GENETIC PREDICTION OF EFFICIENCY IN THE FUTURE: A U.S. PERSPECTIVE

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This presentation will focus on the need to establish a program for evaluating efficiency. By program, we mean the complete package of data collection, model development, and routine genetic evaluations. We will refer to using feed consumption information in combination with management or other variables to define an appropriate economically relevant trait (ERT). The ERT could be consumption to an endpoint (for a variety of endpoints), consumption in conjunction with gain (efficiency of gain), consumption in conjunction with production measures to define cow efficiency, or any other definition or measure of "efficiency." We will not dwell on these options as they are addressed in other presentations.

We will focus on the need for a system that provides data for use in selection. For traits that are above the "low hanging fruit," the most difficult component is the system for capturing data. As an example, for decades we held symposium after symposium on the importance of reproductive performance to the economic well-being of the national cowherd. No one questioned the importance, but we struggled to provide genetic evaluations of reproductive performance simply because of the lack of data. The data structure needed was what we now refer to as whole herd reporting. From that base, evaluations for heifer pregnancy developed by the Animal Breeding Group at Colorado State University and applied to Red Angus data could move forward. There are other examples including meat tenderness evaluations (the Carcass Merit Project of the National Cattlemen's Beef Association), which required an industry-wide effort to establish a data-capture system. We are sure no one would debate the value of having good genetic information related to disease and health, but we do not have a system to address that at this time. So if we are to look to the future for genetic predictions of efficiency, we need to look at the industry first and determine how to generate data!

We will start by considering options for feedlot animals and performance-tested animals. The first problem encountered for feedlot animals is that these animals are typically not identified to sires. There are exceptions: for example, commercial herds that use AI or herds in designed progeny test programs for carcass traits. To generate the mass of data needed, however, would require a parent identification system of calves from many commercial herds. The National Beef Cattle Evaluation Consortium (NBCEC) is currently working on a pilot study with the Bell Ranch in New Mexico to evaluate a system for progeny testing commercial bulls. In that project, we are using DNA markers to establish parentage since the calves are produced in multiple sire breeding pastures. This obviously incurs a cost that must be recovered by selection to improve the ERT for that herd. In the selection system we have designed for that herd, each year 200 to 300 sire-identified steers will be available for data collection downstream.

Given we can amass a reasonable number of animals each year that have the requisite pedigree information, we now face the problem of generating useful data. There are programs that are currently being used to address this problem. Feeding sire progeny groups in small units is one such program. Information from this design provides group consumption data but not always individual consumption data. The measure of comparison then is between average progeny consumption. In Canada, Beef Improvement Ontario uses feed efficiency in a computerized sire selection program, which was developed by the University of Guelph. Feed intake is measured in central bull evaluation centers. Then feed efficiency across-breed EPDs are calculated and combined with growth rate and ultrasound backfat-across-breed EPDs to predict carcass weights and feed intakes in steer progeny. From these predictions, along with other traits such as marbling, net economic values of progeny are calculated based on breeds or crosses of cows, feeding programs, and market prices. The predictions are on an actual level such that all sires are compared on an across-breed basis (Wilton et al., 1998). The obvious problems here are the limited number of animals that can be measured annually and the high cost of the procedures. While procedures of this type do contribute some information, the results of these low-output, high-cost systems may prevent them from becoming a part of routine data collection systems in the field.

This brings us to alternative measures (or indicator traits). The industry has used indicator traits in place of traits that are difficult or expensive to measure. Scrotal circumference is an example of using an indicator trait that is easier to measure than heifer pregnancy. We are also now in the process of generating increasingly large numbers of observations on carcass characteristics using ultrasound. Can we also use indicator traits for consumption or efficiency measures? We could investigate traits correlated to consumption or efficiency measures and then transform the EPDs from those analyses to EPDs for the ERT. This may be difficult if the relationship is nonlinear. Also, under this option, we feel we are obligated to report the accuracy in terms of the ERT EPD. As an example, using ultrasound data to evaluate a sire from progeny records can result in a very high accuracy of the predictions for that ultrasound trait. But the accuracy obtained for the ERT is limited by the correlations between ultrasound measures on breeding animals and carcass measures on harvested animals. A second option is to use the phenotypic information on the related traits in a modeling approach to predict a phenotype on the same animal. The genetic evaluation would then be run on the predicted value. This approach would bring the world of models together with the world of genetic evaluators. This is intuitively appealing.

There are many steps required to use predicted phenotypes for genetic evaluation. The first is model validation. Does the predicted variable reflect the actual measure? The second is whether there is a heritable component to the predicting variable. And third is whether there is a genetic correlation between the predicted variable and the ERT. Think again in terms of ultrasound and carcass measures relative to these steps. Validation of ultrasound was done on animals with both ultrasound measures and carcass data. As confidence in ultrasound technology grew, use of ultrasound on breeding animals to predict slaughter animal performance became an accepted component of data collection in the industry. Recent research from Iowa State (Wilson et al., 1999) using Angus records provided estimates of the requisite parameters for using ultrasound measures in genetic evaluation. The genetic correlations were high and positive between associated carcass and ultrasound measures. Hence, selection for EPDs on ultrasound measures will result in a correlated response in slaughter progeny carcass traits. Correlated responses can exceed responses to direct selection under certain conditions. For ultrasound measures on breeding animals these conditions include 1) early capture of information on potential parents, 2) decreased generation interval and 3) increased selection intensity. To use predicted phenotypes, we need to follow the same philosophy that was used to validate ultrasound.

