Proceedings, The State of Beef Conference
November 4 and 5, 2014, North Platte, Nebraska

TERMINAL AND MATERNAL BREEDING PROGRAMS

M.L. Spangler
Department of Animal Science, University of Nebraska-Lincoln

Justification

Efficiency seems to be a global buzzword that is thrown about with multiple, and often unclear, meanings. Generally it is used in the context of improved feed utilization or reproductive performance. However the premise of this paper is to argue that efficiency can also be gained by simply using available genetic resources in a more optimal manor. An example of optimal use is the clear delineation of maternal and terminal breeding systems. There exists a pervasive thought that some breeds, or some bulls, can maximize profit in any scenario. Moreover, the most common breeding objective is to sell steer calves and cull heifers at weaning (terminal) and retain replacement heifers (maternal). Dividing a firm (ranch), particularly if cow herd size is small, into two distinct and potentially antagonistic goals can lead to minimal progress in either objective or worse, improvement in one at the sacrifice of the other. Unfortunately these beliefs and practices ultimately lead to sub-optimal breeding decisions and thus decreased beef system efficiency.

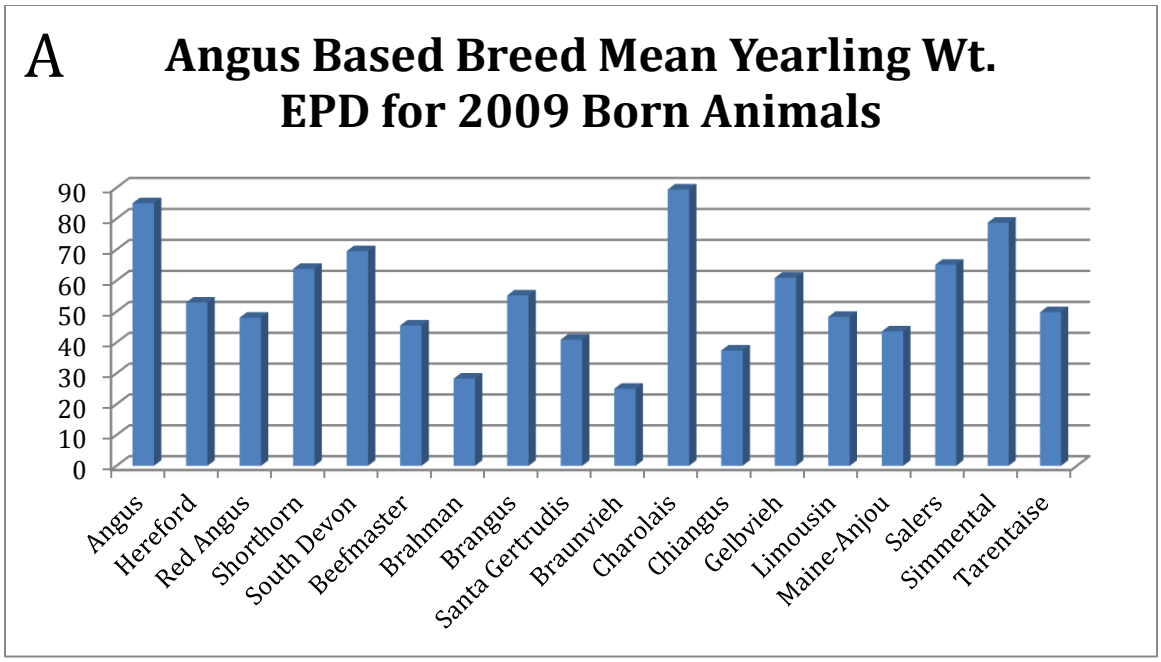
Breeding Programs Review

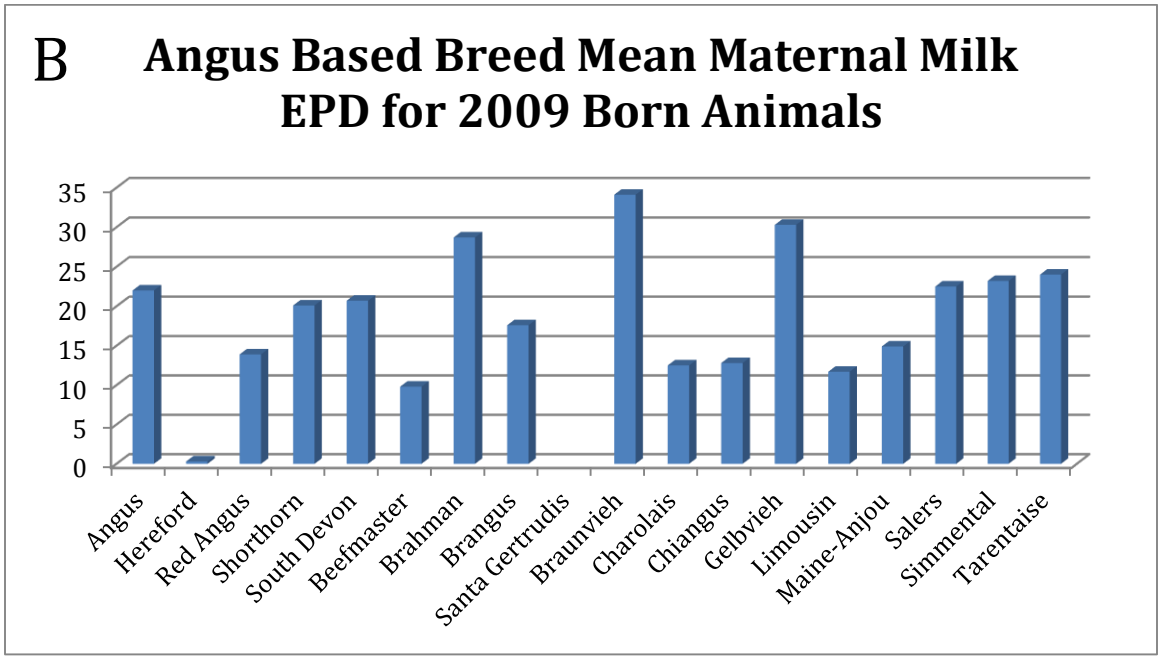
Despite well-documented benefits of heterosis and breed complementarity, the majority of germplasm utilized in the US has migrated towards a single breed. In 2012, the National Association of Animal Breeders (NAAB) reported that Angus semen accounted for over 74% of domestic semen sales. The second most was Simmental with 8.4% of the semen sales market. As a point of reference, domestic dairy semen sales are dominated by Holstein (86.7%) followed by Jersey (10.7%). The 2011-2012 report from the National Pedigreed Livestock Council (NPLC) summarized the annual registrations of 15 beef breeds. From this, 47.8% of registered beef cattle were Angus. From 1995 to 2010, the percentage of fed cattle marketed that