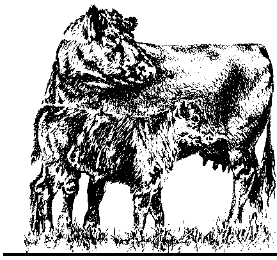

Selecting for Efficiency of Feed Utilization: Now and in the Future

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Feed is the largest variable cost on most cow-calf operations and the largest cost variable in the "profitability equation" over which a producer has control. Therefore, the ability to reduce feed intake (and, therefore, feed costs) without negatively affecting reproduction, growth, carcass performance, or meat quality is becoming a priority in beef cattle selection programs (Arthur et al. 1999).

Efforts to genetically improve the efficiency of feed utilization in beef cattle have been initiated only recently in the U.S. Over the past several decades, beef cattle breed associations have focused primarily on creating expected progeny differences (EPDs) for only growth and carcass traits, which are easily and inexpensively measured (Rumph 2005). Unfortunately, these traits tend to encourage the maximization of productivity by predicting characteristics only related to generating income. Just recently has attention been directed toward traits that relate to the costs associated with U.S. beef production, including feed efficiency.

Measuring Efficiency of Feed Use

Two major challenges are associated with the genetic prediction of feed utilization: (1) historical methods used to calculate feed efficiency are generally lacking, flawed, and/or unproven, and (2) collecting individual daily feed intake for cattle is expensive compared to other performance traits (e.g., body weight gain).

Historically, efficiency of feed utilization has been measured and reported primarily as a ratio, where the amount of feed required to produce a unit of gain was determined. It has been reported as either a feed-to-gain (F:G) ratio or a gain-to-feed (G:F) ratio. Thus, for an animal that consumes 8 pounds of feed (on a dry matter basis) and puts on 1 pound of body weight gain, its F:G would be 8.0 (8 lb ÷ 1 lb) while its G:F would be 0.125 (1 lb ÷ 8 lb).

Unfortunately, the use of these simple calculations ignores an animal's current body weight and rate of gain. As a result, selection for more desirable F:G inadvertently leads to animals that have a greater mature size since animals that have a greater rate of gain are also being selected, albeit inadvertently. Ultimately, the U.S. beef industry is in need of a method to measure feed efficiency that is independent of other performance traits including reproduction, growth, and carcass performance.

Another problem is that collecting individual daily feed intake on cattle is expensive. Currently, the only methods to collect intake data involve the use of costly individual Calan gates (www.americancalan.com), GrowSafe feeders (www.growsafe.com), or small pens that only hold one head. In addition, to effectively characterize weight gain over a "test" period, cattle need to be weighed at regular intervals (typically every 2 weeks) (Exton 2001).

Finally, in order to ensure uniformity across tests and testing locations, additional variables need to be consistent including ration composition (particularly energy level of the diet) and test duration. Therefore, the U.S. beef industry is in need of either an elaborate infrastructure of technology able to record individual feed intakes and weights during a uniform test period (such as central bull test stations), or accurate methods of predicting the efficiency of feed utilization through the analysis of tissue samples (e.g., blood hormone concentration), low cost gene markers, or correlated traits that can be easily measured (e.g., mature body weight at a constant body condition score).

Current Genetic Prediction for Feed Efficiency in the U.S.

Based on producer demands for a genetic prediction of feed efficiency, several breed associations have

Table 1. Averages and ranges of EPDs that predict differences in energy requirements of future daughters of sires.

Breed assn.	EPD	Abbrev.	Units	Within breed		
				Avg.	Top 1%	Top 95%
RAAA	Maintenance energy	ME	Mcal/month	+4.0	–8.0	+13.0
AAA	Cow energy value	$EN	$/cow/year	+4.5	+29.2	–8.6

RAAA = Red Angus Association of America (www.redangus.org); AAA = American Angus Association (www.angus.org). Breed averages and ranges are for current/active sires (Spring 2009).

begun providing a genetic prediction for cow energy requirements of future daughters of sires. These genetic predictions are meant to help commercial bull buyers match their cows' feed requirements with their environment and reduce winter supplementation of beef cows without negatively affecting body condition score, reproductive performance, growth, or carcass traits. However, data used for the creation of these EPDs only include readily available data that are correlated to cow energy requirements and does not include any actual feed intake data from cattle on test.

Two EPDs that are currently available include the maintenance energy (ME) EPD from the Red Angus Association of America (RAAA) and the cow energy value ($EN) EPD from the American Angus Association (Table 1). Generally, both EPDs predict differences in energy requirements of future daughters to a bull, which directly relate to differences in feed required to maintain body weight.

It should be noted that one of these EPDs is reported on a megacalorie (Mcal) per month basis (ME), while the other is expressed in dollars saved per cow per year ($EN). A negative ME EPD is considered favorable while a negative $EN is unfavorable.