As an example, we will use the Cornell Value Discovery System (CVDS) model for prediction of individual feed consumption (Tedeschi et al., 2002). Models require inputs. In the case of the CVDS, the inputs are gain on test and carcass measures, ration ingredient analysis, and environmental factors (i.e., temperature, windspeed, lot conditions, and description of facilities). This modeling approach can also be used for performance tests of potential breeding bulls using ultrasound in place of carcass measures (see Appendix A). The CVDS model has been validated in experimental environments, (Fox et al., current proceedings), and the NBCEC is now running a pilot study with the American International Charolais Association to collect information on performance-tested bulls (see Appendix B). This pilot will be used to estimate parameters for genetic evaluation. The EPDs produced by the genetic evaluation will then be validated. This would include studies similar to those undertaken to validate EPDs for traits such as maternal milk. This process is potentially iterative. Shortcomings in the models that are identified by the genetic studies could be addressed to improve the predictability of the phenotypic prediction models.

Obviously other technologies will come along that may enhance data capture. It is just difficult to envision those technologies addressing the ERT directly. They will most likely enhance the predictability of the phenotypes.

In conclusion, we believe that the future for genetic prediction of efficiency will necessitate a closer relationship between those working with biologically based models for predicting phenotypes and those implementing genetic evaluation programs. The industry would be required to provide the second basic component, which is pedigree information. For performance-tested breeding males and females, this is not an issue, but if we want to evaluate animals closer to the end product, strategies for parent identification in commercial herds will need to be developed.

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APPENDIX A

DETERMINING FEED EFFICIENCY FOR INDIVIDUAL BULLS FED IN GROUPS

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Introduction

Feed costs represent 60% of the total cost incurred in the feeding cattle (Baker and Ketchen, 2000). Simulations with our performance prediction computer programs show that a 10% improvement in feed efficiency can result in a 43% improvement in feedlot profit (Fox et al., 2001). Simulation models developed with published research data on cattle requirements that account for biological differences (mature size, growth rate, milk production, pregnancy requirements, environmental effects) (Fox et al., 1992; Tylutki et al., 1994; and National Research Council, 2000) can be used to identify differences among cattle in feed efficiency (Fox et al., 2002). If differences in individual feed efficiency can be detected economically, this information has the potential to be used in the development of selection indexes.

It is cost prohibitive to measure feed consumption on an individual basis in feedlots where most bulls are evaluated. However, recent improvements in predicting the impact of environmental conditions on maintenance requirements and in determining the composition of gain has led to the development of a model that can accurately allocate feed to individuals fed in group pens (Guiroy et al., 2001). This model uses the animals' own growth rate and average body weight during the test to compute feed required for the observed body weight and growth rate. We have developed a computer program called the Cornell Value Discovery System (CVDS) that applies our published models to determine the feed required for the observed performance of individual steers or bulls fed in pens (Fox et al., 2002). The CVDS model is described in these proceedings in the paper by Fox et al., determining post weaning feed efficiency in beef cattle". This section describes the steps used by the CVDS model and the data collection process to obtain the inputs needed by the CVDS model to predict feed required by individuals fed in pens.

Procedures for computing feed required by individual bulls fed in groups

Steps we use for computing feed required for the observed performance

1. The net energy value of the ration for maintenance and gain must be determined. We use feed analysis of the ration ingredients and the ration dry matter formula to predict the net energy value of the ration dry matter for maintenance and growth with the Cornell Net Carbohydrate and Protein System (CNCPS; Fox et al., 2000), as described by Fox et al. (2002).

2. Beginning and ending weight and days on test are used to compute average weight and average daily gain during the test.
3. The animals' average body weight during test is used to predict their average daily maintenance requirement.
4. The average daily maintenance requirement is adjusted for the effect of environment on the energy required for maintenance.
5. This average daily maintenance requirement is divided by the net energy value of the ration for maintenance to compute the feed required for maintenance/day.
6. The animals' expected weight at 28% body fat (average fatness of low choice grade) is predicted from the animals' weight and backfat, rib eye area, and marbling determined by ultrasound.
7. This 28% fat weight is divided into the weight of the animal used to develop the net energy requirement equations (standard reference weight) to get the ratio of the animal to this standard reference weight (standard reference weight ratio).
8. The standard reference weight ratio is multiplied by the average weight during the test to get the weight equivalent to the standard reference animal (Equivalent weight).
9. The average daily gain during the test and the equivalent weight are used to compute the daily net energy required for gain.
10. The net energy required for gain is divided by the ration net energy value for growth to obtain feed dry matter required for growth.
11. The feed required for maintenance and gain are added together to determine dry matter required/day.
12. Feed efficiency is then the dry matter required/day divided by the average daily gain.

