Tools for Making Genetic Change

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Introduction

Imagine a carpenter who determines which tools to use before actually deciding what is to be built. Such a person would not likely find much success. Not every job requires a hammer, a saw, or a drill. So it is with the beef industry — lots of tools are available but not all are appropriate for the multitude of production scenarios. Thus a discussion of which genetic tools are most useful must be preceded by a determination of which goals ought to be pursued.

As a sidebar, it is probably useful to examine the use of the term genetic change . A more appropriate term might be genetic correction or genetic modification implying that change directed towards a useful purpose is much more valuable in the long term than is the process of generating change for its own sake.

A reasonable goal for the beef industry is to produce low-cost, high-profit cattle that yield competitively priced, highly palatable, lean products; while conserving and improving the resources utilized (Field and Taylor, 2002). Yet the achievement of such a broadly stated objective should be examined in light of the very real conditions of the U.S. beef industry.

The implementation of genetic tools and strategies falls to the cow-calf producer who is challenged by the responsibility of maintaining a cow herd well suited to the conditions of a particular ranch as well as the production of feeder cattle that meet the goals and criteria of the other links of the beef production chain. Thus the goals of individual cow-calf enterprises must take into account trends in the consumer marketplace as well as dealing with the realities of the production environment.

The consumer

In regards to the consumer market there are four primary trends of interest.

1. Nearly 80 percent of the more than 7 billion servings of beef in the foodservice sector are delivered in the form of hamburgers or some other ground beef entr e (NCBA, 2000).

2. Consolidation in the grocery business is such that the top 5 grocery chains control more than 50% of retail sales (Supermarket News, 2003) with Wal-Mart as the driving competitive force.

3. Case-ready beef is another trend that will impact market specifications and thus the decisions of cow-calf producers.

4. The growth in the branded beef market has created more demand for cattle that meet specific criteria particularly in regards to palatability. Properly developed branded product strategies offer opportunities to sell more beef at higher prices. New beef product offerings have totaled more than 1,500 over the past five years.

The collective pressure from these trends has changed the way cattle are marketed in the United States with greater than 50% of cattle sales occurring on a forward priced or grid-based system. These trends equate to more attention on retail product yield (increased muscularity and reduced fat). Those programs that emphasize marbling will continue to have an impact on the industry but given the level of ground beef consumption in the U.S., demand growth for highly marbled, whole muscle cuts is somewhat limited.

Structural challenges

The differing needs of the various segments of the beef industry must also be noted. The magnitude of the industry makes coordination of genetic decisions problematic. Table 1 outlines the participants and products generated by each segment.

Table 1. Overview of the U.S. Beef Industry

Segment	Participants	Inventory/Products
Seedstock	120,000 breeders plus a handful of AI studs	Approx. 80 breeds with 10 breeds most critical and 5 providing about 60% of the genetics, yearling bulls, semen, some females.
Cow-calf	814,000 beef herds 97,500 dairy herds 90% of beef cow herds with < 100 head but controlling only 50% of inventory	33.1 million beef cows 9.1 million dairy cows 29 million feeder calves
Feedlot	1,800 feeding companies with >1000 hd capacity	14 million head bunk capacity 23 million fed cattle marketings
Packer	795 plants harvest steers and heifers 97% of production is boxed beef, 81% of harvest by top 4 firms, and almost 50% of purchases on a carcass basis	34.8 million head harvested 27.1 billion pounds of beef 758 lb average carcass weight

Source: Field and Taylor, 2002

The typical beef producer

It is important to be realistic about the average cow-calf enterprise — not everyone is willing or able to adopt the potential technologies, management protocols, or tools available to them (Table 2). As the NAHMS (1997, 1998) data points out, about two-thirds of cow-calf enterprises are secondary income sources. As such these typically smaller production units may have dramatically different needs than the professional cattle producer who derives the vast majority of their revenue from beef production.

Table 2. Characteristics of U.S. beef cattle enterprises

• 69% of cow-calf enterprises are in place as secondary income sources.
• 49.1% of individual beef cattle enterprises utilize individual calf identification (64.7% of the calves).
• 53.2% of enterprises record individual cow identification (69.8% of the cows).
• No form of identification is applied to 35% and 30% of the total calves and cows respectively.
• 34% of beef cattle herds are routinely pregnancy checked.
• 23% of beef cattle managers observe and record body condition scores.
• Approximately 1/5 of the cowherd is straight bred, 45% are F1s, and about a third result from a three-breed cross.
• Just over 10% of beef cattle enterprises utilize artificial insemination on any part of their herd.
• Only about one-half of producers report establishing a breeding season of specific duration.
• Nearly 80 percent of cattle enterprises rely on handwritten record keeping systems.

