A NEW GENETIC PREDICTION FOR COW MAINTENANCE ENERGY REQUIREMENTS

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Introduction

The increased competition from alternative protein resources such as pork and poultry is challenging the beef cattle industry to be more critical of profitability and sustainability. To ensure financial sustainability in both domestic and global markets, beef cattle producers need to produce a quality product more efficiently. Therefore, the most accurate selection and mating decisions should be made using information that determines the risks and returns (Golden et al., 2000).

Beef cattle are biologically less efficient and require a higher total life cycle dietary energy intake in comparison to other meat animal species (swine and poultry) (Ritchie, 2000). According to Dickerson (1978), a higher proportion of feed energy is required to produce a unit of edible protein in beef cattle relative to other meat animal species (Table 1). Beef cattle are at a disadvantage when evaluated against swine and poultry for product efficiency; however, as a ruminant, cattle can utilize forages that monogastrics are unable to digest (Ritchie, 2000). Therefore, it is important to select and produce cattle that will efficiently convert forage resources to high quality protein.

Table 1. Mean feed energy requirements per unit of protein deposition in different livestock species[1]

Species	MJ Feed / kg of meat protein
Broiler Chicken	336
Turkey	363
Rabbit	438
Pork	633
Lamb	1,787
Beef	1,849

[1]Adapted from Dickerson (1978)

The average maintenance requirements for a mature cow represent approximately 70 percent of her feed expenses (Ferrell, 1988). In a summary of SPA data (1991-1999) for the southwestern states (Texas, Oklahoma, and New Mexico), the average feed cost per cow was 42% of the total annual production cow cost (McGrann, 1999). In order to be profitable and sustainable, it is important that cattle producers be able to select animals that fit their production environment. Some animals simply have lower energy requirements for maintenance and are able to maintain their body tissues with fewer calories. For example, many producers probably have at least one cow that always rebreeds, seems to always be fatter than others in the herd despite poor feed conditions, and will produce a calf each year no matter what the environmental conditions.

What is maintenance energy?

The maintenance energy requirement of an animal is the energy required to sustain their body tissues with no net change in body tissue. Simply stated, it is the amount of feed required so an animal is not gaining or losing weight. This level of energy intake does not include the additional energy needed for an animal to grow, sustain a pregnancy, lactate, or withstand changes in weather.

Previous research has reported maintenance energy requirements in beef cattle to be heritable (Hotovy et al., 1991) and differences are present between breeds (Ferrell and Jenkins, 1985). A 1985 study by Meat Animal Research Center (MARC) scientists, Ferrell and Jenkins, compared several breeds and measured their requirements for maintenance energy (Table 2). Their results showed that maintenance energy needs are different across breeds, especially breeds with above average milk production. Having genetic predictions for maintenance energy requirements could provide cattle producers with an additional selection tool to manage inputs and enhance cow efficiency; however, collecting and recording large volumes of individual feed intake and calorimetry data is both an expensive and time consuming process and is not practical on a breed-wide basis.

Table 2. Estimates of metabolizable energy required for maintenance (MEm) of various breeds or breed crosses[a]

Breed or breed cross	**Physiological state**	**MEm, kcal/(kg$^{.75}$ •d)**
Angus-Hereford	Non-pregnant, non-lactating, 9-10yr	130
Charolais X	“ “ “	129
Jersey X	“ “ “	145
Simmental X	“ “ “	160
Angus	Non-pregnant, non-lactating, 5-6yr	118
Hereford	“ “ “	120
Simmental	“ “ “	134

[a]Adapted from Ferrell and Jenkins, 1985

In the past, mature size has been used as an indicator trait of maintenance energy requirements. On average, animals with heavier mature weights will require more energy intake to maintain their basic body functions when compared to a smaller mature weight animal. Using the relationship between mature size and maintenance energy, an animal's body weight can be used to estimate their maintenance energy requirements. Previously, research has shown that mature weight alone is not the most accurate for this purpose; however, it is more practical than other methods, such as calorimetry.

Maintenance energy requirement is more properly estimated when the mature weight is adjusted to account for differences in body size (surface area) to obtain what is known as metabolic body weight. Metabolic body weight is calculated as a fractional power of shrunk body weight, with the most commonly agreed upon adjustment being body weight to the three quarter power ($BW^{0.75}$) (NRC, 1996). Previous work has shown that $BW^{0.75}$ is proportional to an animal's fasting energy expenditure; therefore, an individual's maintenance energy requirement will scale with weight. All other factors being equal, this means that a small animal will be expected to have a higher metabolism per pound than a larger animal.