Even though these EPDs are reported in different units, they can be compared using assumptions reported by the RAAA. The RAAA assumes that the energy content of average quality range forage is 0.86 Mcal/lb (on a dry matter basis). Therefore, the offspring of a sire with an ME EPD of +6 will require approximately 7 pounds (6 ÷ 0.86 = 6.98) more feed each month (on a dry matter basis) compared to offspring of a sire with an ME EPD of 0.

Sources of data used to calculate both of these EPDs are similar. In both cases, this includes: mature cow body weight and body condition score of a sire's daughters and milk EPDs of the sire's daughters. The mature cow weights and body condition scores are collected by breeders at weaning time and are used to adjust a cow's mature body weight to a common age and common body condition score of 5. Generally, a sire that produces daughters with greater milk production (i.e., higher milk EPDs) and more growth (as seen by larger mature sizes) will have a less desirable EPD for ME or $EN.

In Australia, several breed associations are taking different approaches to predicting differences in feed efficiency of a bull's future daughters. For instance, the Angus Society of Australia (www.angusaustralia.com.au) is publishing an expected breeding value or EBV (which is equivalent to EPDs in the U.S.) for a trait referred to as net feed intake (NFI). This trait, also referred to more commonly in the U.S. as residual feed intake (RFI), is an estimate of the genetic differences in feed intake for an animal adjusted to the same growth rate and weight base. Generally, it is an alternative method of characterizing the efficiency of feed utilization in beef cattle. Since it is based on actual intake data, it will likely be the dominant feed efficiency value that is predicted in the future.

Residual Feed Intake

An animal's RFI value is calculated as the difference (in pounds) between the animal's actual feed intake and its predicted feed intake. To generate these numbers, an animal's actual feed intake is collected daily during a standard 70-day post-weaning test of an entire contemporary group of calves (from the same management group, cohort, and sex). In contrast, the value used for the animal's predicted feed intake is generated from a regression calculation using the animal's body weight and rate of gain in relation to its contemporaries.

Therefore, in order to calculate an RFI value, daily feed intake and bi-weekly weight gain must be collected for individual animals while on test. Fig. 1 contains a scatter-plot of 54 Angus steers evaluated for RFI during a post-weaning growth phase. Each dot represents an animal whose liveweight gain (X axis) is plotted against its feed intake (Y axis).

In Fig. 1, of the two individual steer data points identified within circles, both gained approximately 3.2 lb/day. However, feed consumption for these two steers was 40.7 and 56.1 lb/day, respectively. This difference of 15.4 lb/day represents a normal variation of over 35 percent, which is present within any beef cattle population.

The RFI value was developed to indicate the variation in feed intake beyond what is needed by an animal to support its maintenance and growth requirements. In Fig. 1, each steer's RFI value is the difference between the angled line and the data point for that animal. Thus, an animal that consumes less than expected for its body weight and gain has a negative RFI value and is below

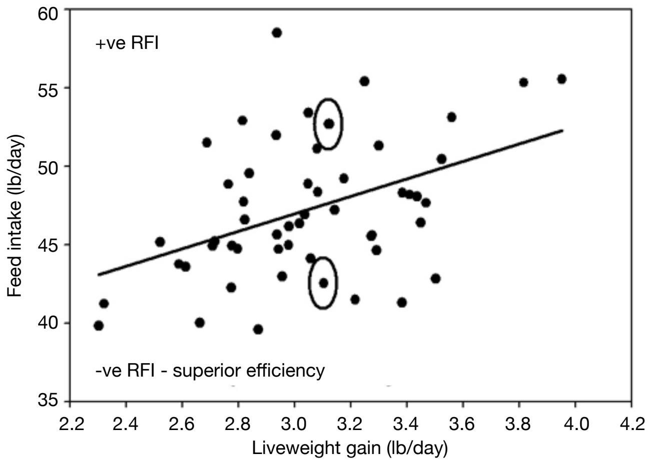

Fig. 1. Relationship between feed intake and liveweight gain in Angus steers (Baker et al. 2006). Animals with data points above the diagonal line are classified as having a positive ("+ve") RFI value, while those below the line are classified as having a negative ("-ve") RFI value, which is considered to be "superior efficiency."

the angled line. This animal is considered "efficient" since this equates to improved feed efficiency.

For example, an animal with an RFI value of –2.0 infers that the animal consumes 2 lb/day less than is required by that animal. Conversely, an animal with a positive RFI value is considered "inefficient" since it eats more than expected and is above the angled line in Fig. 1. Longer-term research is underway to evaluate the effect of selecting sires of the steers below the angled line on the overall feed efficiency of a cowherd.

To further emphasize the value of RFI as a measure of efficiency, results of an RFI evaluation of 35 Angus-sired steer calves during a post-weaning RFI test are reported in Table 2. Means for performance traits have been compared across RFI groups, which were assigned after individual RFI values were determined for each animal on test.

Body weight and carcass weight did not differ across RFI groups. However, the average RFI value was 2.7 lb/day different between the efficient and inefficient steers while average daily gain was the same. This difference in RFI was due to a substantial difference in dry matter intake (2.7 lb/head/day) between the efficient and inefficient steers, but not due to a difference in gain. Therefore, during the entire RFI evaluation period, the efficient steers consumed over 200 pounds less feed on average than the inefficient steers while maintaining the same rate of gain and body weight.

