SPECIALIZED LINES FOR BEEF BREEDING HERDS

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UA RESEARCH

Research conducted by The University of Arizona Animal Sciences Department indicates that the use of specialized sire and dam lines could improve productivity of commercial beef breeding herds.

This conclusion is based on an experiment which compared the breeding performance of topcross progeny of three inbred sire lines with each other and with an outbred control herd. Comparisons involved birth weights, weaning weights, and weaning conformation and condition scores of 400 bull and heifer calves. The cattle were from the registered Hereford herd owned by the San Carlos Apache Indian Tribe. The herd is maintained approximately 60 miles east of Globe, Arizona, on a semi-arid range at an elevation of approximately 5,000 feet. The breeding season normally extends from May 1 to August 1, and calves are weaned and evaluated in October or early November. No supplement was provided for cows and calves during the period of this study.

The topcross parental stock involved in this study were the progeny of eight sires from three inbred lines (1, 6 and 9) of the U.S. Range Livestock Experiment Station, Miles City, Montana. Since some of these lines have become very popular in the beef industry, a brief history of their development is presented.

Line 1 cows traced back to stock purchased in 1926 from George M. Miles of Miles City, Montana. Most of the foundation cows were sired by Colonel Perfection and his two sons, Colonel Grayfield 2nd and Colonel Defender 3rd, and two other bulls, Domino Perfection 3rd and Blanchard 40th. These cows were mated to two half brothers, Advance Domino 20th and Advance Domino 54th, purchased from a Colorado breeder. The first calves were dropped in 1934, and the line has remained closed to outside breeding since that time.

Line 6 was initiated in 1948 with the purchase of 30 heifers and two bulls of Real Prince Domino breeding from a Nebraska breeder. The foundation sires were Perfect Lad 18th and Maude's Mischief 19th. The first calves were dropped in 1949.

Line 9 resulted from twenty-eight head of heifer calves and one bull calf of King Domino breeding purchased from a Montana breeder in 1948. The foundation sire of this polled line was Seth Domino. The first calves were dropped in 1951.

Of the original sires (grand-sires of the calves included in this study), four were from line 1 and two each from lines 6 and 9. Parents designated SC (San Carlos) were the progeny of 30 purebred sires originating within the herd. With the exception of the control matings (SC X SC), the parental stock was composed of 50% SC breeding and 50% of the respective line involved in the topcross mating. Topcross sires were chosen from those available to be as representative of the group as possible. The number of sires used were:

L1 X SC-2	L9 X SC-2
L6 X SC-2	SC X SC-3

Results from the experiment are presented in Table 1. Birth weights of the calves averaged 74 lbs., with minor differences among the various breeding groups. Heaviest calves at birth included line 9 cross cows mated to San Carlos bulls, whereas the lightest calves were from San Carlos cows mated to topcross line 9 bulls.

Substantial differences occurred in weaning weights. The heaviest calves were produced by topcross line 6 cows mated to San Carlos bulls (514 lbs.). Surprisingly, the reciprocal cross (line 6 topcross bulls on San Carlos cows) resulted in calves that were among the lightest (469 lbs.). A difference of this magnitude (45 lbs.) has some important implications. First of all, it indicates that factors associated with the cow (maternal ability) are more important under Arizona range conditions than the genetic potential of the calf in determining growth of the calf to weaning. This probably reflects differences in the milking ability of the cow. Secondly, it suggests that there may actually be an antagonism between preweaning growth and maternal ability. Additional evidence for this antagonism is seen in the results of crosses involving line 1. Although the differences between the reciprocal crosses is not as great in this case (16 lbs.), it is still large enough to be of economic importance.

Table 1. Birth and Weaning Traits by Line of Breeding

Sire Line		Dam Line	Birth Weight	Weaning Weight	Conformation Score[a]	Condition Score[a]
			(lbs.)	(lbs.)		
1	X	SC	74	476	11.1	10.5
6	X	SC	76	469	11.1	10.5
9	X	SC	73	470	11.1	10.8
SC	X	1	76	492	11.5	11.1
SC	X	6	74	514	11.8	11.1
SC	X	9	76	466	11.3	10.9
SC	X	SC	75	479	11.4	10.8
Average			74	479	11.3	10.8

[a] Evaluated on a 15 point scale, with higher values indicating more desirable conformation or greater condition. A condition score of 11-12 is considered optimum.

Conformation and condition scores are also listed in the table. In general, the results followed the same trends as noted for weaning weight. Higher scores were observed when these inbred lines were used in the cow side of the cross. All of the values would be considered very acceptable for Hereford calves at weaning.

