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REVIEW

REVIEW: Life-cycle, total-industry genetic improvement of feed efficiency in beef cattle: Blueprint for the Beef Improvement Federation[1]

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ABSTRACT

On a life-cycle basis, beef animals are able to consume large amounts of low-cost, low-quality forages relative to higher-cost concentrates compared with pigs and chickens. However, of the 3, beef is still more expensive to produce on a cost–per–edible pound basis. Accordingly, there is need for genetic programs and management changes that will improve efficiency, sustainability, and profitability of beef production. Options include improving reproductive rate, reducing feed used for maintenance, or both, while not reducing output. A goal for improving efficiency of feed utilization is to reduce the amount or proportion of feed used for maintenance. Such reduction is a target for genetic improvement, but such a goal does not include defining a single measure of efficiency. A single efficiency measure would likely lead to single-trait selection and not account for any potentially antagonistic effects on other production characteristics. Because we are not able to explain all variation in individual-animal intake from only knowledge of BW maintained and level of production, measuring feed intake is necessary. Therefore, our recommendation is that national cattle evaluation systems analyze feed intake as an economically relevant trait with incorporation of appropriate indicator traits for an EPD for feed intake requirements that could then be used in a multiple-trait setting such as in a selection index. With improvements in technology for measurement of feed intake, individual measures of feed intake should continually be collected to facilitate development of genetic predictors that enhance accuracy of prediction of progeny differences in national cattle evaluations.

Key words: beef cattle, feed utilization, intake

INTRODUCTION

Beef, as a protein source for humans, has 2 major positive characteristics relative to pork and chicken: 1) consumers, on average, place greater preference on beef in its eating characteristics and 2) beef animals, on an industry-wide life-cycle basis, consume large amounts of lower-cost forages as compared with higher-cost concentrates. Although these positive characteristics exist, beef production still needs to improve cost per unit of product because it has greater cost per edible pound than does chicken and pork. If one compares edible

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product per unit of feed energy input, beef production is about one-third as efficient as pork production and about one-fifth to one-sixth as efficient as broiler production (adapted from Dickerson, 1978). Greatly lower reproduction per breeding female in cattle is a major contributor to the inefficiency, and adding the consumer-desired intramuscular fat in beef contributes to slaughter beef animals having greater total-carcass waste fat compared with slaughter pigs and broilers.

Implementing genetic programs and management changes that can improve efficiency of beef production requires answers to several questions. Some of these questions follow, and our goal in this paper is to provide answers to these questions, based on current knowledge. From an industry-wide perspective, what are the opportunities for improving efficiency of feed utilization? What can we learn from the pork and broiler industries in how they have approached genetic improvement of efficiency of feed utilization? Are there potential antagonisms between feed utilization or efficiency measurements and other economically relevant traits in beef cattle? What phenotypic and genomic data collections are warranted, and how will these be incorporated into National Cattle Evaluation programs? Where are the holes in our knowledge base, and what are the needs for future research to generate answers?

REVIEW AND DISCUSSION

Do We Need to Measure Feed?

Efficiency has been conventionally expressed as the ratio of output per unit of input. However, expressing efficiency in a linear form as output minus input has better statistical properties and comes closer to economic measures such as net return (value of output minus cost of input). If we express feed efficiency of the beef life cycle on an average dam basis and in linear form, we have the following (adapted from Dickerson, 1970):

$$\begin{aligned}&(\text{Dam BW} \times \text{Lean Value of Dam}\\&+ \text{No. Progeny} \times \text{Progeny BW}\\&\times \text{Lean Value of Progeny})\\&- (\text{Dam Feed} \times \text{Value of Feed for}\\&\text{Dam} + \text{No. Progeny} \times \text{Progeny Feed}\\&\times \text{Value of Feed for Progeny}).\end{aligned}$$

Note, there is no requirement that the value terms be expressed in monetary units. They could equally well be expressed in biological units (e.g., kcal) to reflect biological efficiency.

In the positive income component we have the output from harvesting the dam (or fraction of the dam accounting for death loss) and from harvesting progeny (again, accounting for death loss); these are multiplied by different per unit prices to obtain the total value output. The negative feed cost component accounts for the input of feed energy, where we can account for different feedstuffs in the calculation of energy. The number of progeny per dam is in both components, and thus, increasing number of progeny will increase efficiency. By simply increasing number of progeny per dam through either selection, heterosis from crossing, or better management, we will increase efficiency of production. We do not need to measure feed intake to get this improvement in feed efficiency.

If we look at feed efficiency of a single animal, we also find that there are possible improvements in efficiency that can be achieved again without measurement of feed intake. To visualize this, first imagine that we can separate feed intake, at least conceptually, into 1) feed required to meet maintenance requirements (**M**, basal metabolism, tissue repair, thermal regulation, locomotor activity, and so on) or the energy required for keeping BW constant; 2) feed required to create new product (**P**, e.g., growth, milk, new offspring); and 3) feed that goes unused (**U**, waste products). For a growing calf, efficiency can be shown simply as

$$\begin{aligned}&\text{Calf BW Gain} \times \text{Calf BW Value}\\&- (\text{Feed}_M + \text{Feed}_P + \text{Feed}_U)\\&\times \text{Feed Value}.\end{aligned}$$

For a pair of calves with the *same* starting and ending BW but with one animal gaining BW more quickly, thus requiring fewer days and less *maintenance* to reach market BW, the faster-growing calf would be more efficient. This can occur with *no* difference in efficiency of feed use for either maintenance or creation of new product; it is "all mathematical." Similarly, with an improvement in reproduction, there is no need to measure feed intake to capitalize on methods to improve efficiency. The same would be true for an individual cow; if there is more output per day and no difference in cow size and in partial costs for maintenance and for production, then the cow with a greater rate of output will be the more efficient.

For a reproducing cow herd, we can express efficiency based on the BW of calf and cull cow as the summed outputs, and total feed intake for the 2 production components as the feed costs. This gets a bit more complicated compared with the growing calf example above. But, we can express this as

$$\begin{aligned}&[\text{Calf BW} \times \text{Calf BW Value}\\&+ (\text{Culling Rate} \times \text{Cull Cow BW}\\&\times \text{Cow BW Value})] - [\text{Feed}_M(\text{cow})\\&+ \text{Feed}_P(\text{cow}) + \text{Feed}_U(\text{cow})]\\&\times \text{Cow Feed Value} - [\text{Feed}_M(\text{calf})\\&+ \text{Feed}_P(\text{calf}) + \text{Feed}_U(\text{calf})]\\&\times \text{Calf Feed Value} - [\text{Feed}_M(\text{heifer})\\&+ \text{Feed}_P(\text{heifer}) + \text{Feed}_U(\text{heifer})]\\&\times \text{Heifer Feed Value}.\end{aligned}$$

So again, there is 1) feed for maintenance, 2) feed for production, and 3) feed that is wasted. So, one goal for improving efficiency of feed utilization, whether with a growing calf in a feedlot or with a reproducing cow and calf in a cow herd, must be to reduce