Matching Beef Genetics with Production Environment

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"….. thus environmental conditions existing at any given time will lead to the natural selection of genes giving rise to characters in harmony with the environment concerned." Hammond, 1947

Introduction

Producers' concerns about the level genetic potential for performance in cattle and the production environment are not new to the cattle industry. Remley (2000) chronicled the history of the Bell Ranch in New Mexico from 1824-1947. To meet market demands, ranch managers during this time period imported improved germplasm into the ranch's indigenous cattle population creating a disconnect with the production environment. Implementing genetic improvements, moving English breeds of "short leg and heavy muscle" to the western range, to meet market guidelines set by a meat packing industry resulted in repopulation of the cow herd with heifers whose genetics "… were not in harmony.." with the production environment. To insure a harmonious state, the managers modified the production environment by adopting innovative new technologies available during that time period including fences, wells, windmills, irrigated pastures, etc.

In comments made during the symposia: *Breeding Beef Cattle for Unfavorable Environments* (1955*)* held to commemorate the King Ranch's centennial celebration, the Vice Chancellor of the then Agriculture and Mechanical College of Texas, Dr. D. W. Williams, described the environment using the wisdom of commercial cattle producers of that and previous eras. The cattlemen's envisioned environment was made up of the raw resources "…grass, weeds, browse, water, and labor..." of the ranch. Dr. Williams further states that when matching cattle to the environment, the commercial cattleman "...knows that a first consideration is that these cattle must be capable of converting to beef the kinds of range and field feeds *he* produces under the temperature and humidity conditions of *his* ranch, and they must be resistant to the diseases and parasites of *his* particular area…". This suggests defining an animal's genetic merit in terms of forces exogenous to the production environment could result in a disconnect between the genetic potential of the animals expected to produce and the production environment. This disconnect creates a need to alter the environment to sustain indexes of previous levels of production. Attempting to sustain desired levels of production may be counter to the profitability of the commercial rancher. In both books, the authors document the paradox faced by many commercial producers, to produce calves to meet the day's marketing standards using cattle germplasm not suited to the production environment of that producer.

Targeting the Production Environment

Broadly defined, the production environment is made up of all non-genetic drivers from all segments of the horizontally integrated United States beef cattle industry. The mobility of cattle in today's beef industry challenges the commercial cow/calf producer to identify the cattle genetics appropriate to meet all the demands of various environments encountered. Meeting this goal is not feasible, but the producer can develop priorities and use these priorities to established boundaries for genetic

potentials suitable for traits that affect productivity in the production environments their cattle are expected to perform. The key to matching cattle genetics with the production environment is to correctly identify the drivers of the production environment(s). Using the appropriate genetics would minimize the need to modify environment; i.e., cost of environmental modification would not exceed the gain in income associated with genetic change. Once characteristics of the production system are well defined, genetic variation within the U.S. beef cattle germplasm base enables producers to match the genetics to the production environment using either genetic improvement programs or by structured mating systems.

Typically producers' discussions about the environment focus on issues such as green grass days, temperature, humidity, forage types and availabilities, water availability, endo and ecto-parasites, need for nutrient supplementation, etc. Another environmental component that should be considered when making a decision making about cattle genetics is: what is the primary product and how will the product be merchandised i.e., what is the market endpoint? The primary product for the commercial farm/ranch is animal weight. Cull cows and market calves contribute to the total weight with the latter being the primary revenue generator. (Some commercial ranches also market breeding stock but this marketing system will not be considered in the discussion). An early question to address is how will the weight from market calves be merchandized: at weaning- product weaning weight, following background period- product weight at end of background period, following stocking- product weight at end of the stocking period, or is ownership retained through the finishing period. If the latter, the product is still weight but the value could be on a live basis or, a carcass basis, that includes simple carcass weight or increasing unit value through other assessments of carcass value; e.g., quality grade, yield grade or in niche markets such grass fed, grass fed natural, organic, etc. Identification of the market endpoint is the first critical step in determining the level of genetic potential for production traits.

Once the decision regarding the market endpoint is made, producer's need to consider the physical environment where production takes place. What are normal features of the environment where the animals are expected to produce? Can breeds or breed crosses be identified with the desired genetic potentials for traits contributing directly or indirectly to production of the primary product. What environmental constraints must be offset to insure this expression of the genetic potential of the identified germplasm? What management interventions will be needed to offset environmental constraints, e.g., replacement heifers purchased, early weaning, use of AI, capital accessibility, labor, grazing management, etc? Will this intervention be cost effective?