Another important source of variation for maintenance requirements is an animal's visceral organ mass, including the stomach, liver, intestines, and cardiac tissue. Additional research by Ferrell and Jenkins showed differences were present between breeds for visceral organ mass because of specialized functions within breed, such as lactation, which places a higher physiological demand on energy requirements. Therefore, differences in visceral organ mass should be associated with differences in level of milk production. If all factors except visceral organ mass are equal, individuals with genes for higher milk production are more likely to have a larger visceral organ mass compared to individuals with genes for lower levels of milk production. In a Texas A&M study (Solis et al., 1988), they reported differences among individuals for milk potential will also manifest as differences in visceral organ mass.

Cattle with genetic merit for higher milk production will often have higher maintenance requirements (Table 2). In fact, a University of Nebraska study (Montano-Bermudez et al., 1990) estimated that milk production was responsible for 23 percent of the variation for maintenance energy requirements. In a related study, Van Oijen et al. (1993) showed that the low milk producing breed groups were consistently more biologically and economically efficient for cattle marketed both at weaning and slaughter. Additionally, a recent research project at Oklahoma State University reported that dry matter intake in Brangus cattle was positively associated with milk production in both mature cows and heifers (Johnson, 2002).

Maintenance Energy EPD

Unlike an indicator trait such as mature weight, an EPD for maintenance energy requirements in beef cattle would fit well into a developing list of economically relevant traits because of its direct effect on the profitability of a cow-calf enterprise (Golden et al., 2000). Cattle producers that emphasize selection to increase growth and milk with no regard for the change to genetic merit for cow herd nutritional requirements risk a detrimental impact on maintenance requirements and production costs. A genetic prediction for maintenance requirements would enable cattle producers to effectively select animals with an optimum level of energy expenditure, to better match cattle to their forage and production environment, and to provide additional insurance for harsh weather conditions.

The development of an economically relevant EPD for cow maintenance energy requirements was feasible because of research at Colorado State University and the USDA-ARS Fort Keogh Laboratory in Miles City, MT. We used equations from the current version of the National Research Council guidelines for beef cattle nutrition and research results of Dr. MacNeil with the USDA-ARS Lab. We combined this information with available genetic predictions in National Cattle Evaluation for mature weight and milk (maternal weaning weight) to construct a prototype maintenance energy requirement EPD (Evans, 2001).

The equations used in this study to predict maintenance energy requirements include mature weight and milk EPD. Using known relationships between mature weight and maintenance energy requirements, we calculated the maintenance requirement using metabolic body weight or weight to the three quarter power and converted it to megacalories (Mcal).

Using mature weight to explain differences in cow maintenance energy requirements is a good place to start; however, mature weight alone might be insufficient to explain differences among animals for maintenance energy requirements. Previously reported research shows that individuals and breeds of similar biological type for mature size are not necessarily equivalent for maintenance energy, especially when we evaluate them at different levels of production (i.e., lactation)(Montano-Bermudez et al., 1990).

Although the milk EPD is not derived directly from milk production and is determined from the maternal component of weaning weight, it is well documented that the milk EPD adequately represents differences in actual milk yield (Mallinckrodt et al., 1993). These differences in milk producing potential can be related to differences in energy requirements for lactation and variation in visceral organ mass. Interestingly, this higher energy demand does not dissipate when a cow is in the dry period of production (Solis et al., 1988). Even though a cow is not milking, she still must maintain the body tissues that drive her higher milk production.

Researchers have also determined how animals lactate over time and what the energy values are for milk components (Wood, 1969; NRC, 1996). Using this information, we are able to represent lactation with a mathematical function (lactation curve) and use milk EPD to predict an animal’s milking ability. The genetic merit of an individual for higher or lower milk production would affect their prediction for cow maintenance energy requirements. Therefore, animals of the same mature size but different levels of milk production would consequently have different maintenance energy requirements. This approach to predicting maintenance energy helps explain additional differences among animals in a population and improves the accuracy of each maintenance energy requirement prediction.

