Initial genome-wide association study of feed intake related traits in beef cattle

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Importance of feed efficiency

The ability to improve the utilization of nutrients has tremendous potential to improve profitability. It has been estimated that a 10% improvement in performance (gain) would increase profit by 18%, while a 10% improvement in efficiency could improve profit by upwards of 43%. It has also been estimated that a 10% improvement in feed efficiency (assumed to be a 2 lb/day reduction in RFI) across the entire feedlot sector would equate to $1.2 Billion in reduced feed costs.

Although progress has been made in feed conversion (F:G) over the past decade, it has been small relative to the progress of other species. The poultry industry, for instance, has made a 250% increase in feed efficiency since 1957. Iowa cullout data suggest a 0.047 lb/yr decrease in F:G from 1978-1992 and from 1988-2002 Midwestern cullout data suggest that the change has been slightly less (0.033 lbs/yr decrease). Advancements in dietary regimes and technology (implants and feed additives) have made substantial differences, but direct genetic selection for efficiency remains an untapped source of potential improvement.

Why a genomics approach?

Genomic-enhanced expected progeny differences (EPD) were first estimated for carcass traits and then evolved to other production traits for which EPDs already existed. These traits were chosen due to the need for phenotypes to develop the genomic predictions (training), which were already being collected. Consequently, genomic tests for "novel" traits such as different measures of efficiency or disease susceptibility require a significant effort in order to build large resource populations of animals with both phenotypes and genotypes. These two particular suites of traits (Feed Efficiency and Bovine Respiratory Disease) are currently the foci of two integrated USDA projects. In these two cases, use of genomic tools could have an economic advantage over routine collection of costly phenotypes.

Current efforts and results

A multi-institutional integrated research, extension and educational effort to develop and deploy selection tools to improve the efficiency of feed utilization in growing cattle is currently underway (www.beefefficiency.org). Since feed intake phenotypes are expensive to measure and a genomics approach is logical, this project seeks to develop genomic predictors for feed intake/efficiency using dense single nucleotide polymorphism (SNP) panels (50,000 and 770,000 SNPs). The project also plans to dissect regions of the bovine genome that harbor genetic variants that explain relatively large portions of the genetic variation for these traits. This is being done in an effort to discover the genes that control the underlying mechanisms that make animals more efficient. To do this requires the collection of feed intake records from thousands of animals that are genotyped with either the 50K or 770K (HD) SNP assays across multiple breeds in order to develop genomic predictors that are accurate and robust across cattle populations. Table 1 contains initial results from the USDA project National Program for Genetic Improvement of Feed Efficiency in Beef Cattle. Four populations of cattle involving over 5,000 animals were used for a genome-wide association study (GWAS) of different feed efficiency related traits. The heritability estimates (h2) represent the proportion of phenotypic variation explained by the SNPs. Although all estimates suggest that these traits are moderately heritable, differences in parameter estimates exist between the resource populations likely due to differences in population, structure (e.g., the number of contemporary groups), and data collection methods. Some of the Angus (AN) animals, for instance, were fed in Calan gates whereas other populations were fed by automated feed intake systems (e.g., GrowSafe).

Results from the GWAS also identified regions of the genome that appear to harbor large effect quantitative trait loci (QTL). Given the complex nature of these traits (the fact they are controlled by numerous genes), a large effect QTL was considered as a locus explaining greater than 1% of the additive genetic variation. A total of 5, 5, 17, and 10 of these large effect QTL were identified for ADG, DMI, MBW and RFI, respectively. Some of the identified QTL had substantially larger effects than might have been expected. For instance, a QTL in Angus explained over 10 and 14% of the additive genetic variation in DMI and MBW, respectively. No QTL identified for RFI explained greater than 2.5% of the additive genetic variation. These QTL regions were generally breed specific, further illustrating why genomic predictors are not easily transferable across breeds.
Table 1. Genomic heritability estimates for ADG, MBW, RFI and DMI

