Feed Efficiency in Cows

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Introduction

The definition of *efficiency* is a ratio of outputs to inputs. Businesses use measures of efficiency to establish benchmarks and goals for production and finance. Measuring efficiency may result in decisions that increase productivity without increasing costs of production resulting in greater margins. A well-run, profitable commodity business is usually run more efficiently than its competitors. In the case of beef cattle, competition can come from two sources: other producers who sell similar classes of cattle; and, other protein producing species, such as pork and poultry, which compete with beef in the marketplace. Measuring efficiency across the entire integrated beef system is difficult due to the different classes of cattle (growing, breeding, fed), breed differences, and how the different biological systems (nutrition, reproduction, lactation, basal metabolism) interact (for example how nutrition interacts with reproduction). There are measures of efficiency that can be used in beef production. One of these is feed efficiency.

In Florida, the predominant classes of cattle are females (replacement heifers, young and mature cows) that graze forages. However, most feed efficiency research has focused on growing cattle, with little work data collected on cows that consume a majority of an operations feed resources.

Approximately 55 to 75% of the total costs associated with beef cattle production are feed costs (NRC, 2000; Arthur et al., 2001a; Basarab et al., 2002). A 5% decrease in feed efficiency could have an economic impact four times greater than a 5% improvement in average daily weight gain (Basarab et al., 2002). In feedlot studies demonstrated that a 10% improvement in average daily gain (ADG) as a result of a 7% increase in appetite improved profitability 18%, whereas, a 10% improvement in feed efficiency returned a 43% increase in profits (Fox et al., 2001). Thus efforts at improving the efficiency of feed/forage use will have a large impact on reducing input costs of beef production. For example, in Florida alone with approximately 1.83 million cattle on inventory, a 10% increase in feed/forage efficiency could reduce production costs by at least $36 million annually.

Defining Feed Efficiency

Feed efficiency (or its inverse, feed conversion), is described as units of feed/forage consumed divided by the units of animal weight gain over a specific time period. Many factors influence feed/forage efficiency including age, diet type, environmental temperature, breed, growth promotants, and many other management and environmental variables (NRC, 2000). There is genetic variability in feed efficiency beyond that explained by size and growth rate of beef cattle (Herd and Bishop, 2000; Archer et al., 1999; Arthur et al., 2001a; Arthur et al., 2001b).

Feed Conversion Ratio

Feed efficiency is a measure of how much saleable product is being produced for each unit of feed consumed. In beef operations (specifically for growing cattle), the most common measurement of feed efficiency is feed conversion ratio (FCR), which is the ratio of feed intake to live-weight gain. A calf that consumes 15 pounds of feed per day and gains 3 pounds live-weight per day would have a FCR

of 15 to 3 or 5:1 or simply 5. Feed conversion ratio is a gross measure of feed conversion and most often used as a tool to evaluate groups or pens of growing cattle to determine costs of production and break even prices in feeding operations. Cattle that will convert at a high rate (lower FCR) are highly desirable for cattle owners and for feedlots that charge on a gain basis. Feed conversion ratio is moderately heritable (Crews, 2005) and cow/calf producers who have access to this data can potentially use this information as a marketing tool to promote the sale of their feeder calves. However, in terms of benefit to a beef producer transferring this form of feed efficiency to their cow herd producers may only use correlations and assume that dams of calves with low FCR on grain diets are more feed efficient on forage based diets than dams of calves with higher FCR.

Residual Feed Intake

Residual feed intake (RFI) measures the variation in feed intake beyond that needed to support maintenance and growth requirements, and is calculated as the difference between actual feed intake and the feed an animal is expected to consume based on its body weight and average daily gain. When cattle consume less feed than expected for their body weight and average daily gain they have a negative RFI, which equates to an improvement in feed efficiency. Understanding the interactions of feed efficiency or RFI on biological processes and management procedures is critical to utilizing RFI as a tool for cattle selection by beef producers. Feed and forage efficiency improvement will increase ranch profit through reduced input costs and reduce potential environment disruption through reduced animal nutrient waste. This is especially critical when the cost of feed resources continues to increase, the availability of forages continues to decrease, and our need to consider the effects of the cattle industry on environmental impacts.

