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GENETIC SELECTION FOR MORE PROFITABLE COW-CALF ENTERPRISES: TACKLING INPUT COSTS

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Introduction

Steep increasing genetic trends for growth traits (weaning and yearling) and mature cow weight can be seen in many breeds but perhaps more alarming are those producers that have dramatically increased the genetic potential for milk production in their cow herds. Although it seems logical that profit (Revenue – Expense) should drive our selection decisions, it is hard to rationalize phenotypic changes overtime that can be seen in the U.S. cowherd. In order to actually select for increased profit, knowledge of environmental constraints, genetic antagonisms, and the selection tools that have the potential to measure profit are critical.

Sire selection does not need to be overwhelming or complex. Centuries of work by geneticists and statisticians have allowed for the development of tools that help producers make decisions regarding which bull(s) to use; do not ignore them. The key questions that every rancher needs to answer are:

1) What are my breeding/marketing goals?
2) What traits directly impact the profitability of my enterprise?
3) Are there environmental constraints that dictate the level of performance that is acceptable for a given trait in my enterprise?

Once these three questions are answered, sire selection becomes much simpler. The answers to these questions inherently lead a producer to the traits that are economically relevant to their enterprise. We call these traits Economically Relevant Traits (ERT).

Environmental Constraints

The development of an obtainable breeding objective begins by clearly identifying environmental constraints and marketing goals. Table 1 illustrates levels of production that are suited for differing production environments.

If feed resources are limited in a stressful environment then selection for increased output (high growth, milk, and red meat yield) could have negative impacts on the ability of cows to be successful breeders without the need for large quantities of harvested feed. The beginning of a profitable breeding objective is identifying what the environment will allow you to produce, at least until we have tools to apply direct selection to traits of adaptation.

Table 1. Matching genetic potential for different traits to production environments[1]

Production Environment		**Traits**					
Feed Availability	**Stress[2]**	**Milk**	**Mature Size**	**Ability to store energy[3]**	**Resistance to stress[4]**	**Calving ease**	**Lean yield**
High	Low	M to H[5]	M to H	L to M	M	M to H	H
	High	M	L to H	L to H	H	H	M to H
Medium	Low	M to H	M	M to H	M	M to H	M to H
	High	L to M	M	M to H	H	H	M
Low	Low	L to M	L to M	H	M	M to H	M
	High	L to M	L to M	H	H	H	L to M

[1] Adapted from Gosey, 1994.
[2] Heat, cold, parasites, disease, mud, altitude, etc.
[3] Ability to store fat and regulate energy requirements with changing (seasonal) availability of feed.
[4] Physiological tolerance to heat, cold, internal and external parasites, disease, mud, and other factors.
[5] L = Low; M = Medium; H = High.

Crossbreeding

At a meeting in 2016 it hardly seems fit to even mention crossbreeding. Commercial producers who have not yet adopted it are a burden to the beef industry. However, it is an excellent example of selection for profitability. We know that the two primary benefits of crossbreeding are complementing the strengths of two or more breeds and heterosis, neither of which create trait maximums. If we think about it simplistically, crossbreeding for a trait like weaning weight leaves us with a calf crop that is better than the average of the parental lines, not better than both parental lines. Crossbreeding, if done correctly, seeks to optimize many traits through complementing breed strengths and produce animals that are better than the average of the parental lines that created them. The best tool that the commercial cattleman ever had is based on optimization, not the production of extremes.

Genetic Correlations

All traits that might be included in a breeding objective are not independent of each other. Sometimes this is beneficial as we see a favorable correlated response, and other times these genetic correlations pit revenue against cost. A good example of this comes from the suite of weight traits. Depending on the targeted marketing endpoint either weaning weight (WW), yearling weight (YW) or carcass weight (CW) become a source of revenue and all are related to a major factor influencing the cost of production, mature cow weight (MW). Table 2 illustrates the genetic correlations between MW and WW, YW, and CW, respectively.

Table 2. Genetic correlations between mature cow weight (MW) and weaning weight (WW), yearling weight (YW), and carcass weight (CW).

	WW[1]	YW[1]	CW[2]
MW	0.62	0.45	0.81

[1] Estimates from Northcutt and Wilson, 1993.
[2] Estimate from Nephawe et al., 2004.

Other similar estimates between MW and WW have been shown in the literature ranging from 0.65 to 0.82 in Red Angus field data (Williams et al., 2009). The same authors estimated the genetic correlation between postweaning gain and MW to range between 0.48 and 0.59. This is particularly relevant in the context of producers that sell some portion of calves but also keep back their own replacement females. Care should be given not to focus solely on the revenue portion, sale weight, but rather optimizing input costs associated with mature weight and revenue sources from calf sale weight. The mature sale weight, CW, shows a strong and positive relationship with MW and again care should be taken to optimize selection between the two.