<table>
<thead>
<tr>
<th>Population</th>
<th>N</th>
<th>SNP Density</th>
<th>ADG h2</th>
<th>MBW h2</th>
<th>RFI h2</th>
<th>DMI h2</th>
</tr>
</thead>
<tbody>
<tr>
<td>HH</td>
<td>847</td>
<td>HD</td>
<td>0.27</td>
<td>0.50</td>
<td>0.45</td>
<td>0.41</td>
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<tr>
<td>USMARC</td>
<td>1,160</td>
<td>50K</td>
<td>0.30</td>
<td>0.47</td>
<td>0.49</td>
<td>0.35</td>
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<tr>
<td>SM x AN</td>
<td>1,444</td>
<td>HD</td>
<td>0.23</td>
<td>0.38</td>
<td>0.32</td>
<td>0.27</td>
</tr>
<tr>
<td>AN</td>
<td>1,580</td>
<td>HD</td>
<td>0.19</td>
<td>0.49</td>
<td>0.21</td>
<td>0.35</td>
</tr>
</tbody>
</table>

1 ADG = Average daily gain, MBW = mid-test metabolic body weight, RFI = Residual feed intake, DMI = dry matter intake.
2 HH=Hereford cattle fed at Olsen Ranches, USMARC=F12 composites from the Meat Animal Research Center Cycle VII, SM x AN=Legacy Simmental x Angus animals fed at the University of Illinois, AN=Angus cattle fed at Circle A and University of Missouri.

Summary

Results from the 2014 study illustrate that by using either the 50K or 770K SNP assay, the genomic heritability estimates of traits related to feed efficiency are in general agreement with heritability estimates from the scientific literature using phenotypes and pedigree information. The fact that these traits are moderately heritable and that the SNP assays can explain large proportions of the phenotypic variation suggests that genetic progress in these traits can be made by using genomic selection. However, this study further illustrates the breed-specific nature of genomic predictors and for this reason, caution should be used if attempting to use a genomic predictor in a population that is distantly related to the training population (e.g., across breeds). The continued collection of feed intake phenotypes will be required to refine and retrain genomic predictions overtime.

The ability to select for improved feed utilization is exciting and will be enabled by genomic tools. It should be noted that the improvement of efficiency is inherently a multiple-trait issue and thus the development and utilization of indexes to select for the most profitable animals is critical. An interactive example of such an index is available at http://www.beefefficiency.org.

Full research article reference

Demonstrating decision support tools and increasing understanding of underlying economic drivers of profitability and risk to beef cattle producers

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As a decision maker on your operation, when you need tax management advice you likely would not turn to your nutritionist for that information. Likewise, it is doubtful that you would turn to your accountant to help you resolve production related problems the operation may be facing. The point is that as a decision maker one of your tasks is to make sure you identify the person(s) best suited to answer the question at hand. Similarly, when analyzing decisions on your operation, it is important to have the right tool for the job at hand. When analyzing decisions, we typically think of using three basic decision support tools – partial budgets, net present value analysis, and enterprise/whole-farm budgets. These tools are very useful for analyzing decisions from several different perspectives. The objective of this paper is to introduce some of the different decision support tools that are commonly used and discuss their relative strengths and weaknesses for analyzing decisions.

Partial budgets

A partial budget analysis is generally a fairly straightforward analysis, but depending on the question at hand, it can become more complex. Typically, a partial budget is used to examine the expected economic returns associated with a particular management change. The word expected is used because partial budgets are almost always based on projected data. Ideally, historical data would be used to measure the actual observed returns associated with a particular management change. However, often insufficient data exist with regards to both the number of observations (operations and/or years) and information about the characteristics of the different operations (e.g., size, cost structure, etc.). In this case, a partial budget analysis based on sound assumptions about expected impacts is often the best indicator as to the expected returns of a particular management change.

This type of analysis simply examines the impact a change in the operation has on net returns in a three step process. The first step is to identify the total added returns of the change. Second is identification of the total added costs associated with the change. Finally, a comparison is made between the total added returns (income-increasing items) made in the first step and the total added costs (income-reducing items) identified in the second step. To construct a partial budget, four values need to be identified: (A) added returns, (B) reduced costs, (C) reduced returns, and (D) added costs. It is important to note that not all four of these values will always be relevant and in some cases some of them cannot be quantified.