The actual feed fed to the pen is allocated to the individual bulls to determine the cost for each individual animal as follows.

1. The dry matter required/day required for each bull in a pen are summed to get the total required/day for the pen.
2. Each bulls' dry matter required/day is divided by the total for the pen to compute the proportional share of the actual feed fed to the pen.
3. The proportional share for each bull is multiplied times the total feed fed to the pen to obtain the amount and cost of the feed for each individual bull.

The above calculations give the feed efficiency and cost for the actual weight gained during the test. However, the bulls will be at different stages of growth at the end of the test, because of differences in initial age and weight, and rate of gain during the test. Therefore the data need to be adjusted to the same final endpoint to evaluate the bulls. To accomplish this, each animals' data is entered into the CVDS and performance is evaluated over a standard growth period, using the feed required to adjust dry matter intake to that observed during the test.

Collecting inputs required

1. Body weights.
   - Beginning of test (minimum 90 day test period)
   - When ultrasound measurements are taken
   - End of test
2. Ultrasound measurements (taken as near the end of test as possible)
   - Fat depth
   - Rib eye area
   - Marbling
3. Age and hip height (taken at time of ultrasound measurements)
4. Ration
   - Dry matter formula (keep as constant as possible during the entire test)
   - Ration ingredient analysis (take as many samples as needed to represent each ration ingredient during the entire test).
     1. Dry matter, NDF, Lignin, CP, protein solubility, NDIP, ADIP.
     2. Total feed fed to each pen during the test.
5. Environment description (average for each month during the test)
   - For the entire test
     1. Lot type (choose from the list)
     2. Square feet/head
   - Average for each month during the test
     - Wind speed and temperature the cattle are exposed to, lot conditions (choose from the list)

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Example data input sheets

Pen Space: square feet per head: ____________

Animal Data-IN	Pen No.________			
Date	ID	Breed	Weight	BCS
Animal Data-OUT	Pen No.________			
Date	ID	Breed	Weight	

Date: ____________		
Animal ID	Hip Height	Birthdate

Ration		
Date	Ingredient	Lbs/batch
Date	Pen No.	Amount fed

Ultrasound Data					
Date					
	An ID	BF	Rump Fat	IMF	REA

Environmental data							
	Temp. (^oF)	RH (%)	Mud (in.)	Wind (MPH)	Hair Coat[1]	Hair Depth (in.)	Min. Temp. (^oF)
Month							

[1] 1=No mud; 2=mud on lower body; 3=mud on lower body and sides; 4=heavily covered with mud.

APPENDIX B

CONTEMPORARY GROUPING AND MANAGEMENT PROCEDURES FOR BULLS INVOLVED IN THE CHAROLAIS FEED EFFICIENCY PROJECT

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Introduction

The phenotype of an animal may be defined as genotype plus environment (P = G + E). One purpose of genetic evaluation is to accurately remove environment from the equation so that the estimation of the genotypic value of the animal is based on the genetic merit of the animal rather than any outside (environmental) influences. Contemporary grouping is one method that is used to accomplish this. Calves are assigned to a particular contemporary group if they are in the same location (pasture, not ranch), are of the same sex, are of similar age, and have been managed alike. Remember, as the group of calves get older, a contemporary group will decrease in number due to sickness, death, culling or allotment into different pens at weaning. A contemporary group may decrease in numbers, but it will never increase in numbers after calving season is over. Groups cannot be recombined and cattle that have been removed from a pen cannot be put back into a contemporary group.

Contemporary grouping and management procedures

1. Your breed association procedures or BIF guidelines will assist you in contemporary grouping for your breed from birth to yearling.

2. Our recommendation is that in addition to your regular bull feeding pens, set up one more pen that is not included in our trial. This may be a cull pen, or a pen where you feed a few steers or cull heifers. We would like to have you put any bulls from the test pens into this pen and remove them from the trial if they have been in a sick pen away from their group for three or more days. The model to predict feed efficiency can be adjusted to account for animals taken out of a pen, but not for animals put into a pen after the start of the trial period. When an animal is permanently removed from a pen, weigh the animal and decrease the pen feed by the amount of one animals' daily intake. We cannot deal with additions to a pen or animals that are put back into a pen after more than a three-day absence.

3. If you sell a bull before the end of the trial period, weigh the bull when he leaves the pen, and adjust the total ration downward by that bulls percent of the total ration.

Records that will be provided by producers

1. On test weight and off test weight. Contemporary group information and pedigrees will be furnished by the breed association.

2. Ultrasound images. To be processed through CUP Laboratories.

3. Feed analysis on each individual ingredient in the ration. To be processed at Dairy One. Producer will be responsible for the cost of the samples ~$20 each. The cost to the producers will vary depending on the number of ingredients in the ration.

4. Feed records to indicate pounds of fed feed over the feeding period to each pen. This may take the form of daily feed records, weekly records or simply total amount of each ingredient fed to each pen.

5. The wind speed, humidity, and temperature will be drawn from the NWS website by researchers at Cornell University.

6. The predictions will be greatly enhanced by your recording of feedlot conditions, although we will not require it for participation.