Economic Implications of RFI Selection

Residual feed intake is becoming the broadly accepted gold standard for measuring feed efficiency in the research community because it is superior to the other feed efficiency measures mentioned earlier. Since RFI is moderately heritable ($h^2 = 0.16$ to 0.43) (Herd et al. 2003), it offers a genetic selection method to improve beef cattle feed efficiency without also increasing growth rate and mature size (Johnson et al. 2003), or affecting growth performance (Herd et al. 2003). In Australia, selection of parents with low RFI values (considered efficient) resulted in progeny that consumed less feed as yearlings but weighed the same at harvest as offspring from high RFI parents (Richardson et al. 2001).

Implementation of RFI has a potentially large economic gain that could be realized by the industry in a short time-frame. Since RFI is independent of most other known performance traits, a savings in feed costs and energy costs used to produce feed (including fossil fuel savings) can be expected. Archer et al. (2004) used two different models to estimate that long-term improvement in profitability may be between 9 and 33 percent. Note that these calculations did not factor in recent increases in grain prices, which are unlikely to return to previous levels.

Using a conservative figure of 7 percent cost savings and modeling this savings under typical U.S. conditions, RFI implementation could improve both resource use and economic viability of cattle operations (e.g., $350 feed cost/cow/yr x 0.07 = $24.50/cow/yr). However, it should be noted that the effect of long-term genetic selection based on RFI values (generated via bull or steer progeny developed on moderate- to high-concentrate diets) on high-forage cowherd feed costs has not yet been well documented.

Table 2. Least squares means for performance traits of steers classified into "efficient," "marginal," and "inefficient" groups based on residual feed intake (RFI) value (adapted from Ahola et al. 2007).

	RFI group		
Trait	**Efficient**	**Marginal**	**Inefficient**
N =	9	18	8
Initial body weight (d 0) (lb)	680	662	682
ADG (lb/day)	2.84	2.95	2.86
Dry matter intake (lb/day)	19.8[b]	21.1[b]	22.5[c]
Residual feed intake (lb/day)	–1.3[b]	0.0[c]	+1.4[d]
Feed conversion ratio (DMI:ADG)[a]	6.97[b]	7.21[b]	7.92[c]
Gain-to-feed ratio (ADG:DMI)	0.144[b]	0.140[b]	0.127[c]
Final body weight (d 84) (lb)	920	911	922
Hot carcass weight (lb)	716	703	716

[a]Steers were classified as "efficient" (> 0.5 standard deviation above the mean; n = 9), "marginal" (± 0.5 standard deviation from the mean; n = 18), and "inefficient" (< 0.5 standard deviation below the mean; n = 8) groups based on RFI values.

[b,c,d]Means in the same row without common superscripts are different ($P < 0.05$).

RFI Relationship with Other Traits

The potential for improvement in feed efficiency arguably will have the greatest economic impact on beef production seen in decades, but it is essential that product quality is considered in development of any new performance trait. One of the greatest advantages in using RFI as a feed efficiency trait is that it appears to be independent of most other performance traits that have been evaluated to date. Thus, it is ideal for use in multi-trait selection indices, and other broad-based performance evaluations. As a result, Australian researchers are now using RFI in a selection index to simultaneously target efficiency and other parameters such as performance and product quality (Arthur et al. 2004). Exton et al. (2004) have identified Angus bulls in Australia that are superior for both marbling and RFI.

During the past 6 years, research at the University of Idaho has focused on the interaction between RFI and product quality. In agreement with research in other countries, there appears to be no relationship between RFI and measures of carcass and product quality, such as ribeye area, fat thickness, yield grade, or quality grade in Angus cattle (Baker et al. 2006).

Future of Predicting Feed Efficiency

One of the greatest impediments to implementing RFI is the cost of identifying sires with superior RFI values. The most reliable data are provided by measuring RFI in multiple progeny in a standard 70-day post-weaning test. Measurement of at least 15 progeny per sire is a minimum requirement, and increasing the number of progeny evaluated improves the accuracy of the trait estimate. Thus, there is a high cost associated with collecting these data. In response, researchers have recently begun to search for useful indicator traits for RFI including plasma hormone concentrations and candidate genes. It is likely that in the future the cost of evaluating RFI will be reduced through use of indicator traits. However, data from indicator traits will still need to be validated and referenced to absolute measures of RFI.

Due to the correlation between post-weaning RFI and average daily feed intake, selection for feed efficiency using the RFI trait could potentially improve feed efficiency in cattle through reduced feed intake (Herd et al. 2003). Cost-effective methods of characterizing large numbers of cattle for RFI (in order to enable and promote genetic selection for RFI) are not yet widespread in the beef industry. However, based on the substantial amount of variation in RFI within a population, it is likely that cattle producers will place increased pressure on seedstock suppliers to develop and provide them with an RFI EPD for efficiency.

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