Excerpts from "Crossbreeding Beef Cattle For Western Range Environments" by D.D. Kress and T. C. Nelsen

The beef cattle industry has increasingly turned to crossbreeding as a tool for improving productivity through heterosis and for combining traits from different breeds to match cattle to varying environments and markets. Beef cattle production will be at biological and economical optimums when cattle are matched to the environment. The environment includes not only the important elements of climate and terrain, but also the effects of parasites, disease, and the overall level of management.



Breeders should utilize a planned crossbreeding system to take advantage of heterosis. Even if a breeder has only one breeding pasture, there are several effective or simplified systems that can be used.

Variation in the environment over time must also be considered. Highperforming cattle that require more care and a high quality and large quantity of feed will be hurt much more by drought, disease, or neglect than will lower performing cattle with lower requirements. On the other hand, resources are wasted if cattle don't have the genetic potential to use abundant resources.

It is important that both commercial and purebred beef cattle breeders understand the advantages and disadvantages of using crossbreeding and different crossbreeding systems. Commercial breeders must evaluate crossbreeding results and understand the different crossbreeding systems before implementing a crossbreeding program for each unique operation. The same applies to the purebred breeder, who must be able to 1) give intelligent advice to commercial breeders that buy his seedstock; and, 2) know where his genetic product best fits into crossbreeding programs.

Advantages and Limitations of Crossbreeding

There are many reasons for the commercial beef breeder to crossbreed and few disadvantages if the crossbreeding program is based on sound information and a bit of common sense. A discussion of the advantages of crossbreeding follows:

1. Individual Heterosis. Heterosis or hybrid vigor is the degree to which crossbred calves deviate from the average of calves of the parental

breeds. The amount and percentage of heterosis can be calculated as follows where straightbred Red Angus (A), straightbred Hereford (H), and crosses between Red Angus and Hereford (AH and HA) were raised as contemporaries:

Amount of Heterosis = AH + HA - A + H

Percent of Heterosis = amount of heterosis $A + H \times 100$

As an example, for weaning weight, if A = 400 lb, H = 450 lb, AH = 440 lband HA = 450 lb, then: **Amount of Heterosis =** 445 lb - 425 lb = 20 lb**Percent of Heterosis** = $20 \times 100 = 5\%$ 425

Note that heterosis may be positive or negative and that there may be positive heterosis even when one of the parental breeds performs better than the average of crossbreds.

2. Maternal Heterosis. Maternal heterosis arises from using crossbred cows. A maternal heterosis value of 6 percent for calf weaning weight means that crossbred cows wean calves that weigh 6 percent more than if those same calves had been raised on straightbred cows. Maternal heterosis is usually greater than individual heterosis for maternally influ-

enced traits and, as a result, crossbreeding programs should include use of a crossbred cow.

- 3. Complementarity of Male and Female Traits. Certain crossbreeding systems allow the breeder to match traits of the bull breed to traits of the crossbred cow. Normally, this means that the breeder chooses a bull breed that will transmit rapid growth and desirable carcass traits to progeny while the crossbred cow provides ample milk for the rapidly growing calf and produces a live, healthy calf every year. Complementarity can work in a negative way in poorly designed crossbreeding programs where large terminal sire breeds are bred to small, young, hard-calving cows. This can result in an excessive frequency of dystocia.
- 4. "Building" the Best Match of Crossbred Cow to Environment. This advantage has been overlooked

by some breeders. But, in many different range environments, this may be the most important consideration. There are many beef breeds available to the producer and some combination of these breeds should result in a desirable match of crossbred cow genotype to the particular range environment.

5. Effects of Crossbreeding

Accumulate. Crossbreeding may result in relatively small levels of heterosis (4 percent) for each trait, but these heterotic effects tend to accumulate so that there can be large increases (25 percent) in overall productivity!

6. Rapid Adaptation to Changing Market or Resources. Terminal sire systems give the breeder an opportunity to change sires rapidly so that calves can be changed according to market demands or resources.

Crossbreeding will not compensate

for poor management. Crossbreeding systems that utilize two or more breeds of sires (for example, the rotation systems) may cause increased variability of calves and lead to marketing or management problems. Some crossbreeding systems require several breeding pastures and some require that cows be identified by year of birth and breed of sire.

Summary of Beef Cattle Crossbreeding Results

For the commercial breeder to use crossbreeding effectively, the breeder must understand the biological differences among breeds and know the level of heterosis to expect for various traits. Summaries of research results on these two issues are presented in the following tables:

Table 1 lists various beef breeds and groups them according to biological type based on: 1) level of milk production; 2) growth rate and mature

size; 3) percentage retail product; and 4) age at puberty. This is not an exhaustive list of characteristics that could be used to classify cattle, but from a practical standpoint it does a good job of classifying breeds into different biological types.

