percent reduction in fatness translates into 0.0066 inch of backfat. These results are consistent with the published responses to selection on these traits based on phenotypic information.^{5,7,8}

CONCLUSIONS

The study confirmed the associations of the RFI analysis for *Bos indicus* cattle from IGENITY with actual feed intake and feed efficiency measures.

Phenotypic correlations computed between the RFI analysis from IGENITY and various traits showed that selecting animals based on the RFI analysis will reduce feed intake, improve feed conversion, with no significant impact on growth performance, body weight, ribeye area or marbling score.

Table 1. Pearson correlations between results from IGENITY for RFI and actual performance on feed and carcass merit in *Bos indicus*-influenced cattle.

Trait*	RFI	DMI	FCR	ADG	FBW	MWT	BF	IMF	REA
RFI_MBV	0.364	0.220	0.246	-0.050	-0.016	-0.004	0.095	-0.061	0.030

*FBW = final body weight; MWT = metabolic midtest body weight; ADG = average daily gain; DMI = daily dry matter intake; FCR = feed conversion ratio; RFI = residual feed intake; REA = ribeye area; IMF = intramuscular fat; BF=Back fat.

AUSTRALIAN RESEARCH CONFIRMS ASSOCIATION

In the second *Bos indicus* RFI study, phenotypic data for feed intake traits were recorded on groups of cattle (predominantly steers) feedyard finished on high-energy, grain-based diets. The average age at the start of the feed test was 14 to 18 months. The *Bos indicus* and *indicus*-influenced steers used for validation studies were fed to three different market weight endpoints and entered the feed test at an average age of 15, 19 and 21 months of age.^{5,9,10}

RESULTS

Results from the pooled *Bos indicus* and *indicus*-influenced datasets (Table 2) using the effects derived from previous studies showed significant and positive regression coefficients for RFI. This study confirmed the associations of analysis for RFI from IGENITY with feed efficiency in *Bos indicus* and *indicus*-influenced cattle.

Table 2. Regression coefficients (β) for results of the *Bos indicus* feed efficiency analysis from IGENITY on actual RFI measured in *Bos indicus* and *indicus*-influenced cattle.

Second <i>Bos indicus</i> study dataset	β^*	SE	ddf**	P-value
<i>Bos indicus</i> -influenced combined	0.107	0.04	1133	0.005
<i>Bos indicus</i> and <i>Bos indicus</i> -influenced combined	0.090	0.049	510	0.035

*The IGENITY marker effects are reported on a dry matter basis while the phenotypes used for validation were recorded on an as-fed basis. This contributed to the considerably lower regression coefficient between the marker effects and phenotype. This does not affect the correlation between the marker effects and the phenotype.

** ddf = denominator degrees of freedom

INTERNAL DEVELOPMENT POPULATIONS AND RESULTS FOR RFI ANALYSIS FOR *BOS TAURUS* CATTLE FROM IGENITY

Three populations of cattle were used to re-evaluate and confirm marker associations, originally discovered at independent research institutions.

- The first two groups consisted of purebred bulls whose feed intake measurement began at an average age of 270 and 328 days of age. These bulls were fed a high-roughage diet and intake was recorded for 70 days.
- The third group included crossbred steers and heifers fed a barley-based total mixed ration after weaning. Intake was recorded on these animals for 70 days and their average age was 349 days at the beginning of the measurement period. Details of the descriptive statistics on these animals can be seen in Table 3.

Table 3. Combined descriptive statistics for cattle used to confirm individual marker associations with RFI.

Trait	Animals	Mean	SD	Min	Max
ADG	1005	3.33	0.64	0.045	5.26
MWT	1005	217.86	25.63	132.33	369.02
DMI	1005	23.47	3.70	11.34	48.43
RFI	1005	0.00	1.42	-5.73	7.78

ADG = average daily gain; MWT = metabolic midtest body weight; DMI = daily dry matter intake; RFI = residual feed intake.

IMPLICATIONS

Genetic effect of RFI analysis for *Bos taurus* cattle

- The analysis for RFI was significantly correlated to RFI and DMI phenotypes. The correlation of the RFI analysis with other phenotypic measures are shown in Table 4; however, a number of the correlations are quite low resulting in limited biological significance. The RFI analysis from IGENITY was not correlated to ribeye area or birth weight EPDs.
- A larger population of 10,362 animals resulted in an observed range in RFI of -2.20 lb/day to 2.01 lb/day when adjusted for the mean, based on the RFI analysis from IGENITY and a standard deviation of 0.61 lb/day.

Table 4. Pearson correlations between the RFI analysis for *Bos taurus* cattle from IGENITY calculated for animals in the development population and their phenotypic measures of feedyard performance and carcass merit, and the corresponding EPDs in *Bos taurus* cattle.

Trait*	Phenotype					EPDs								
	RFI	DMI	ADG	FBW	MWT	WWT	YWT	MILK	CWT	MB	BFAT	HPG	SC	DOC
RFI MBV	0.206	0.344	0.140	0.068	0.085									
RFI MBV	0.225	0.260	0.287	-0.090	0.240	0.126	-0.131	-0.104	-0.116					
Animals	1994	1986	1994	1032	1344	1247	418	1242	357					

*RFI = residual feed intake; DMI = daily dry matter intake; ADG = average daily gain; FBW = final body weight; MWT = metabolic midtest body weight; WWT = weaning body weight EPD; YWT = yearling body weight EPD; Milk = milking ability EPD; CWT = hot carcass body weight EPD; MB = marbling EPD; BFAT = backfat thickness EPD.