These results indicate that two (1 and 6) of the three inbred lines tested were much more valuable when incorporated into cows than in bulls. This would mean that different criteria for selection of bull and heifer calves at weaning would be the most efficient system. A natural outgrowth of this procedure would be a breeding program using specialized sire and dam lines for commercial beef production.

One of the more effective methods of developing specialized lines is through crossbreeding. Breeds of cattle often excel in different desirable traits. These same traits are present within different lines of the same breed of cattle, but the differences are normally not as great as between breeds and thus are more difficult to identify. Desired traits for brood cows are early puberty, high fertility, ease of calving, adequate milk production, adaptability, a strong mothering instinct, etc. Oftentimes large mature size or weight is a disadvantage in the cow herd, especially on southwest ranges. The bull's major contribution is in size and weight as reflected by growth rate of his calves. Other traits are also important, such as the ability to travel, libido (sex drive), desirable muscling, relatively small calves at birth, etc.

One example of such a crossbreeding program is the "terminal sire" system. All of the cows are crossbreeds developed from two (or more) breeds selected specifically for maternal characteristics and adaptability. Bulls are selected from a breed differing from those in the cow herd with primary emphasis on growth and carcass characteristics. All calves produced go to market, hence the term "terminal sire." Research results indicate an increase of approximately 25% in pounds of calf weaned per cow with this system.

The use of specialized sire and dam "lines," either within a breed or through the use of different breeds, provides the breeder with a technique to substantially improve production.

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BULL SELECTION

Richard W. Rice[1]

One of the most important decisions that a cattle producer makes is the selection of bulls for his cow herd. Bulls contribute half of the genetic material for the cow herd. If replacement heifers are selected from within the herd, the bull will influence the production of the herd for up to 10 years or more.

BASIS FOR BULL SELECTION

Bulls are selected for their genetic potential. It is difficult to determine genetic values of bulls since the outward appearance (phenotype) are a result of both genetic potential and the conditions under which the animal was developed (environment). Nutrition, climate, diseases, parasites and insects plus weather conditions influence the outward appearance of the bull. Where possible the animal should be compared with other animals within the same herd and should be raised under conditions similar to those which he is expected to perform. However, the genetic value of bulls can be determined and compared with bulls throughout the country because of the sire record systems of the purebred beef cattle associations.

INDIVIDUAL EVALUATION

The genetic value of a bull can be estimated by his own performance. In addition, the physical attributes he expresses visually will aid in selection. Genetic values are often available that take into account the performance of his sire, dam, grandsire, granddam, herdmates and brothers and sisters. The genetic evaluation is called Expected Progeny Differences (EPD).

For Bull Selection, a breeder should establish goals for his own herd, evaluate herd strengths and weaknesses and select bulls which will improve the production and genetic merit of the herd. Selection has to include a realistic appraisal of the resources available to support the cow herd and growth of calves.

There are three major categories of bulls needed for commercial beef production.

1. Maternal bulls for use on heifers.
2. Maternal bulls for use on cows.
3. Terminal bulls for use on cows.

One or all of these categories may be useful in a breeding program based upon the goals of the manager and the quality and quantity of feed resources provided by the ranch.

EDP values may be used to achieve desired production goals. However, EPD's for many desirable traits are not available. A listing of important traits for which information may be available is given in Table 1.

Table 1. Traits for Selection of Bulls Based Upon Function

Trait	Maternal Bulls For Heifers	Maternal Bulls For Cows	Terminal Bulls For Cows
Scrotal Circumference	Large	Large	Medium-Large
Pelvic Area	Large	Large	Not Important
Calving Ease	High	High	High
Birth Weight	Low	Medium	Medium
Weaning Weight	Match	Match	High
Milk	Match	Match	Not Important
Total Maternal	Match	Match	Not Important
Yearling Weight	Match	Match	High
Carcass Percent Protein	Conflict	Conflict	High
Carcass Quality	High	High	High

Where match is listed, the bulls selected should be matched with the resources available on the ranch. Matching is illustrated in Table 2.

Table 2. Matching Bulls to the Resources

Mature Size	Milk Level	Availability of Food from Grazing: Low	Medium	High
L	H	-	0	+
L	M	-	+	+
L	L	0	+	+
M	H	-	-	+
M	M	-	0	+
M	L	-	+	+
H	H	-	-	0
H	M	-	-	0
H	L	-	0	+

+ = Matching mature size and milk production with resources.
0 = Risky, extra feed may be necessary or fertility and production may be affected.
- = Avoid the combination, production will be unsatisfactory.

