Utilizing Brahman Germplasm in Crossbreeding Systems

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Greater than half of the cattle in the world are managed in tropical environments, while approximately 40% of beef cows in the United States are located in subtropical areas. Furthermore, approximately 80% of global beef production is *Bos indicus* based. Given this, *Bos indicus* germplasm plays a critical role in both US and worldwide beef production particularly when used as part of a well-structured crossbreeding program.

The decision of whether or not to utilize a particular strategic system of crossbreeding depends upon individual production goals. First must come the blinding realization that no one breed excels in all areas that lead to profitability. In order to take advantage of breed complementarity, breeds must be paired such that they excel in different areas that are critical to the overall production goals. The advantages of crossbreeding can be thought of as: 1) Taking advantage of breed complementarity, 2) Taking advantage of non-additive effects (dominance and epistasis) thus leading to heterosis (hybrid vigor).

Heterosis

Heterosis is the unexpected and often beneficial deviation from the average of the two parental lines. Hybrid vigor can also be thought of as the 'anti-inbreeding'. Percent heterosis can be calculated as:

% Heterosis = [(crossbred average – straightbred average) ÷ straightbred average] x 100

The amount of heterosis that is realized for a particular trait is inversely related to the heritability of the trait. With that in mind, traits of low heritability (reproductive traits) generally benefit from heterosis the most. They generally have a heritability of less than 10% and can be improved thru the adequate use of crossbreeding systems. End-product traits on the other hand are moderately to highly heritable and benefit less from heterosis. The other critical part to understand is that the more divergent the parental breeds, the more heterosis you can garner. For instance, a *Bos indicus* x *Bos taurus* cross animal will benefit from a greater degree of heterosis than will a *Bos taurus* x *Bos taurus* cross animal.

Unfortunately there exists a popular misconception that heterosis exists only in the first generation of crossbreds (F_1). Heterosis is retained in the breeding of crossbred animals and is related to the probability of alleles from different parental lines joining together. The proportion of heterosis retained in the second generation of crossbred animals is equal to the following:

Heterosis retained = $1- [(PS_1PD_1) + \ldots + [(PS_nPD_n)]$

Where PS_1 is the proportion of the sire from breed 1 and PD_1 is the proportion of the time from breed 1 and n is equal to the total number of breeds involved. Using the example of mating a Hereford bull to a F_1 Brahman x Hereford cow, we can see that the corresponding calves will retain 50% of the heterosis because the sire and the dam share Hereford in common. If, however, an Angus bull were mated to the same cow above, the calves would retain 100% heterosis because there are no breeds in common between the sire and dam.

The real benefit to commercial cow herds is the crossbred cow. Research results have shown that heterosis increases production per cow exposed by approximately 20-25% in *Bos taurus* breed crosses (Cundiff et al., 1974; Gregory and Cundiff, 1980). Experiments by Cartwright and others as well as Cundiff involving *Bos indicus* X *Bos taurus* crosses have shown that effects of heterosis are much larger than in *Bos taurus* X *Bos taurus* crosses for most traits and increase production per cow at least 50 percent.

Current Breed Differences

To date, one of the best resources for breed comparisons and estimates of heterosis is the Germplasm Evaluation Program (GPE) at the US Meat Animal Research Center (USMARC). The GPE at USMARC has allowed for comparisons of progeny of sires of different breeds with known current EPDs in order to estimate across breed expected progeny differences (AB-EPD) factors. These adjustment factors, updated annually, can also be added to yearly breed averages available from most breeds to estimate and compare genetic trends for different breed's birth weight, weaning weight, yearling weight and maternal milk. The most recent AB-EPD adjustment factors (Kuehn and Thallman, 2012) can be found at www.beefimprovement.org.

Estimates of across breed genetic trends indicate that breed differences for birth weight have narrowed over the past 40 years. Current estimates of breed means indicate that calves sired by Brahman bulls are still significantly heavier at birth than calves sired by any other breed. However, as will be discussed later, this is reversed in the case of calves out of Brahman influenced dams. Brahman sired progeny have relatively heavy weaning weights but relatively lighter yearling weights. The lighter yearling weights reported at USMARC might reflect genetic differences or perhaps Genotype by Environment (GxE) interactions with the season at USMARC where postweaning gains would have occurred during the winter months. Breed means for Maternal Milk indicate that Brahman sired females excel in milk production, although the genetic trend for milk in this breed has been relatively flat as opposed to Angus (increasing) and Simmental (decreasing). Breed differences change overtime and consequently the evaluation of breeds contained in a crossbreeding system must be reevaluated as well.