Reducing feed costs in beef cattle can significantly improve profits to the production enterprise. Studies have shown differences in RFI values that range between -4.3 lb/day to 4.0 lbs/day. This represents a difference of over 8.3 lb/day feed savings in efficient versus inefficient animals. The savings in feed costs between low and high RFI animals could be as high as $92 (assuming 170 days on feed and $130/ton of feed). Benefits to the cow-calf and seedstock producers have yet to be quantified; however, results would be expected to be similar to those found in growing cattle. One of the important findings in almost all of the studies to date, show little correlated response in other important traits when selecting for RFI.

Unlike FCR, RFI is phenotypically independent of the traits that are used to calculate it. As an example, a data set that was collected in the Feed Efficiency Facility (FEF) at the North Florida Research and Education Center in Marianna is shown with RFI and average daily gain (ADG) presented. There is a substantial representation of different gains and variation in RFI. Calves A and B (noted in the figure) both entered the FEF weighing 819 pounds and left weighing 1051. Their weights and gains (3.32 lbs/day) are identical. Based on their weight and performance numbers, the calves were expected to consume 24.32 pounds of feed/day. However, calf A's actual daily intake was 22.86 pounds and calf B's actual daily intake was 25.76 pounds for RFI's of -1.46 and +1.44, respectively, a difference of 2.90 pounds of feed consumed per day.

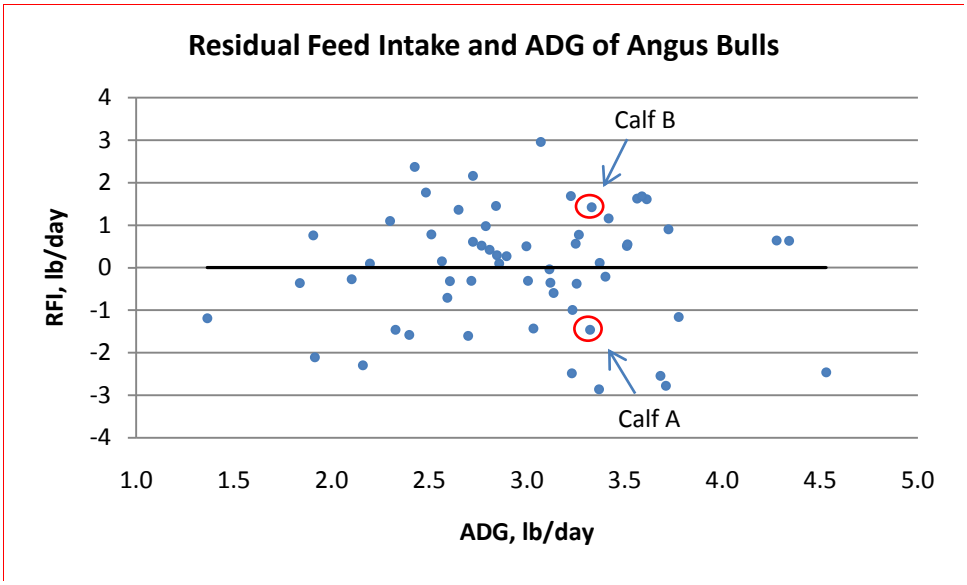
Over the course of the 70 day feeding period, calf A consumed 203 pounds less feed than calf B, yet performed exactly the same. Assuming similar diets and a similar rate of gain (3.32 pounds/day) it would take each calf 180 days to gain 600 pounds but calf A would consume 522 pounds less feed. For 100 calves in a feedlot pen, this translates into 52,200 pounds less feed, and at $0.08/pound feed, this would result in a savings of $4,176 ($41.76 per calf). Assuming all other costs are equal the resulting cost of gain in pen A would be $0.07/lb less than in pen B. Once again this is a significant savings for the feeder.