High levels of milk production require more feed resources. An increase of 5 lb. in milk production increases energy required by 15%, protein required by 21% and minerals (calcium and phosphorus) by as much as 37%.

Larger cattle require more feed. An increase in mature cow size from 1000 to 1200 lb. results in a 15-20% increase in the maintenance requirement.

Most of the genetic traits available from performance records and EPD's are based upon increases in the weight and growth of cattle. If we all select for size increases, the result may be a mis-match of resources to support the herd, loss of maternal factors affecting fertility and a reduction in the efficiency of production. Excessive size is not desired by the meat industry, therefore, requirements for the final product must be involved in selection.

Size affects weight required for puberty, successful reproduction and desirability of the final product. For example, a 1400 lb. cow will produce heifers that will not reach puberty until they weigh 900 and steers that will not grade choice until they reach a weight of 1300 lb.

Heifer development and fertility are important and resources normally available will not produce the desired puberty of large animals at a young age. Cattle feeders, packers and retailers do not desire excessively heavy cattle. Therefore, sire selection has to be matched with the resources available, maternal efficiency of heifers produced and the product desirable to feeders, packers, retailers and consumers.

Breeding systems to achieve productivity, fertility and a desirable final product can be classified into three systems.

1. **All purpose:**

   Cow size and milk production are matched with feed resources and bulls of the same biological type are selected. Replacement will have similar desired attributes as the cow herd.

2. **Combination:**

   Cow herd size and milk production matched to the feed resources. Replacements are produced by mating bulls with maternal desirability with heifers and young cows.

   Mature cows, 4 years old or older, are mated to terminal sires, all calves are sold.

3. **Terminal Sire System:**

   Matched cows are mated to large bulls. All calves are sold. Replacements are purchased or bred separately.

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RANGE BEEF HERD GROWTH SELECTION

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A major economic goal of the cattle producer and others in the beef industry is the genetic improvement of growth traits in range cattle. Superior genetic growth potential is reflected in improved feedlot efficiency and carcass desirability. These factors make it imperative that the cattle producer use accurate objective measurements and selection methods to identify the superior genotypes in his herd.

The growth performance of range beef cattle in areas of year-long grazing reflects forage availability as well as climatic stress conditions. Because annual rainfall and temperature patterns in an area directly influence quantity and quality of range forage, all range stock are subjected to varying periods of feed or nutrient restriction. Live weight and body measurement data show that with only range feed available, growth in weight is strictly seasonal from weaning to maturity.

A successful selection program for improvement of performance traits in beef cattle depends on selection for a specific trait and understanding how selection for one trait may influence other traits. The major purpose of the study to be described was to obtain information on genetic parameters of growth of range beef cattle under a practical management system. This information should be directly applicable to a performance testing program for the range cattle producer.

MATERIALS AND METHODS

Data were obtained from the registered Hereford herd owned and maintained by the Apache Indian Tribe at San Carlos, Arizona. With the initiation of the study, individual breeding pastures were developed for the registered herd. Each pasture carries 30 to 35 cows and averages about 600 acres in size. Cows were allotted to the breeding pastures in January for calving during the following three months and remained in the individual pastures through the breeding periods, May 1 to July 30.

The general range area is at an altitude of 5,000 feet, with range forage consisting primarily of desert grassland vegetation. Annual rainfall averages about 14 inches with most of it occurring during the summer months of July and August. Temperatures may range from -20°F in January to 95°F in July.

Individual data recorded at birth included identification, birth date and weight. The calves were ear tattooed with individual identification numbers. During the nursing period pertinent comments concerning unusual maternal or calf information that could affect performance were noted.

In the fall all cows and calves were brought to corrals for weaning. The calves were weighed and individually scored by three judges for conformation and condition.

Bulls and heifers were maintained separately after weaning. Subsequent weights and scores were obtained in the early spring (about March 1) before the appearance of new range forage, again in the fall at weaning time and the following spring. Thus, four stages of development were represented, with an average mean age at each stage of 8, 11, 20 and 23 months. Records from more than 1,500 calves were utilized in this 10-year study.

None of the bull calves were castrated during this period. The herd was maintained on a year-long grazing program with little, if any, supplementation. It should be noted that during the more severe winters of the test period snow cover remained on the ground for several days at a time.

Sires used in the herd during the years of this study came from many different sources. They included purebred herds from Arizona and surrounding states, the Arizona Agricultural Experiment Station, United States Department of Agriculture performance tested lines, and bull progeny produced in the herd.