were black hided doubled reaching 64%. Furthermore, some surveys have suggested that upwards of 60% of bull turn out is Angus. Although a uniform distribution of semen sales and breed registrations is not expected, nor necessarily desired, some degree of balance relative to commercial bull breed composition is beneficial.

The pervasive thought that one breed can excel in all areas of production in a geographically diverse industry with multiple marketing goals is simply not logical. Every breed has strengths and weaknesses relative to an individual firm's production and marketing goals. That is the benefit of crossbreeding, blending strengths from various breeds to meet production goals while fitting within environmental constraints, and heterosis becomes the reward for having done so. Consequently, knowledge of current breed differences, not historic generalizations, and honest accounting of environmental constraints coupled with identified marketing goals are among the first steps in developing a sustainable and profitable breeding system.

A great deal of research has been conducted over the last 30 years at various federal and state experiment stations to characterize beef breeds in the U.S. These studies have been undertaken to examine the genetic merits of various breeds in a wide range of production environments and management systems. During this time, researchers at the U.S. Meat Animal Research Center (MARC) have conducted the most comprehensive studies of sire breed genetic merit via their long term Germplasm Evaluation (GPE) project. This project evaluated over 30 sire breeds in a common environment and management system. The data summarized by the MARC scientists consisted of records on more than 20,000 animals born between 1978 and 1991, with a re-sampling of the most popular sire breeds in 1999-2000. The various sire breeds evaluated were mated to Angus, Hereford and crossbred cows. Thus, the data reported were for crossbred progeny. During the study, Angus-Hereford crossbred calves were produced in the study as a control for each cycle of the GPE project.