One potential way to mitigate these antagonisms is the use of specialized sire and dam lines. Using specialized sire and dam lines is not a new concept in beef cattle and in fact was fairly prominent in the 1970s. When Continental breeds first made an appearance in the US some four decades ago, these high growth and high yielding cattle were bred to British breed cows that were much more conservative in size and generally tended to have more fat (internally and externally). Challenges that arose included increased calving difficulty and the ability to source replacements in what was essentially a terminal based system. However, breeds have changed since then and data recoding schemes have improved to allow for additional EPD of economic relevance.

The goals of a terminal-based system revolve around the following traits: Early growth rate, calving ease direct (trait of the calf), calf survival, disease susceptibility, feed intake, meat quality, carcass composition, and male fertility. In contrast, the suite of traits of economic importance to a maternal-based system include: female fertility, maternal calving ease, longevity, moderate size, adaptation to production environment, disease susceptibility, milk production (optimal levels), maternal instinct, and temperament (optimal?). The only trait in common between the two is disease susceptibility, and many of the traits between the two are antagonistic. For instance, the genetic correlation between calving ease direct and calving ease maternal is -0.30. The genetic correlation between hot carcass weight and mature cow size is 0.8. If both systems, maternal and terminal, use the same bull battery (duel purpose) there is substantial opportunity cost given the differences in economically relevant traits between the two and the antagonisms that exists between the two. Although all the traits in the two systems above could be merged into one single breeding objective and thus one index, a fewer number of traits under selection allows for faster progress. The pork and poultry industries have this figured out.

Selection for Decreased Input

Traditionally, there have been few EPDs that could be used to directly select for decreased input costs. However, there has been one for some time, milk (maternal weaning weight). Research has shown cows with the genetic propensity to milk heavily require more energy for lactation and maintenance. The National Research Council (NRC) data shows a cow who produces 25 lbs. of milk at peak lactation requires 10% more feed energy than a cow producing

15 lbs. of milk at peak lactation. To see a 10% difference in feed energy with regards to mature weight it would require moving from a 1,000 lb. cow to a 1,200 lb. cow, or a change of 200 lbs. of body weight. Moderating mature cow size and selecting for an optimal window of milk production is beneficial when it comes to cutting costs regardless of your production environment given that milk production has been estimated to explain 23% of the variation in maintenance requirements (Montano-Bermudez et al., 1990). However, in limited feed environments females with high maintenance energy requirements may also have difficulty maintaining an acceptable body condition score and rebreeding. Nugent et al. (1993) determined with limited nutrient availability, breeds with a high genetic potential for milk production had longer anestrous periods, which lead to lower conception rates during a fixed breeding season. Other researchers have concluded selection for increased milk production past an adequate threshold is not economically or biologically efficient if the marketing endpoint was at either weaning or slaughter (van Oijen et al., 1993). While the lactation requirements may be intuitive, cows with a higher milk yield also tend to have increased visceral organ mass this increasing energy requirements even when the cow is not lactating (Solis et al., 1988).

Other selection tools exist for decreasing input costs including mature weight EPDs and more recently the Maintenance Energy EPD published by the Red Angus Association of America (Evans, 2001; Williams et al., 2009). The study by Williams and others clearly depicts selection for immature weights is occurring thus increasing MW. Furthermore, the study illustrates without accounting for this prior selection in the development of ME predictions, and inherent bias is created.

Bio-economic Index Values

Hazel (1943) summarized the need to formalize a method of multiple trait selection in the opening paragraph of his landmark paper on the topic of selection indexes:

> *The idea of a yardstick or selection index for measuring the net merit of breeding animals is probably almost as old as the art of animal breeding itself. In practice several or many traits influence an animal's practical value, although they do so in varying degrees. The information regarding different traits may vary widely, some coming from an animal's relatives and some from the animal's own performance for traits which are expressed once or repeatedly during its lifetime....These factors make wise selection a complicated and uncertain procedure; in addition fluctuating, vague, and sometimes erroneous ideals often cause the improvement resulting from selection to be much less than could be achieved if these obstacles were overcome.*

Although Hazel's contribution was groundbreaking, the US beef industry was slow to adopt a tool that had the potential to greatly simplify sire selection and place emphasis on that which is economically important. Economic indices are the preferred tool for multiple trait selection. A bio-economic index (I) is simply a collection of EPDs that are relevant to a particular breeding objective, whereby each EPD is multiplied by an associated economic weight (a). For example, the economic index value I can be written as:

$$\mathbf{I = EPD_1a_1 + EPD_2a_2 + EPD_3a_3 + ... + EPD_na_n}$$

where EPDs 1, 2, and 3 are multiplied by their corresponding economic weight and summed.