RESULTS

Average weights and the heritabilities of the weight at each age are summarized in Table 1. Only the bull calves are included in this report, although similar results were obtained with heifers. The average weaning weight of 480 lbs. at an average age of eight months translates into a daily gain from birth to weaning of 1.7 lb. This emphasizes the importance of having cows calve early in the season, as one month's difference in birth date resulted in an average difference of 50 lb. for the calf at weaning.

Table 1. Average Weights and Heritabilities

Age	Weight (lbs.)	Heritability Percent
Birth	76	50
Weaning	480	15
340 days	440	30
600 days	825	50
710 days	700	50

The weight losses that occurred over the two winter periods (weaning to 11 months and 20 to 23 months of age) should be very typical of unsupplemented range cattle in Arizona and many other parts of the world. It is not uncommon for animals to lose 10% or more of their weight from fall to spring under these conditions.

The highest values for heritability (50%) were for birth weight, long yearling weight (20 months) and weight as coming two-year olds.

The lowest heritability was for weaning weight (15%), with short yearling weight having a heritability of 30%. Many times the meaning of heritability is misunderstood. Probably one of the best ways to use a heritability value is in predicting how much improvement can be made when selecting for a particular trait. As an example, assume we selected replacement bulls and heifers in this herd that averaged 50 lb. above the weaning weight for the herd. We call this value (50 lb.) the selection differential. If we mate these replacements together, then we would expect their calves to have an average weaning weight 15% (heritability) of the selection differential (50 lbs.) above the herd average (480 lb.). In this case, that would be 15% x 50 lb. + 480 = 487.5 lbs. Obviously, the higher the heritability value for a trait, the more improvement we will make in the process of selection.

The major questions posed in this study were (1) what effect does selection for a specific trait have on other traits, and (2) when would be the "best" time to select replacement animals. To help understand Table 2, let's consider the information on the first line. In this case, we are selecting only for heavier birth weights (which we probably would not do). If this were the actual situation, birth weight would be increased by 5 lb. per generation. Due to what we call the correlated response, the other weights would also increase. In this example, selection for birth weight would also result in weaning weight increasing by 4 lb., yearling weight by 5 lb., and 20 and 23 month weights by 10 lb. each.

Table 2. Direct and Correlated Response to Selection

Trait Selected For	Change in Weight (lb.) At:				
	Birth	Weaning	11 months	20 months	23 months
Birth weight	5	4	5	10	10
Weaning weight	1	6	7	9	8
11 month weight	1	7	12	13	15
20 month weight	2	7	11	25	22
23 month weight	2	6	12	22	25

If we are primarily concerned with weaning weight, we would expect to improve it by 6 lb. per generation if we selected directly for it. However, we can make just as much (or more) improvement in weaning weight if we select for weights measured later in life. This may not seem reasonable, but it is due to three factors: 1) the heritability of weaning weight is low; 2) the heritability of yearling or two-year old weights is higher; and 3) the correlation between the latter traits and weaning weight is high. The weight taken at long-yearling age (20 months) appears to be "best" when we consider both preweaning and post-weaning gain performance, as it is the youngest age which results in a near-maximum improvement of all traits. One possible disadvantage of selecting for this weight is a greater increase in birth weight than we would expect by selecting at weaning time. To overcome this problem, we could use an index which selects against heavier birth weights and at the same time selects for heavy long-yearling weights. One index that has been suggested is 1 = Y - 3.2B, when 1 = index value, Y = yearling weight, and B = birth weight. As compared to selection on yearling weight alone, this index would reduce the expected increase in birth weight by 55% while reducing the improvement in yearling weight by only 10%. Thus, near maximum improvement can be made in growth rate while minimizing the usually undesirable increase in birth weight.

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ESTRUS SYNCHRONIZATION AND ARTIFICIAL INSEMINATION FOR BREEDING BEEF CATTLE

R. Rice[1]

Artificial insemination of cattle has proven to be very effective for the improvement of the genetic potential for production. In dairy production, over 80% of all cattle are now bred artificially. The success of dairy producers in improving milk production has been impressive. A large proportion of the success is due to improvement of the genetic potential of dairy cattle through use of outstanding sires by artificial insemination.

Artificial insemination in beef cattle has had limited use. The management necessary for success has limited its application primarily to seed stock producers. One of the main barriers to use in commercial beef cattle operations is the time and labor necessary for detection of estrus (heat) and insemination at the proper time during heat.

This barrier has been effectively removed with the availability of methods to synchronize heat. With estrus synchronization groups of cattle can be induced into fertile heat and bred at a specified time following initiation of the heat period. The success of this program is based upon a total management program. **Synchronization will not improve cattle fertility**. In fact, it is difficult to achieve fertility levels similar to those resulting from natural mating. For success, a total fertility management program is necessary.