It is important to match the biological type of the cow to the environment of the beef operation. Table 1 can be very helpful during this process. For example, if the environment is characterized by high annual precipitation, good quantity and quality summer forage, and plentiful winter feed, then the proper biological type of cow to match that environment would be a high milking, fast growth rate type of cow with early age at puberty. However, if the environment is more limiting, as in most low rainfall areas, then the proper biological type of cow would be one with lower milk production, a slower growth rate, and an early age at puberty. Intermediate

Table 1. Breeds grouped into biological types for four criteriaa

	Growth rate	Lean-to-fat-ratio	Age at	Milk
Breed Group	<u>& mature size</u>	(% retail product)	<u>puberty</u>	<u>production</u>
Jersey (J)	X	Χ	Χ	XXXXX
Hereford-Angus (HAx)) XXX	XX	XXX	XX
Red Poll (R)	XX	XX	XX	XXX
Shorthorn (Sh)	XXX	XX	XXX	XXX
South Devon (Sd)	XXX	XXX	XX	XXX
Brangus (Bg)	XXX	XX	XXXX	XX
Brahman (Bm)	XXXX	XXX	XXXXX	XXX
Gelbvieh (G)	XXXX	XXXX	XX	XXXX
Simmental (S)	XXXXX	XXXX	XXX	XXXX
Salers (Sa)	XXXXX	XXXX	XXX	XXX
Limousin (L)	XXX	XXXXX	XXXX	X
Charolais (C)	XXXXX	XXXXX	XXXX	X

^aincreasing number of Xs indicate relatively higher values

types of environments would dictate intermediate biological types of cows. Low quality and quantity summer range would dictate biological types of cows with lower milk production. Low quality and quantity winter feed would dictate smaller mature size. All biological types considered for the cow side of the herd should have average or earlier age at puberty. Therefore, the proper biological type of cow may be a Red Angus x Hereford cross in one environment and a Simmental x Red Angus cross in another environment.

The primary characteristics to be desired, in regards to terminal sire breeds, are rapid growth rate and a high percentage of retail product.

It is also important for the producer to know the level of heterosis to expect from crossbreeding beef cattle. Table 2 lists individual traits and the average percentages of individual, maternal, and total (sum of individual and maternal) heterosis that have been reported in research publications. Since some traits are influenced by both the calf and the cow, both individual and maternal heterosis influence the trait. The total heterosis that can be achieved in a crossbreeding system is the sum of the two.

Careful study of Table 2 reveals the following interesting results: 1) The level of heterosis varies from zero to very high, depending upon the trait, and therefore, the producer should not expect crossbreeding to result in

Table 2. Average levels of individual heterosis and maternal heterosis for traits of beef cattle.

	Individual	Maternal	Total
<u>Trait</u>	<u>heterosis, %</u>	heterosis, %	heterosis, %
Calving rate	0	6	6
Weaning rate	0	8	8
Survival birth	2	-1	1
Calving difficulty	2	0	2
Birth weight	4	2	6
Weaning weight	5	6	11
Yearling weight	4		4
Cow condition	-4		-4
Carcass weight	3		3
USDA Carcass Grade	2		2
Fat thickness	6		6
Carcass yield grade	5		5
Feed conversion (TDN/ga	iin) -2		-2
Calf weaning wt./cow wt.			8
Cow lifetime productivity			25

heterosis for dressing percentage, but should expect substantial gain in calf weaning weight per cow exposed to breeding. 2) Maternal heterosis is very important for some traits, thus

requiring a crossbred cow. 3) Heterosis tends to accumulate so traits that are made up of several traits (like cow lifetime productivity) exhibit the greatest overall heterosis.

4) Heterosis is extremely important to the commercial breeder because increased productivity from heterosis can easily pay for any additional costs of crossbreeding!

Table 3 is provided as a means of summarizing the results on levels of heterosis for different categories of traits. It is relatively easy to remember that heterosis is low for carcass measurements but high for maternal ability.

Characteristics of cattle can be changed rapidly through crossbreeding, but producers must be aware that biggest is not always best. Producers should be aiming for optimums rather than maximums for most traits. The optimum biological type can change as environments are changed. For example, in Havre, MT, the Simmental x Hereford cows outperformed the Angus x Hereford cows. At Miles City, MT, in a lower and

drier environment, the Angus x Hereford cows outperformed the Simmental x Hereford cows. Brahman x Hereford crosses generally do better than Angus x Hereford crosses along the Gulf Coast of the United States, but in the higher, drier, and colder plateaus of NV, the Brahman x Hereford calves have problems with survival.

All in all, crossbreeding can be beneficial for most commercial beef producers. However, like any other breeding plan, crossbreeding works best when it has been well thought out before it is started.