Residual feed intake is moderately heritable. Lines of cattle that were selected for low RFI after two generations had similar weights and performance yet consumed 11% less feed (Arthur et al., 2001c). In addition, there

is a strong correlation with RFI measured after weaning and RFI measured in mature breeding females (Archer et al., 2002). Selecting for RFI has not been shown to increase mature weights or affect other phenotypic traits in cattle.

weight gain are also limited. Some researchers have demonstrated a moderate relationship with average daily gain in that fast growing animals also tended to be efficient (Koots et al., 1994a), but others have demonstrated essentially no

Figure 1 Residual feed intake (RFI) and average daily gains (ADG) from cattle fed at the University of Florida - North Florida Research and Education Center, Marianna.



Selecting for Feed Efficiency

Selection for feed efficiency in cattle has traditionally been accomplished by indirect procedures and various management strategies (i.e., not direct selection). Many factors influence feed/forage efficiency including age, diet type, environmental temperature, breed, growth promotants, and many other management and environmental variables (NRC, 2000). Cattle selected for divergent RFI lines over a five-year period showed average selection differentials of -0.32 and 0.39 kg/d per year for the low and high lines, respectively. An annual divergence rate in RFI of 0.21 kg/d was achieved between the lines with a realized heritability of 0.33 (Arthur et al., 2001a). While RFI, feed intake (FI) and feed conversion rate (FCR) changed significantly over the duration of the study, average daily gain (ADG) and 365-Day body weight remain constant indicating selection for RFI did not impact growth rate.

Published relationships of feed conversion or RFI with other traits such as average daily

relationship (Herd and Bishop, 2000; Herring and Bertrand, 2002). Relationship of carcass fat content was also inconsistent with no relationship in some studies (Herd and Bishop, 2000; Arthur et al. 2001c; Richardson et al., 2001) and a moderate relationship in another (animals with improved efficiency were also leaner, Herring and Bertrand, 2002). Relationships with mature cow size are even more limiting, but Herd and Bishop (2000) presented preliminary evidence that selection for improved feed efficiency has little effect on mature cow size. Little is known about the relationship between feed efficiency and reproductive efficiency, demonstrating the need to continue this work. In fact a search of the literature indicates that a single abstract (Lancaster et al., 2006) noted a relationship between residual feed intake and reproductive efficiency.

Selection for RFI in cattle can have dramatic implications in the beef cattle industry.

Table 1. Average forage intake (DMI) of cows with low and high residual feed intake (RFI; adapted from Meyer et al., 2008)

Variable	Low RFI	High RFI
Experiment 1		
DMI, lbs/day	27.28	34.32
Experiment 2		
DMI, lbs/day	27.50	31.02

Low RFI in cattle consume less feed and have lower maintenance requirements while growth appears to be unaffected. Improving feed efficiency by selecting for RFI also has the potential to reduce animal waste and methane gas production. Generation of RFI expected progeny differences (EPDs) will allow for the selection of more efficient animals. Preliminary data indicate that post-weaning RFI is highly related to mature cow efficiency without reproduction being reduced. Recent research at the U.S. Meat Animal Research Center (MARC) in Clay Center, NE demonstrated that tropically adapted breeds (Brangus and Beefmaster) performed as well or exceeded *Bos taurus* genetics in most of the economic traits of importance with the exception of carcass quality traits (Cundiff, 2004). Previous studies have shown that this advantage can be tripled in tropically adapted cattle when studies are conducted in subtropical/tropical environments (Olson et al., 1991). This project will allow for the evaluation of tropically adapted breeds in a subtropical environment, thereby improving the ability of producers using these types of cattle to compete in a global economy.

Feed Efficiency in Cows

Improving feed efficiency is not just relegated to growing cattle and some differences may be seen in mature cows. About half of the feed in beef production systems is used to maintain the breeding herd. Of the remaining 50%, about 20% is used by the breeding cow for pregnancy and lactation and 30% is used by the growing. Although little work has been validated in lactating and non-lactating beef cows, two studies have indicated that selection for low RFI may have positive effects on future forage intake and reproductive efficiency.