Options for Matching Cattle Genetics

Matching cattle genetics to the production environment can be accomplished by using breeding programs. Management decisions regarding breeding programs can be made once a phenotype(s) is identified that increases profitability of the ranch through cost effective modification of the production environment. Questions to ask include- what is the cow inventory required to attain production goals, what is the desired phenotype, what is the frequency of the favorable phenotype(s) in the present cow herd, are replacement heifers raised or purchased, is on ranch testing feasible, is pedigree information available on individual animals, is within herd genetic improvement a viable option, etc. Mating decisions can be made to alter the genetic make up of cowherd by deciding how the individuals will be mated. Use of decision support software such as the Decision Evaluator for the Cattle Industry (DECI) coupled with financial information allows managers to make these evaluations.

Genetic variation in the cattle (Mason, 1971), within and between breeds, provides producers the opportunity to 1) create progeny appropriate for the merchandising program and 2) produce females that genetically are suited to the local production environment (i.e., cost effective intervention). This variation may be utilized by mating systems designed to exploit breed differences and increasing the fit to the environment by using heterosis (Gregory and Cundiff, 1980) or implementation of within herd or geographic location breeding programs of selective matings to enhance gene frequencies for phenotypes deemed advantageous in the environment.

Breed options for use in mating systems increased with the cattle importations of the 20th century. The "green revolution" beginning in the 1960's altered the structure of the feedlot industry by reducing the cost per unit of feed during the finishing period and modifications in the packing industry facilitated adoption of heavier slaughter weights. This upstream merchandising change motivated commercial cow/calf producers to want heavier weights at weaning and owners of postweaning animals to have higher average daily gains. These changes, coupled with a consumer's desire for a leaner product, stimulated the impetus for the importations from Europe beginning in the 70's and 80's. We now collectively reference these breeds from this round of importation as the "Continental breeds". Producers' need to have beef cattle capable of producing in a unique environment; e.g., the challenge of producing in the Gulf Coast- heat, humidity, and parasite problems provided impetus for these importations resulting in the importation of *Bos indicus* breeds that contributed to the formation of the American Brahman. The National Beef Quality Audit (1995) stimulated producers' interest in an alternative to Brahman or Brahman cross cattle in this Gulf Coast environment resulting in the importations of breeds of *Bos taurus* cattle that had evolved in tropical environments (e.g., Tuli, Romosinuano).

However, besides carrying the genes for the desired phenotypes, introduced breeds carried genes affecting other traits which might not be desirable or create problems under current production environment. Because the genetic potentials for these additional traits were established in environments with differing resource availability, under different management protocols, and driven by a different market demand, these genetic potentials often do not fit with "normal" management protocol in the U.S. cattle industry. For example, the desire for high yields of lean in some European countries has resulted in the phenotype of "double muscling" which we now know is the result of a single point mutation at approximately seven different locations within the gene affecting myostatin. Matings involving breeds having the mutated form of this gene resulting in a homozygous genotype in the calf results in a calf phenotype that produces a high incidence of severe dystocia resulting in a high frequency of caesarian births. Management protocols in these countries where the frequency of the mutated gene was increased consider caesarian delivery as "normal management" but certainly would not be the case under most management protocols in the U.S.

Characterization of breed performance potentials for all relevant production traits is needed to implement a sound mating system. The Germ Plasm Evaluation project at the Meat Animal Research Center led by Dr. L. V. Cundiff provides the cattle industry with an assessment of breed potentials in a common environment. Breed means for many production traits, including growth, carcass attributes, age at puberty, reproductive rate, and mature weight are available from the 23 reports available at the MARC web site:
http://www.ars.usda.gov/npa/marc.