Source: NAHMS, 1997 and 1998

Table 2 points out that beef producers do not uniformly adopt even the most rudimentary technologies and best management practices. The reasons for non-adoption range from cost to lack of knowledge to tradition. Nonetheless, any discussion of genetic tools must be assessed with an awareness of the resistance to adoption that will likely be encountered.

The keys to widespread adoption of new technologies are two-fold:

1. They must be **cost effective** by returning clearly identified benefits beyond direct and indirect costs.
2. The technology **must** be user friendly.

Cost effectiveness

At last year s BIF conference, Barry Dunn (2002) made a strong case for evaluating profitability as a series of relationships that include productivity levels, market value of production, annual costs associated with production, and the investment required to maintain productive capacity. Most, if not all, of these relationships are either directly or indirectly affected by genetic influence. Yet, almost none of the current genetic tools available in the industry are reported in terms directly related to profitability.

For example, the use of ultrasound or genetic markers as selection tools for changing carcass traits are in vogue. However, it is extremely difficult to determine how much selection differential is required in intramuscular fat EPDs to actually change the profitability of a cattle cow-calf enterprise. This is particularly worrisome given the high cost of technologies used to estimate carcass traits in live animals — approximately $15 per head for ultrasound and $80 for a two-marker test. Don t assume that I am suggesting that there is no value in these technologies but that there is considerable confusion about how to use the results to improve return on assets.

Simplicity has a high value on most cow-calf enterprises. Any technology that betrays the premise of simplicity must have an easily recognizable high net value to the enterprise if it is to be integrated into the business. Given this fact, most genetic technologies will have to be initiated by the seedstock sector and the benefits then transferred to the commercial cow-calf sector via bull transactions. However, the real benefit of these technologies must translate into value for the commercial cow-calf enterprise if demand is to be sustained.

Genetic tools

In essence there are by my estimation three primary genetic tools available to the cow-calf producer — **selection pressure, breed differences, and mating systems**. This should come as no surprise to serious cattle breeders.

Don Scheifelbein (2003) advances the idea of five undeniable truths of the beef business and these principles make a good foundation for a discussion about genetic tools:

1) The success of commercial cow-calf producers is the foundation of any breed s longevity.
2) One breed cannot do it all.
3) Crossbred cows are essential for maximum financial success (longevity alone is worth the effort of creating them).
4) Uniformity and consistency drives producer success (manage breed composition to achieve this goal).
5) Simplicity is the key to success.

Dunn s argument for measuring return on assets as a function of the interaction of several factors leads to the notion that genetic influences should be evaluated in terms of how much is produced, what it costs to produce it, and the market value of what is produced. The major factors affecting the volume of production is weight per animal and total number of animals. The traits of interest then would most likely be as follows:

<u>Volume of production (per animal):</u>
Market weight (offspring plus culled breeding animals)

<u>Units of production (per enterprise):</u>
Reproductive rate
Calf survival
Cow survival

The driving force continues to be weight. For example, take a look at changes in the trigger point for incurring discounts for heavy weight carcasses. Many packers are accepting carcass weights up to 1,000 pounds without discount. While the advent of grid pricing has been a useful way of communicating desired carcass trait specifications throughout the industry, weight still drives the gross value of a carcass. Table 3 illustrates that heavy carcasses receiving lower prices can still generate more gross revenue than a higher-priced, but lighter, carcass.

Table 3. Gross revenue for various carcass weights at differing prices.

	$106/cwt	$104/cwt	$102/cwt	$100/cwt	$98/cwt	$96/cwt
650 lb	$689	$676	$663	$650	$637	$624
700 lb	$742	$728	$714	$700	$686	$672
750 lb	$795	$780	$765	$750	$735	$720
800 lb	$848	$832	$816	$800	$784	$768
850 lb	$901	$884	$867	$850	$833	$816
900 lb	$954	$936	$918	$900	$882	$864

The market signal that has favored weight was clearly interpreted by the industry. Research results from MARC point out in most cases the average birth weight and growth breed performance has increased while differences between breeds have declined (Table 4).

Table 4. Average birth weight and finished weight of breeds — 1970s vs. 1990s.

	Birth weight	Birth weight	Finished weight	Finished weight
Breed	1970s	1990s	1970s	1990s
Hereford	79	90	1046	1363
Angus	79	84	1046	1375
Simmental	89	92	1141	1390
Gelbvieh	91	89	1115	1348
Limousin	92	89	1035	1308
Charolais	86	94	1143	1370

Source: MARC

The traits that impact cost of production include maintenance costs (mature weight, milk production), cow longevity, calving difficulty, fleshing ability, feed efficiency, and the convenience traits such as disposition, pigmentation, and horned vs. polled.