Trait Expression

Currently, the trait for mature cow maintenance energy is expressed as megacalories per year (Mcal/yr). Because this is a relatively new trait, we are still determining if this is the most appropriate way to express the trait. The benefits of using megacalories instead of other units of measure are that it is easy to translate to other energy units and it conforms to what is accepted by the nutrition community and National Research Council guidelines for nutrition in beef cattle. Additionally, people are familiar with calories on nutrition labels, so expressing the trait in these units is not completely foreign.

It will be important to express the trait for maintenance energy requirements in such a way that cattle producers will thoroughly understand the interpretation and correctly apply it in their breeding programs. One way to enhance the understanding of a maintenance energy EPD would be to use example diets (i.e. pasture grass, grain, or hay) to provide a frame of reference for producers to interpret and compare animals for maintenance energy requirements. Using an example diet and reasonable estimates of feed prices, a cattle producer could directly assess the economic risk of using one sire over another sire in a breeding program.

Current Research

A prototype EPD for cow maintenance energy requirements has been completed for the Red Angus breed (Evans, 2001). There is a summary of the results in Table 3 and the EPD are expressed on an annual scale (Mcal/yr). The results of this analysis show that differences are present among all animals and sires for maintenance energy requirements. For all animals, there is greater than a 1,000 Mcal per year difference between the highest and lowest animal. A cattle producer could use this EPD in a selection program to modify maintenance energy needs in his/her herd and select cattle whose maintenance energy requirements are most appropriate for the environment in which they will be managed.

How does this maintenance EPD work? For example, we have a herd of Red Angus cows and two sires available at breeding time. Sire A has a maintenance energy EPD of 400 Mcal/yr and sire B has an EPD of 0 Mcal/yr. On average, we expect the progeny from Sire B to require 400 fewer Mcal per year for maintenance energy requirements relative to progeny of sire A. You might be asking yourself how many days on feed does that value equal? If we take an average Red Angus cow, she will require 11 Mcal per day or 4,015 Mcal per year of energy. Reducing her energy needs per year by 400 Mcal would result in a 10% reduction in annual feed inputs. If all other factors remain constant, this reduction in the number of calories should result in fewer feed inputs and a lower cost of production. If the average annual feed cost per cow was $167/year (McGrann, 1999), the reduction in feed inputs for maintenance energy requirements would result in more than a $16 reduction in feed inputs.

Table 3. Mean, standard deviation, and range of EPD (Mcal/yr) for mature cow maintenance energy for Red Angus cattle

	All Animals (N = 56,582)	Sires (N = 5,912)
	EPD	EPD
Mean	22.4	23.8
Standard Deviation	102.1	94.8
Minimum	-427.9	-381.9
Maximum	581.9	434.0

A change in maintenance energy requirements for any one animal might be viewed as unimportant; however, these changes do accumulate across an entire herd and over multiple generations. Selecting animals to reduce maintenance energy requirements could impact a producer's profitability through a reduction in production costs given all other performance indicators were unaffected.

The genetic trend for maintenance energy requirements is illustrated in Figure 1. This trend shows the average EPD for maintenance energy requirements in the Red Angus breed for years 1945 to 1995. There is a 2.0 Mcal/yr change in the genetic trend for all years; however, mature weight data collection started in 1970. After 1966, the rate of change for the genetic trend increased to 3.8 Mcal/yr. This trend was maintained until 1989 followed by a decreasing rate of change and leveling of the genetic trend for maintenance energy requirements.

New Directions

The EPD that we proposed for maintenance energy requirements is a prototype. More research is necessary to improve the accuracy of the genetic predictions. Currently, we are just using mature weight and milk (maternal weaning weight) to predict mature cow maintenance energy requirement. We selected these traits because the genetic predictions and methods were available to develop an EPD for the trait. Alternative indicator traits and direct measures of maintenance energy are needed to improve the accuracy of this EPD. Other candidates for indicator traits might include body condition, visceral organs (i.e., liver size), and cell-level indicators of maintenance energy requirements. Additional research will be required to determine how these sources of information can be incorporated into the current genetic prediction.

Body condition score data are another source of information to enhance the accuracy of an EPD for maintenance energy requirements. The trait for body condition score is easy and cost effective to collect and body condition is a heritable trait (Marlowe et al., 1985). Including body condition score information has the potential to account for differences among animals with the ability to store excess energy because of lower maintenance energy requirements. However, further research is needed to determine the most appropriate way to include body condition data into an EPD for maintenance energy requirements.