Crossbreeding Systems

Traditional crossbreeding systems usually require several breeding pastures (or artificial insemination). For many commercial breeders, the use of several breeding pastures is not economically feasible, so the traditional crossbreeding systems will not be

Table 3. Summary of total heterosis by type of trait

Trait **Total heterosis**

Carcass measurements Skeletal measurements

Mature weight Low (0 to 5%)

Growth rate Early weights

Milk production Med (5 to 10%)

Maternal ability Reproduction Health

Cow longevity

Overall productivity High (10 to 30%)

practical. Producers should study these systems and decide which one would work best in their operation. It is important for producers to use a planned system even if it is a simple one.

Table 4 serves as a basis for comparing expected cow productivity from the different systems. The measure of productivity is amount of calf weaned

Table 4. Comparison of crossbreeding systems by type of system1

systems by type or system i				
	Advantage			
Type of system	<u>(%)</u> 2			
Traditional Crossbreeding Systems				
Rotation 2 - breed	16			
3 - breed	20			
4 - breed	22			
Static terminal sire (3-breed)	20			
Static terminal sire (2-breed)	9			
Rotational terminal sire				
2 - breed	21			
3 - breed	24			
Simplified Crossbreeding Systems				
Rotate sire breed				
2 - breed	12			
3 - breed	16			
2 - breed rotation with F1 sires	19			
Multiple sire breed with crossbred females				
2 - breed	10			
3 - breed	15			
Multiple sire breed with straightbred females				
2 - breed	7			
3 - breed	7			
Composite ³				
2 - breed	13			
3 - breed	15			
4 - breed	17			
8 - breed	20			
Static terminal sire				
buy crossbred F1 females	28			
buy composite or rotational	20 to 27			
* *				

¹After Gregory and Cundiff (1980), Baker (1982), Kress (1985) and others.

per cow exposed to breeding. The advantage refers to the increased productivity from the particular system relative to what would be achieved using straightbreds. For example, suppose that a straightbred Red Angus averaged 400 lb and Herefords averaged 350 lb for amount of calf weaned per cow exposed. The 2-breed rotation of Red Angus and Hereford is expected to increase productivity by 16 percent over 375 lb (average of Red Angus and Hereford) or to a level of 435 lb (375 lb + .16 times 375 lb = 375 lb + 60 lb).

No single crossbreeding system will be best for all situations, but a planned system should be used. Simple systems may sacrifice heterosis and/or complementarity, but

²Percentage advantage for pounds of calf weaned per cow exposed when compared to the average of the breeds involved in the crossbreeding system. assumes 80% calf crop weaned, 20% replacement rate, individual heterosis = 8.5%, maternal heterosis = 14.8% and 5% increase in calf weight due to terminal sire. Also assumes that cow breed type has been adequately matched to environment and sire genotype and that proper advantage has been taken of complementarity of sire genotype and dam genotype in terminal sire systems.

³Breeds in equal or nearly equal proportion.

may be just right for an operation. Producers should remember to be innovative!

Application of Results and Systems

The previous sections have illustrated the advantages that can be gained when beef cattle breeders utilize crossbreeding. Individual heterosis has been shown to be important for traits like preweaning growth. However, a tremendous advantage can be reaped by the beef cattle breeder who uses crossbred cows that are well adapted (matched) to the breeder's environment. A breeder has some options in changing the environment, but many options in changing the cattle.

Crossbreeding is beneficial, but the benefits can be reduced by poor planning. So, breeders should remember 1) to pick breeds carefully so there is a good match of genotype to management and environment; 2) to select sires and female replacements wisely so the crossbreeding system is powered by superior genetics; 3) not to regard crossbreeding as a substitute for poor management; and 4) to choose sire breeds carefully in terminal sire systems to maximize positive complementarity and control negative complementarity (e.g., calving difficulty).

Implementation of a crossbreeding system proceeds in the following ways: 1) A breeder starts by evaluating the environment and resources available to the operation. Most breeders can do this accurately, but occasionally a breeder is rather optimistic in appraising the type of cattle a given environment will support. 2) The level of management is matched to the environment. The level of management includes the number of breeding pastures, whether or not AI will be practiced and the degree to which the breeder will use management to modify the environment. 3) The crossbreeding system is matched to the level of management and environment. 4) The type of crossbred female is matched to the crossbreeding system, management, and environment. 5) The sire genotype (if not already decided by steps 3 and 4 above) is matched to the dam type, crossbreeding system, management, and environment.

Summary

Crossbreeding has several possible advantages. Results from beef cattle experiments have shown that crossbreds are superior to straightbreds for many traits an that important levels of heterosis occur. It is important that the biological type of the cow is well adapted to the environment and resources of the operation.

Breeders should utilize a planned crossbreeding system to take advantage of heterosis. Even if a breeder has only one breeding pasture, there are several effective or simplified systems that can be used. The choice of the appropriate system, type of crossbred cow, and sire breed must be based on sound research information and a dose of common sense.