One of the major outcomes of the GPE project was the characterization of sire breeds for a wide variety of economically important traits. Because all of the animals were in a common management system and production environment, the average differences observed in performance were due to genetic differences. Historically, British breeds such as Hereford, Angus, Red Angus and Shorthorn have been evaluated as moderate in growth and mature size, relatively higher in carcass fat composition, reach puberty at relatively younger ages and are moderate in milk production. However, with the dramatic changes growth rate and lactation potentials of several popular British breeds, these views need updated. Contemporary evaluations of lactation potential and growth rate to a yearling endpoint suggest that some British breeds have closed the gap that once existed between British and Continental breeds. Figure 1 panel A and B illustrate the Angus based breed mean Yearling Weight and Maternal Milk EPD for 2009 born animals for a number of breeds resulting from the application of the US MARC 2012 across-breed EPD adjustment factors. Continental European breeds, with a heritage that includes milk production, including Simmental, Maine-Anjou, and Gelbvieh tend to have high growth rates, larger mature sizes, moderate ages at puberty and relatively high levels of milk production. Another group of Continental European breeds, with a heritage of meat and draft purposes, including Charolais, Chianina and Limousin tend to have high growth rate, large mature size, older ages at puberty, very lean carcasses and low milk production. Cundiff et al. (2007) summarized a large body of data collected at US MARC for a variety of traits. The most recent reported sampling of breed germplasm suggests that there are no differences among the major British and Continental breeds for mature weight of cows with the exception of Gelbvieh sired cows, which were significantly lighter. Angus and Simmental sired calves had similar final carcass weights. These results stand in stark contrast to observations made among these breeds 30 years earlier (Cundiff et al., 2007). Although the convergence of breed means might erode complementarity, it does not mean we have witnessed and erosion in heterosis. However, the changes in breed means does impact the decision of which breeds to use for the production of terminal or maternal oriented calves.





[a]Adapted from breed means (Kuehn and Thallman, 2012a) and Across Breed EPD Adjustment factors (Kuehn and Thallman, 2012b).

Simulation research by Tomsen et al. (2001) compared total-system (all purebred plus crossing groups) profitability (income – expenses) for beef production using literature data on 14 breeds of cattle. All systems were simulated for a fixed amount of grazing resource and with slaughter of young animals at a constant level of fat (0.3 inch over the rib). Because there were many crossing systems with 14 breeds, the 10 best for various crossing systems were averaged and compared to the average of the best 3 pure breeds. The average of the best 10 two-breed rotation systems was 32% greater in profitability than the average of the best 3 purebred systems.

The 10 best rota-terminals (two-breed rotation dams) averaged 55% better and the 10 best composites, all composed of four breeds, averaged 51% better for profitability than the average of the best 3 purebred systems. These results illustrate the benefits of correctly utilizing breed strengths, and both individual and maternal heterosis. In terms of utilizing breed strengths, or breed complementarity, there is not greater example than using maternal crosses to produce dams, and terminal crosses to produce sires.

Opportunities in Beef Cattle

A breeding program must first start by defining a breeding objective. A breeding objective represents each animal's genetic value for economic merit. To define a breeding objective requires identifying which traits should be included and their marginal economic values. If done properly, comparison of animals then reflects differences in genetic potential for profit (Tang et al., 2011). An example would be defining an objective that centers on selling all offspring as terminal towards a specified grid (e.g. CAB). This clearly defines the traits of economic importance (growth, lean yield, marbling, and feed intake for example). In the absence of EPD for these traits, indicator traits would be used. The lack of clearly defined breeding objectives represents an initial stumbling block towards improved system efficiency. Another stumbling block is practicing selection based on index values derived with a specified breeding objective in mind that does not match the breeding objective of the user (bull buyer). An example of this would be selecting bulls based on a terminal index (e.g. Angus $B or Simmental TI) but marketing all male calves at weaning and retaining replacement heifers. In this example, the breeding objective of the bull buyer does not align with the selection criterion used to select bulls.

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.

So why the disparity in the way the beef industry approaches breeding as opposed to other industries?