In non-lactating beef cows fed a forage-based diet, the most efficient cows (top third) consumed about 20 % less forage than the least efficient cows (bottom third; Meyer et al., 2008). Therefore, when forage is limited small improvements in efficiency can make a large improvement in cowherd maintenance. Therefore, selection of replacement heifers based on efficiency could assist in the reduction of maintenance costs of the cowherd. However, little data is available that demonstrates the overall productivity of beef cattle operations that have selected for feed efficiency over several generations.

A recent study investigated the postpartum performance of Brahman first-calf heifers and multiparous cows which had been previously evaluated shortly after weaning for feed efficiency (RFI; Lloyd et al., 2009). Although prepartum and postpartum body weight and body condition score did not differ by RFI group for either cows or heifers, efficient cows exhibited estrus sooner (42 ± 4.1 vs. 55 ± 3.7d), developed a corpus luteum (CL) sooner (40 ± 4.1 vs. 53 ± 3.7d), and exhibited estrus in conjunction with CL formation sooner (42 ± 4.1 vs. 54 ± 3.9d) than inefficient cows. However, no difference was detected between efficient and inefficient heifers for estrus and/or CL formation. The authors concluded that selection for efficient cattle using RFI as a selection tool may result in a shorter postpartum interval in multiparous Brahman cows.

The Future of Feed Efficiency Research

Research in beef cattle has focused on growth and more recently carcass traits while genetic variation that controls feed/forage efficiency has gone unexplored. In addition, the relationship of fertility and feed efficiency has barely been researched. To beef producers, fertility often is overlooked as one of the most important traits to ensuring the economic viability of their operations. With feed and forage accounting for the single largest variable expense for most beef cattle production systems, one would think that more research in beef cattle feed efficiency would have be conducted. However, it is a trait that is often overlooked but has a strong economic impact upon the production of beef cattle. One of the greatest detriments to feed efficiency evaluation is the cost of measuring the trait and resources needed to conduct this type of research. With the advent of systems (GrowSafe) that reduce the tedious labor required in data collection, feed efficiency has become the focus of several researchers as its potential economic impact is beginning to be realized by the beef cattle industry. This technology also allows scientists to evaluate other important biological and management related effects on animal production.

To date, RFI studies have used primarily *Bos Taurus* breeds adapted to temperate climates (Herd and Bishop, 2000; Arthur et al., 2001a; Crews et al., 2003) while almost no information is available on subtropical adapted breeds. Preliminary data in Brangus (Shirley et al., 2006), Bonsmara (Brown et al., 2004; Fox et al., 2004) and Santa Gertrudis (Brown et al., 2005) cattle indicate that there is sufficient variation within and between subtropical/tropical breeds for genetic selection for RFI. The objectives of future studies needs to investigate feed efficiency in animals that are known to be adapted to subtropical/tropical climates (such as Brangus, Braford, Brahman, Beefmaster, Mashona crosses, Red Brangus, Senepol, etc.). Comparisons between and within these breeds would allow for estimation of breeding values and opportunities for selection of animals that are more feed efficient. Producers growing cattle in the subtropics/tropics would then have germplasm available for the production of more feed-efficient beef cattle.

Summary

Feed efficiency is not a new measure, but it is one that is receiving more attention as feed costs have increased. Many seedstock producers and bull testing facilities have installed technology that allows for the determination of RFI and some breed associations have started the process of standardizing data collection and analysis and soon EPD's and Value Indices for feed efficiency will be reported. The use of DNA testing for feed efficiency is becoming more widely available. Producers who would like to include feed efficiency in their selection criterion will have several tools available to them.

In sum, selection for RFI for growing and mature cattle has the potential to: 1) lower maintenance requirements of the cow herd by up to 10%; 2) reduce overall feed intake by up to 15%; 3) improve feed conversion ratio by up to 15%; 4) reduce weights of visceral organs; 5) improve calf-weight-per-cow feed intake by as much as 20%; 6) reduce methane emissions; 7) reduce manure nitrogen, phosphorus an potassium production by as much as 20%;

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