Consequently, a high index value does not necessarily mean an animal excels in all EPD categories given that superiority in trait can compensate for inferiority in other traits depending on how the EPDs are weighted in the index. A high index value should be thought of as excelling in the ability to meet a breeding objective. It is important to note before proper use of an index can be ensured, a breeding objective must be clearly identified. For example, the use of an index such as the American Angus Association's Dollar Beef ($B) in an enterprise that retains replacement heifers can lead to adverse effects, given that sire selection pressure has been placed on terminal traits via $B.

Table 3. Breed association selection indexes, market progeny endpoints and breeding system[1]

Breed	Index Name	Progeny Endpoint	Breeding System[2]
Angus	$W (Weaning)	weaned feeder calves	A
Angus	$EN (Maintenance Energy)	replacement heifers	M
Angus	$F (Feedlot)	live fed cattle	T
Angus	$G (Grid)	beef carcasses sold on a CAB grid	T
Angus	$B (Beef)	beef carcasses from retained ownership sold on a CAB grid	T
Charolais	TSPI (Terminal Sire Profitability Index)	beef carcass sold on grid	T
Gelbvieh	$Cow	replacement heifers	M
Gelbvieh	EPI (Efficiency Profit Index)	feedlot efficiency	T
Gelbvieh	FPI (Feeder Profit Index)	beef carcass sold on grid	T
Hereford	BMI$ (Baldy Maternal Index)	beef carcass sold on grid; replacement heifers retained	A
Hereford	BII$ (Brahman Influence Index)	beef carcass sold on grid; replacement heifers retained	A
Hereford	CHB$ (Certified Hereford Beef Index)	beef carcass sold on CHB grid	T
Hereford	CEZ$ (Calving Ease Index)	matings to replacement heifers	M
Limousin	MTI (Mainstream Terminal Index)	beef carcasses sold on grid	T
Red Angus	HerdBuilder	beef carcass sold on grid; replacement heifers retained	A
Red Angus	GridMaster	beef carcasses sold on grid	T
Simmental	API (All Purpose Index)	beef carcasses sold on grid; replacements retained	A
Simmental	TI (Terminal Index)	beef carcasses sold on grid	T

[1] Adapted from Weaber fact sheet available at www.eBEEF.org.

[2]T=terminal, A=all-purpose, M=maternal

An example of an all-purpose index (often called maternal in the beef industry because it contemplates the retention of females) that compares the importance of different weight traits comes from the Beefmaster breed. Ochsner et al. (2017) developed a maternal selection index for use by Beefmaster breeders. The index assumed Beefmaster bulls would be bred to British based cows and heifers and that heifers would be retained in the system and all cull heifers and steers would be sold at weaning. Six objective traits (the economically relevant traits we wish to improve) were considered for the maternal index including calving difficultly direct (CDd), calving difficulty maternal (CDm), 205-day weaning weight direct (WWd), 205-day maternal growth (WWm), mature weight (MW) and heifer pregnancy (HP). Results showed decreasing CDd, CDm and MW while increasing WWd, WWm and HP would increase profitability of the operation. Mature weight was the primary driver receiving 49.2% of the emphasis, implying that for the assumed parameters decreasing MW will do the most to improve profitability of operations with a maternal objective. Weaning weight direct was the second highest priority objective trait receiving 27.2% of the emphasis. These two traits are antagonistic to each other relative to the breeding objective, but since the genetic correlation between them is not unity progress can be made in both traits simultaneously.

Implications

Trends are rarely flat, as an industry we have measured ourselves by steep lines in one direction or the other. From a seedstock perspective this may have been perceived as necessary in order to differentiate themselves (either as breeders or as breeds) from others in the market place. Clearly identifying your production environment and realistic production goals given the environment is critical. Selection for profit will require more effort, detailed financial records, and a structured breeding objective that builds a cow herd based on optimum values and not extremes. One final thought, extremely low maintenance cows will push the lower threshold of what is biologically possible for weight and produce virtually no milk. High output cows will represent the other extreme, weigh more than most mature bulls and milk heavier than the best Holstein. Both excel in some measure of the profit equation (i.e. lowest cost or highest revenue) but neither promises to be profitable.

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