The traits that impact the market value of production include retail yield, marbling, and conformance to specifications such as carcass weight (avoidance of outliers).

A cow-calf producer must evaluate how production, market value, and cost of production interact within their own system to determine which traits directly or indirectly impact profitability (Table 5). Some traits will respond to selection pressure while others will be more responsive as a result of generating heterosis via planned mating systems.

Table 5. Heritability and heterosis of various traits and their impact on the components of cow-calf profitability.

Traits/trait classes	Heritability	Heterosis	Increases impact on cost	Increases impact on production	Increases impact on mkt. value
Market weight — offspring	40%	Moderate	Variable	Positive	Neutral
Market weight — culled breeders (mature size)	50%	Moderate	Variable	Positive	Neutral
Reproductive rate	<20%	High	Variable	Positive	Neutral
Survival rate - offspring	20%	High	Favorable	Positive	Neutral
Survival rate — parents	20%	High	Favorable	Positive	Neutral
Milk production	20%	Moderate	Variable	Positive	Neutral
Calving difficulty	15%	Moderate	Unfavorable	Negative	Neutral
Fleshing ability	40%	Moderate	Favorable	Variable	Variable
Feed efficiency	45%	Moderate	Favorable	Positive	Neutral
Convenience traits	Variable	Variable	Variable	Variable	Variable
Marbling	35%	Low	Neutral	Neutral	Positive
Retail yield	25%	Low	Neutral	Variable	Positive
Degree of conformance to specifications	Variable	Variable	Neutral	Neutral	Positive

Adapted from Field and Taylor, 2002

Two of the challenges facing producers include 1) measuring directly for the economically relevant trait versus having to rely on indicator traits and, 2) antagonisms between traits. Many of the traits of particular interest cannot be directly selected for due to problems with ease of measurement or the lack of availability of selection tools for specific traits. Cow-calf producers are further challenged by the problems encountered when selection for changes in one trait has favorable impacts on productivity but unfavorable effects on cost of production. For example, increased levels of mature weight favorably impact the volume of product sold from the cull cow but may unfavorably impact the feed costs associated with maintaining the female during her productive life on the ranch.

Producers have at their disposal a partially complete set of tools to assist them in making effective within breed selection decisions. While the current list of EPD provide a basis for making selection decisions, too many of the traits are indicators of economically important traits as opposed to being direct measures. For example, scrotal circumference is an indicator of age of puberty. Furthermore, EPD are lacking for many of these important traits such as feed efficiency.

Ultimately, selection must be based on a multiple trait strategy (Tess, 2002). As more cow-calf producers choose to retain ownership of their cattle beyond weaning or decide to participate in integrated beef production arrangements, there is a growing need for more effective multiple trait selection strategies that encompass lifetime productivity. Balancing selection for traits important at the ranch, the feedlot, and the packing plant is crucial.

While within breed selection is a useful tool, maximum genetic benefit is typically obtained via the exploitation of breed differences and the creation of heterosis as a result of planned crossbreeding systems. While the convenience of a straight breeding system is attractive, such an approach prevents the use of hybrid vigor and breed complementarity. While these topics have been thoroughly dealt with in the historical literature, the following summary points are useful reminders.

- No one breed does all things well and no one breed is without weaknesses.

- Careful matching of breed strengths and weaknesses can yield optimal trait combinations.

- Hybrid vigor (heterosis) provides a buffer against environmental stress that allows crossbred animals to be more productive in some traits than the average of the parental breeds that originated the cross.

- The advantage of heterosis is greatest in reproductive performance, calf survival, and cow longevity. The advantage increases as the environmental conditions become harsher.

- Implementing an effective crossbreeding system requires thoughtful planning, may increase the intensity of management, and must account for the resource limitations of a particular farm or ranch.

- Crossbreeding is not a silver bullet and a poorly designed program may yield less than desirable results.

Why might a crossbreeding system fail? The late Bob DeBaca suggested four primary reasons:

1. Over-use of individual cattle breeds that have too much in them — too much milk, mature size, growth, or birth weight.
2. The mating system was too complicated or wasn t implemented in a systematic manner.
3. Seedstock providers failed to develop the expertise and service orientation to assist their clients in the development of effective crossing systems.
4. The use of poor quality bulls in a crossing system will not yield desirable results. The use of objective selection criteria is critical to the success of the mating system.

The choice of a mating system depends on a careful assessment of the environmental and market constraints associated with a particular ranch. Environmental considerations include forage availability, regularity of precipitation, feed costs, and the design of a grazing system that best utilizes and conserves the forage resources. The performance of progeny from the mating system should be appropriate for the desired market outlet. In a retained ownership setting a producer may want to emphasize cutability, marbling, and growth rate.