By coupling breed potentials with a merchandising plan and knowledge of key physical environmental factors such as number of green days, forage production (type and quantity), typical weather patterns, labor

resources, etc a producer can establish the phenotype of cow needed for his/her local production environment and produce market progeny capable of producing at desired levels in other types of production environments. Two breeding programs provide producers an effective way to utilize breed differences to fit "cattle genetics" to their production environment: rotational mating systems or composites. Both systems provide the additional benefit of heterosis, especially for those associated with lowly heritable traits. The former has been described as needing a relatively large herd size and high level of management. If a producer's operation falls outside of these parameters, use of composites represents an effective mating system strategy to use breed differences and retain some heterosis. This option has resulted in new breed formation such as the Braford, Murray Grey, Barzona, Belmont Red, Beefmaster and Santa Gertrudis to name a few. This process is ongoing today with composites being created that seek both a marketable product and ability to produce in challenging environments.

Within breed, herd or geographical area breeding programs designed to increase frequency of desired phenotypes for a ranch/farm or geographical area within the existing population represents another option. Again, the producer's merchandising plan must be in place and the production environment characterized prior to using genetic improvement programs. For seedstock producers, this means they must have knowledge of their commercial cattle producer customer's environment). Once these environments are characterized, traits that directly or indirectly impede performance must be identified, measured, and it must be determined if observed variation for this trait has a genetic component. Recording information on traits associated with annual production of a calf, i.e. annual calving and successful weaning of a calf, etc. are examples of a comprehensive indicator traits measured on individual cows that will work over time. Once the desired phenotype established within the cowherd (or if it is already present) genetic improvement programs based on phenotypic selection may be implemented to increase the frequency of the desired gene(s) in the population. However, improvement based on EPDs or marker information for indicator traits may require an extensive amount of time to increase the frequencies of desired genes controlling the traits of interests within the population.

What is the Contribution of Seed Stock Producers?

Reflecting over the technological advances occurring in the five decades since William's remarks one can question if his remarks have relevance in today's cattle production industry. Innovative technology provides the opportunity to transfer genetic improvements in production traits deemed economically relevant to seedstock cattle producers. Have breed organizations adopted the philosophy expressed in the children's book "Me to, Iguana" (Reinach, 1977)? In this story, an iguana seeks to alter her features (phenotype) to be just like the other animals that inhabit her neighborhood because it thinks the other animals phenotype are more acceptable. In trying to become like the other, not only does the iguana cover up the very feature that allow her to survive but the community loses as well by the loss of the iguana's unique characteristics that contributed to the community's (industry) wellbeing.

Breed associations need to make a firm commitment to sustain genetic variation both among and within breeds. It is imperative that the resource of between and within breed genetic variation for production traits relevant to the beef cattle industry be sustained by the industry (Cundiff et al., 1986 a,b). Cattle producers are aware of marketing and production challenges faced within the industry today. Factors grouped together under the heading of environment are not static, rather many are transitory and frequently beyond the producers' control; e.g., markets, consumer

demand, government policy, and global warming. The ability to institute change within the cattle population exists only if sufficient genetic variation to exists to allow these challenges to be met.

Summary

In conversation with commercial cow/calf producers a favorite topic of conversation is to describe an "ideal cow". This cow is designed to express desired performance under their local production conditions, and would be described as an "easy keeper", a "good doer", or simply "matched" to the environment. From a limited number of "easy keepers" the problem faced is how to expand the numbers of this kind of cows. If the production environment of the cow herd needs "upgrading" to insure heifers produced from matings with "improved" sires and are retained as replacements are reproductively successful, the result for commercial cow/calf producers may be an increase in gross income but not net profit (Jenkins and Ferrell, 2002).

To successfully match cattle genetics with the production environment the following steps need consideration (Jenkins, 2004):

1) Identify merchandising plan

2) Identify the most limiting environmental feature (constraint or bottleneck)

3) Identify phenotype(s) that directly or indirectly provide an advantage

4) Identify breed(s) or animals with phenotypes that overcome the constraint

5) Define an objective measure of the identified trait(s) to overcome the constraint

6) Determine if trait is under genetic control

7) Design and implement a breeding program to increase the frequency of the desired genotypes in the inventory

8) Sustain genetic diversity

Implementation of these steps reflects a commitment to an underlying philosophy of management to improve profitability through optimizing resource use rather than one of maximizing revenue through environment modification by a commercial cattle producer. Steps 1, 2 and 3 are among the most critical. If neither the merchandizing plan nor the environmental constraints are fully understood, the cattle genetics can not be identified.

Step 8 represents an industry commitment to maintaining a diverse genetic base in the total population of cattle thus providing the industry access to genes that are needed for infusion into local breeds or breed crosses to relieve new environmental constraints.

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