The visceral organ mass, more specifically the liver, represents one potential source of information for the prediction of maintenance energy requirements. In beef cattle, the liver is one of the most metabolically active organs and consumes approximately 22% of an animal's energy expenditure as a function of an animal's fasting heat production, but it only accounts for 1.6% of animal's weight (Ferrell, 1988). Compared to other visceral organs, the liver is a good candidate for an indicator trait of maintenance energy requirements.

A challenge with collection of data for liver size is how to collect the information without harvesting the mature animal. Previously, ultrasound technology has been studied as a method to predict the size of the liver (Braun, 1990). Research conducted at Colorado State University evaluated the application of this technology using feedlot cattle. The research results showed no relationship between several linear measures of liver size using ultrasound technology and actual liver weight (Ruppert, 2001). Further research is needed to determine the application of ultrasound technology for the prediction of liver size, in addition to the most appropriate age and class of animals to use.

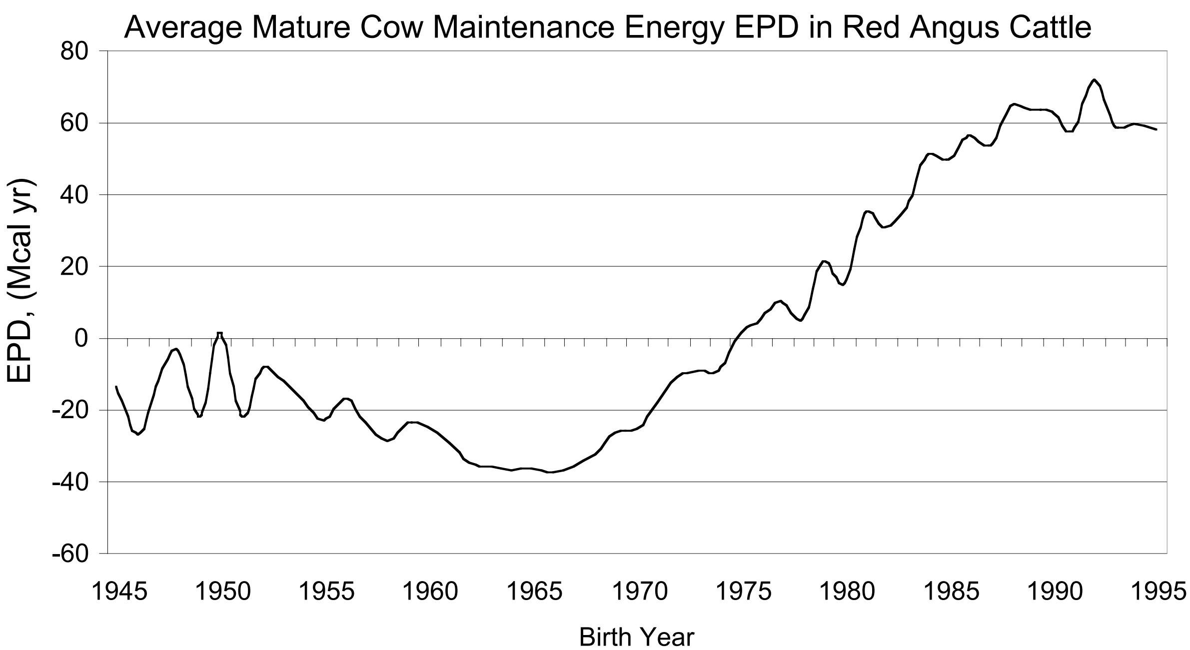

Figure 1. Average EPD (Mcal / yr) for mature cow maintenance energy requirements by birth year in Red Angus cattle.

Summary

A predictor for mature cow maintenance energy requirements should provide both commercial and seedstock producers with a selection tool for a trait that directly impacts cost of production. An EPD for maintenance energy requirements will add to a developing list of economically relevant traits and provide producers with the tools to practice balanced selection for traits with direct impact on profitability. If adopted by the industry, producers will need to continue their efforts to collect mature weight information and other indicator trait information. Furthermore, researchers will need to continue to research and enhance this new economically relevant trait.

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