EXTERNAL RESEARCH CONFIRMS PREDICTIVE POWER OF RFI ANALYSIS FOR *BOS TAURUS* CATTLE FROM IGENITY

Population and results

- Three external research institutions provided DNA from cattle with individual-feed-intake measurements to IGENITY for genotyping.
- The results from the RFI analysis for *Bos taurus* cattle from IGENITY were returned to the respective research institutions and all subsequent data analyses were conducted by their scientists in cooperation with input from the NBCEC.
- Researchers at each institution developed statistical analysis models to determine if the results from IGENITY were predictive of individual animal feed intake in their respective populations.

Study 1

Feed intake was measured over several years on a total of 610 crossbred steers, heifers and bulls in Study 1. Cattle were placed in the feedyard shortly after 200 days of age; intake was recorded for at least 40 days. The cattle were fed a predominantly high-moisture corn diet.

Study 2

The second study consisted of a variety of purebred *Bos taurus* steers and some heifers purchased over several years from producers at weaning. They were backgrounded and fed to one of three market endpoints in feedyards on a high-energy, grain-based diet. Individual feed intake was measured on average for 60 days with the average age at the beginning of measurement ranging from 15 to 21 months, depending on the market endpoint.

Study 3

Average feed intake measurements were recorded on 202 progeny test calves, mostly steers, starting at the age of 14 months for an average of 70 days. Study 3 also spanned multiple years.

Study 4

The fourth study was made up of 415 steers. The data was collected over several years. The number of days on feed and actual market endpoints were not disclosed.

Study 5

Study 5 consisted of cattle fed over several years. No disclosure was made by the research institution on the study population's diet, age, days on feed, treatments, management, contemporary groups, etc. Attempts to further characterize the animals in this dataset have not been possible.

CONCLUSIONS

- Results from independent scientists in Studies 1 and 2 confirmed that the analysis for RFI in *Bos taurus* cattle from IGENITY is predictive ($P < 0.05$) of individual feed intake in growing cattle as represented by data from multiple breeds recorded in different environments and under different management scenarios (Table 5).
- Study 3 results only approach significance, most likely due to the small number of total cattle in this analysis fed over multiple years.
- Study 4 was not significant. The results of Study 4 were inconsistent with Studies 1 to 3, but it could not be determined if the results were due to the large variation in endpoints, days on feed or the marker panel.
- The results of Study 5 were not significant and the standard error was larger than the regression coefficient.
- All five studies were combined in a meta-analysis conducted by the NBCEC, with the results indicating a strong trend toward significance ($P = 0.09$).
- In addition, a final validation analysis was conducted of this same RFI analysis for *Bos taurus* cattle using a much larger population of animals, which are part of Merial's multiple resource populations. Results from that analysis are included in Table 5.

Table 5. Regression of the RFI analysis for *Bos taurus* cattle from IGENITY on RFI phenotypes in multiple populations.

Test population	ddf	β	SE	P-value
External 1	706	0.351	0.127	0.005
External 2	546	0.309	0.174	0.040
External 3	189	0.393	0.401	0.165
External 4	327	-0.426	0.261	0.950
External 5	831	-0.105	0.117	0.813
Merial	1879	0.45	0.08	8.04x10 ^a

IGENITY offers powerful analyses for feed efficiency traits — and much more.

Only IGENITY offers the most powerful profiling technologies with user-friendly applications and consultation. The comprehensive IGENITY profile empowers producers to make more confident real-time decisions and higher-quality, more profitable products.

IGENITY works with research partners around the globe to continue to discover and integrate innovative technologies, and enhance the value of the IGENITY profile. At press time, IGENITY offered analyses related to the following economically significant traits:

- Residual feed intake
- Average daily gain
- Tenderness
- Marbling
- Quality grade
- Yield grade
- Fat thickness
- Ribeye area
- Heifer pregnancy rate
- Stayability (longevity)
- Calving ease
- Docility
- Myostatin
- Arthrogyrosis Multiplex
- Coat color
- Breed-specific horned/polled
- Multisire parentage
- BVD-PI diagnostic test

Table 6. Breeds of cattle included in the development and/or validation of *Bos indicus* or *Bos taurus* RFI analyses.

<i>Bos taurus</i>	<i>Bos indicus</i>
Angus	Brahman
Red Angus	Brangus
Gelbvieh	Santa Gertrudis
Charolais	Belmont Red
South Devon	Composites
Murray Grey	
Salers	
Balancer	
Simmental	
Hereford	
Tarentaise	
Holstein	
Limousin	
Pinzgauer	
Shorthorn	
Composites	
Senepol	
Maine Anjou	

As IGENITY advances the science of DNA technology, more analyses will be added. For the latest information about the IGENITY profile, visit www.igenity.com or call 1-877-IGENITY.

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