From an end-product perspective, it is clear from work at USMARC that Continental and *Bos indicus* breeds have higher retail product yields while British breeds (Angus, Red Angus, and Shorthorn) excel in marbling. Crouse and others (1989) showed that shear force required to slice through half-inch cores of cooked rib steaks increased 1.6 lb for each 25% increase in Brahman inheritance. This issue cannot be ignored, however, the issue of tenderness can be mitigated in commercial beef production by the use of breed complementarity. Additionally, since 2000 the ABBA has collected carcass data on over 1,000 progeny from 350 sires leading to the development of a genomically-enhanced EPD for tenderness. Given the heritability of tenderness (approximately 40%) large strides can be made by within-breed selection for a product that is more tender. Consequently, the blending of breeds with various strengths can be advantageous for carcass merit particularly when carcass merit is correctly valued relative to other key traits (survivability, reproductive performance and efficient growth) throughout the production chain.

To this end, it is fundamentally important to understand differences in terms of efficiency. Biological efficiency differences in *Bos indicus* X *Bos taurus* and *Bos taurus* X *Bos taurus* cross cows were evaluated at USMARC using the Hereford-Angus reciprocal cross and Brahman cross cows produced in the Cycle III of GPE. In terms of efficiency (calf gain divided by Mcal metabolizable energy intake by cow and calf), Brahman cross cows were approximately 10% more efficient than Hereford-Angus crosses. The condition of teeth in the cows remaining in the study was examined and the frequency of normal teeth was much greater in Brahman crosses than in Hereford-Angus cross cows. This suggests that the inclusion of Brahman germplasm in a maternal cross aids in longevity above the benefits of improved fertility.

Matching Genetic Potential to Environmental Constraints

Choosing a breed that is best suited to your production environment is dependent on several factors including the availability of feed, and level of stress (temperature, amount of moisture, etc.). Table 1 outlines the biological type of cattle that are best suited for particular levels of feed resources and stress.

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	H
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, 2001.
[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.

Given knowledge of how one breed performs in a certain environment is important, but what if that breed were transferred to a differing environment all together, would the advantages of that breed erode or disappear? In GPE Cycle III, the existence of GxE interactions for reproduction and maternal performance of *Bos indicus* X *Bos taurus* F_1 cross and *Bos taurus* X *Bos taurus* F_1 cross females in a temperate (Nebraska) and subtropical (Florida) environment were evaluated. Findings from this experiment showed that birth weight of calves produced by *Bos indicus* X *Bos taurus* cross females were significantly lighter at birth and weaning weight per cow exposed was significantly (28% in Florida and 5.8% in Nebraska) greater than for *Bos taurus* X *Bos taurus* cross females. While Brahman sired calves out of Hereford and Angus dams were significantly heavier at birth than Hereford-Angus reciprocal crosses, *Bos indicus* X *Bos taurus* cross females have a remarkable ability to limit prenatal growth of their offspring and to excel in calving ease. This favorable maternal effect was especially pronounced in Nebraska and illustrates a very favorable heterosis effect.

The question remains relative the environmental fitness of *Bos indicus* influenced animals in cold environments. To answer this question, *Bos indicus* X *Bos taurus* F_1 cross (Brahman X Hereford, Brahman X Angus) and *Bos taurus* X *Bos taurus* F_1 cross females were mated to evaluate alternative ratios of *Bos indicus* and *Bos taurus* inheritance in Nebraska. As the average daily temperature during calving decreased, increasing *Bos indicus* inheritance was less favorable relative to calf mortality in spring born animals. However, even on the coldest days mortality of 100% *Bos taurus* was not different from that of 25% *Bos indicus* calves. Results from this experiment at USMARC illustrated that from a mortality perspective, greater than 50% *Bos indicus* might not be advisable if calving in cold weather, but 25% of less *Bos indicus* inheritance can be acceptable as would be achieved from mating a half-blood Brahman cow to a Continental or British breed bull. Cundiff and colleagues at USMARC also studied effects of season and proportion *Bos indicus* inheritance on performance of steers from birth to harvest. Results showed higher ADG for Brahman than Angus sired steers during spring and summer months for both pre-weaning (March – July) and post-weaning (June -August) periods, but significantly lower post-weaning average daily gains during winter periods (November - December, January – February, March – April). However, Brahman sired steers produced significantly greater retail product weight (447 days of age) than any other sire breed because of significantly higher yields. The results from these two studies show that it is critical to carefully match genetics to the production environment and that when done correctly, Brahman influenced cattle can excel in part due to the added heterosis that can be garnered from *Bos indicus* x *Bos taurus* matings as opposed to *Bos taurus* x *Bos taurus*.

Conclusions

Every breed has strengths and weaknesses relative to an individual commercial operations’ 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. Research results are clear that *Bos indicus* X *Bos taurus* cross females excel in cow efficiency, productivity and longevity and have the unique ability to limit prenatal growth. This allows for substantial improvements in weaning weight per cow exposed while minimizing calving difficulty. Climatic conditions are an important consideration when choosing breeds to utilize in a crossbreeding program and caution should be utilized to ensure environmental fitness is addressed. However, the use of composite females allows for flexibility such that, depending on environmental demands and the choice of sire breeds, proportions of Brahman in the calves can range from 25-75% and thus fitting a wider range of environments. It is important to remember that successful crossbreeding programs focus on optimums, not maximums or minimums, to achieve breeding and marketing goals that fit within the production environment.