The logistics, benefits, and drawbacks associated with several crossbreeding systems are outlined in Table 6. The key summary points are that rotational crossing systems are excellent approaches to acquiring high levels of heterosis for pounds of calf weaned per cow exposed but they require multiple breeding pastures which may conflict with the grazing plan. Steer progeny from these systems may also tend to be more moderate in growth rate and retail yield. Thus, the flexibility of marketing may be reduced. Terminal crossing systems offer producers more options in the market place but they do intensify management requirements. Composite breeding systems produce less heterosis but may be more easily integrated into a grazing system. Numerous studies (Lamb and Tess, 1989, Lamb et al 1992 a and b, Tess and Kolstad, 2000) point out that crossbreeding systems improve net income from 11 to 19 percent as compared to straightbred systems.

Table 6. The Benefits and Drawbacks Associated With a Variety of Crossing Systems.

Mating Systems	Benefits	Requirements/Drawbacks
2-Breed Rotational	Weaning wt./cow exposed 16%	Minimum of 2 breeding pastures. Herd size of 50 or greater. Replacement heifers identified by sire breed. Generation-to-generation variation may be large. Management intensity moderate.
3-Breed Rotational	Weaning wt./cow exposed 20%.	Minimum of 3 breeding pastures. Herd size of 75 or greater. Replacement heifers identified by sire breed. Generation-to-generation variation may be larger. Management intensity high.
Rotation Terminal Sire (2-breed)	Weaning wt./cow exposed 21%. Target specific marketing goals.	Minimum of 3 breeding pastures. Herd size of 100 or greater. Replacement heifers identified by sire bred and year of birth. Management intensity high.
Terminal SireX Purchased F1 Females	Weaning wt./cow exposed 21%. Average herd size. Target specific marketing goals.	Purchased females. Replacement heifers identified by source. Increased risk of disease. Management intensity moderate.
4-Breed Composite	Weaning wt./cow exposed 17.5%. Minimum of 1 breeding pasture. Any herd size. Reduce inter-generational variation.	Availability may be limited. Genetic information (EPD) may be limited or lower in accuracy than from traditional bulls due to population size. Management intensity low (after composite formation).
Composite-Terminal Sire	Weaning wt./cow exposed 21.0%. Minimum of 1 breeding pasture. Any herd size.	Availability of composite may be limited. Management intensity moderate.

The general targets in regards to carcass traits are 70% or better Choice, 70% Yield Grade 1 and 2, and 0% discounts for outliers. Table 7 illustrates the rationale for this recommendation. For most commercial cattle producers, the use of multiple breeds in a planned crossing system will be required to hit these targets. Cattle that are 50% British and 50% Continental breed influence are typically recommended as being best able to provide optimal levels of marbling and retail yield. In some instances, 75% British and 25% Continental may be most desirable when the target is weighted towards rewarding higher levels of marbling. It is important to remember the huge impact of weight on gross revenue and as such the use of Continental breed cattle should be seriously considered. For those environments where bos indicus cattle are required, the terminal sire may be a British breed bull.

Table 7. Conformance of Various Breed Crosses and Composites to Yield and Quality Grade Targets in Steers Produced at the U.S. Meat Animal Research Center.

	MARC I[a]	MARC II[b]	British	Continental	MARC III[c]
‡ 70% Yield Grade (YG) 1 & 2	83.1	56.1	37.6	89.3	52.5
‡ 70% Quality Grade (QG) Ch & up	43.1	54.7	69.6	30.4	66.0
% Non-conform YG	16.9	33.9	62.4	10.7	47.5
% Non-conform QG	56.9	45.3	30.4	69.6	34.0
Deviation from acceptance					
Non-conform (30%)					
YG	0	3.9	32.4	0	17.5
QG	26.9	15.3	0.4	39.6	4.9
Total	**26.9**	**19.2**	**32.8**	**39.6**	**21.5**

[a] MARC I = _ Charolais, _ Limousin, _ Braunvieh, _ Angus, _ Hereford.
[b] MARC II = _ Gelbvieh, _ Simmental, _ Hereford, _ Angus.
[c] MARC III = _ Pinzgauer, _ Red Poll, _ Hereford, _ Angus.

The use of selection, breed differences and mating systems are of benefit to managers of commercial cow-calf enterprises. Deciding not to use one of these tools should be undertaken only with a detailed assessment of the value of lost opportunities. New approaches will surely be developed that enhance our ability to utilize these three tools. However, they will only be implemented if they are cost effective and user friendly.

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