Small cowherds produce the majority of calves in the US and this seems unlikely to change. The majority of these herds retain replacement heifers. The problem with this scenario is the lack of efficiency. In smaller herds there are generally not enough replacement heifers each year to make it practical to manage them as a separate group. It also seems a waste of time to wake up during the night to attend a very small group of heifers as they calve for the first time. A more profitable, and maybe more enjoyable, system for small herds would be to purchase bred females (ideally bred for their second calf or even older). In this scenario females would be selected for maternal traits and terminal sires would be used. All offspring would be sold for harvest. This would represent a decrease in labor and an increase in profitability. This system, and the benefits of it, could also be realized by large producers as well. Admittedly the cultural change is a large paradigm shift for the beef industry and unfortunately the cow/calf industry (commercial and seedstock) is not noted for making rapid progress relative to adopting new ideas (e.g. development of selection index theory is 1943 and adoption in beef in the early 2000s).

An opportunity exists for larger commercial and seedstock ranches to produce replacement females for smaller to medium sized commercial herds. The use of sexed semen could prove beneficial. Bull claves in a maternal system, or heifer claves in a terminal system, create a source of inefficiency (although not as large as the use of all-purpose herds). Being able to alter the frequency of the undesired sex would be beneficial. An example of this comes from the dairy industry where replacement heifers are generated using sexed semen. This has actually produced more replacement dairy heifers than needed. Given the excess of dairy females, older, lower producing cows are mated to beef bulls (generally Angus or Limousin) for the production of terminal offspring. This has greatly improved system efficiency. It is interesting that one of the largest impacts to the fed beef sector has come from advances in dairy cattle. Newer technologies are also available, although it is unclear if they will be marketable, in which gene editing is used to create the desired sex.

Obstacles for Implementation

Obviously tradition, as it most often is, represents a tremendous obstacle. If cattle production is the primary source of revenue for a firm, then the opportunities described herein make sense. If, however, cattle production is a byproduct of land ownership and making limited use of land resources not fit for crop production is the objective then this type of cultural shift will be a challenge. However, it could be argued that this simplifies decisions if beef production is not the primary focus for a firm given females will be produced by others and bull selection becomes simpler if only terminal traits are required. The other challenge is akin to the “chicken or the egg” argument. Producers will likely be slow to develop maternal systems until a large market develops for bred females focused on maternal traits. Similarly, all-purpose producers are likely to resist changing to an all-terminal system until a reliable source of bred females becomes available.

Implications

The easiest thing to do is always nothing, and then when profit potential disappears to blame external forces. The benefits of a migration of breeding systems to more defined purposes (maternal and terminal) has multiple benefits to the beef industry and individual producers. It allows for the production of heavy terminal calves from smaller mature cows, thus increasing the efficiency of terminal producers. Calving difficulty should be reduced, as the majority of heifers would reside in maternal herds. It should also increase the uniformity of calves entering feedlots because a more defined breeding objective was in place. Finally it allows for producers, in particular smaller producers, to focus on a narrower set of traits and to excel in doing one thing—producing terminal calves.

Literature Cited

Cundiff, L. V., R. M. Thallman, L. D. Van Vleck, G. L. Bennett and C. A. Morris. 2007. Cattle Breed Evaluation at the U.S. Meat Animal Research Centre and implications for commercial beef farmers. Proceedings of the New Zealand Society of Animal Production 2007, Vol. 67, p 9-17.

Kuehn, L. A. and R. M. Thallman. 2012a. Mean EPDs Reported By Different Breeds. Proc., Beef Improvement Federation 44th Research Symposium and Annual Meeting, Houston, TX. April 18-21, 2012. pp. 147-151.

Kuehn, L. A. and R. M. Thallman. 2012b.Across-Breed EPD Tables for the Year 2012 Adjusted to Breed Differences for Birth Year 2010. Proc., Beef Improvement Federation 44th Research Symposium and Annual Meeting, Houston, TX. April 18-21, 2012. pp. 147-151.

Tang, G., J. Stewart-Smith, G. Plastow, S. Moore, J. Basarab, M. D. MacNeil, and Z. Wang. 2011. Optimizing a beef production system using specialized sire and dam lines. Can. J. Anim. Sci. 91: 353-361.

Tomsen, U. Jon, D. Kirk Darnell, and Merlyn Nielsen. 2001. A comparison of beef cattle crossbreeding systems assuming value-based marketing. Nebraska Beef Report. MP 76-A:3-7.