By identifying these four factors the profitability of a particular management change can be calculated. If total added returns exceed total added costs, the proposed adjustment will increase net returns. On the other hand, if total added costs exceed total added returns, the proposed adjustment will reduce net returns. In addition to calculating the profitability as total added returns less total added costs, a benefit-cost ratio can also be calculated (i.e., total added returns / total added costs). This ratio simply indicates the dollars of return generated for every dollar of cost. Once the partial budget has been constructed, it is often useful to do a breakeven analysis and/or a sensitivity analysis around some of the projected values to determine the impact they have on the profitability of the management change.

Partial budgeting provides the required process to accurately assess those changes in income and expenses that are specifically associated with a particular management decision, without the problem of having the profitability of that decision confounded by other activities on the operation that are irrelevant to the question at hand. Thus, the partial budget is a very powerful tool for analyzing different changes management might be considering. Weaknesses of the partial budget are that it requires projections and the fact that some income and/or cost impacts are overlooked. This is not a serious issue for those producers that have good historical data to use in making projections and deciphering which incomes and/or cost figures to include. Another weakness of the partial budget is it only shows the “marginal” impact on the business and there are times knowing what this does to the bottom line of the business will be important.

Net present value analysis

Net present value (NPV) analysis is a means of taking into account the fact that a time value of money exists (i.e., a dollar tomorrow is worth less than a dollar today). Generally a NPV analysis is nothing more than a partial budget (i.e., changes in income and costs) that takes into account the timing of the income and cost changes.
The NPV analysis discounts future returns such that all results are in “today’s dollars” and thus the interpretation of results is relatively straightforward. If the NPV is positive, meaning that the discounted future earnings are greater than the initial investment, then the project has earned a rate of return greater than the discount rate and is profitable to pursue. If the NPV is negative it means that future earnings discounted back to the time of the investment are less than the investment. The project will earn a rate of return less than the discount rate, and it is not profitable.

There is no question that a properly done NPV analysis that also takes into account taxes is the best type of analysis to use; however, this increases the complexity of this method. Furthermore, NPV can be very sensitive to the discount rate used; therefore several methods and sensitivity analysis need to be used to determine an appropriate discount rate.

**Enterprise or whole-farm budgets**

An enterprise or whole-farm budget is similar to a partial budget except that as its name implies it is for the entire operation. This tool is very useful for looking at alternative scenarios with regards to facilities, feed rations, or any other management change. For a beef operation that also has a crop enterprise, it is suggested that the crop income and costs be examined separately and thus have a beef specific enterprise budget. For beef operations that do not have other enterprises, the enterprise and whole-farm budget are the same thing. The advantage of the enterprise budget is that all factors have been accounted for and thus it could be argued that it is more difficult to “overlook” some impacts (a potential weakness of the partial budget). Thus, an enterprise budget subsumes a partial budget, i.e., anything you can look at in a partial budgeting framework can be duplicated in an enterprise budgeting framework. The difference being that many income and cost categories might not change across the scenarios being analyzed. A weakness of the enterprise budget is that, like the partial budget, it relies upon projections. However, as previously stated, this is not a serious issue for those producers that have good historical data to use in making projections. Additionally, by conducting a sensitivity analysis, the enterprise budget can be very useful for examining and quantifying the potential risk associated with a particular scenario or management change.

**Summary and conclusions**

While there certainly is a host of decision support tools available to producers beyond the ones highlighted here, perhaps the most important thing is to “pause and think” before one acts and “follows the herd” in today’s dynamic cattle markets. Regardless of an operation’s individual situation, all producers would be well-served to make decisions with as much information as they can reasonably obtain. Moreover, when making a significant enterprise changing decision it is important to consult with the team of experts you have assembled including your beef extension specialist, farm management specialist, accountant, herd health veterinarian, and nutritionist.