KEY ELEMENTS OF FERTILITY MANAGEMENT

There are three groups of animals which need to be considered separately:

1. *Replacement heifers*
2. *Young cows with their first calf*
3. *Mature cows, having 2 or more calves*

Replacement Heifers

If the goal is to breed the replacement heifers at 12-14 months of age, a special heifer development program is essential. Some general rules apply:

1. They must be at least 12 months old or preferably older at breeding.
2. They must weigh at least 650 lb at breeding.
3. They must have a body condition of 5 or higher at breeding.

When replacement heifers are selected, usually in the fall, plans for the development program must be made.

1. Evaluation of heifers in the fall:

   An estimate of the age, weight and condition of the heifers is required so that the heifer development plan can be made.

   For example: For a heifer, born in March/April and weaned on or about 1 October, the following calculations should be made:

Weaning weight	500 lb
Age at weaning	6 months
Target weight breeding season	650 lb
Gain necessary to meet target wt.	150 lb
Breeding date desired	1 May
Days weaning to breeding	211 da
Average daily gain to breeding	0.75 lb/day

   Nutrition required to achieve target weight:

Generally the nutrients which are most likely to be required for growth and development are protein, energy and phosphorus.

Requirements for the desired gain are:

Protein	lb/day	1.5		
Energy	lb TDN daily	10.0		
Phosphorus	Daily	14.0g	.03lb	.5 oz

In alfalfa hay equivalents the heifers would require:

Alfalfa hay 16% protein, 52% TDN, .25%P	
For protein requirement	9.4 lb daily
For TDN requirement	19.2 lb daily
For phosphorus requirement	12.0 lb daily

The heifers would have to eat 19 lb alfalfa hay daily to meet energy (TDN) requirements. At the weight and age of our example, they would not likely eat 19 lb. Therefore, to ensure desired performance, a better energy source would be necessary.

For our calculations, we will feed an average of 9 lb alfalfa hay daily and choose a good energy source for the rest of the ration:

Heifers, pregnant with first calf in the fall.

Evaluate weight and condition of heifers in the fall. Condition is the most important indicator of management needs prior to calving and rebreeding for second calf:

> In fall, condition of these heifers should be at least 5-6. During winter, without extra feed, except range forage, they would be expected to lose weight and at least one condition score. If the condition score at breeding in the spring is 4 or less, the fertility in the breeding season will be lowered. At fall evaluation, you can anticipate whether or not supplements may be required during late pregnancy and into the breeding season for this group. If fall condition appears to be marginal, supplements begun 1 month prior to calving and into green feed following calving should be planned.

It takes about 80 lb gain in weight to improve 1 condition score. Cattle will not usually gain weight during the winter and most likely will lose weight on range forage. Heifers should be handled separately, if possible, and wintered on the best winter range. A second condition evaluation about 1 month prior to calving should be made and supple-

For example:

1. *Corn at 80% TDN to supply required energy:*

TDN required		10.0	
TDN from hay 9 lb x .52	=	<u>4.7</u>	
TDN needed from corn		5.3	
Lb corn = 5.3/0.80	=		6.6 lb corn daily

Ration for heifers:

9 lb alfalfa hay
<u>6.6 lb</u> corn
15.6 lb Total

2. *Whole cottonseed at 90% TDN to supply energy:*

5.3 lb TDN required/.90 TDN cottonseed = 6 lb cottonseed daily

Ration for heifers:

9 lb alfalfa hay
<u>6 lb</u> cottonseed
15 lb daily ration

ments of PEP planned if needed. If a gain of 80 lb is needed (1 condition score) two months prior to the breeding season, the animals would have to be fed to gain 1.3 lb per head daily. For this gain the requirements are as follows:

	Last 1/2 Pregancy	Lactation/Breeding
Protein (lb/day)	1.7	2.0
TDN (lb/day)	10.0	12.0
Phosphorus (g/day)	19/0	25.0
Again, alfalfa hay required lb/day		
Protein	10	12.5
TDN	18	22
Phosphorus	16	24

It would require about 20-25 lbs alfalfa hay daily which could be provided and eaten. However, a combination of hay plus an energy source could be superior.

For example: Feed 10 lb alfalfa daily

TDN required	12
TDN from alfalfa	5.5
TDN from energy source	6.5 lb

With corn 6.5/.82 = 8 lb corn daily

Ration: 10 lb alfalfa hay
8 lb corn

With cottonseed
6.5/.9 = 7 lb cottonseed daily

Ration: 10 lb alfalfa hay
7 lb cottonseed

The ration to be fed approximately 1 month prior to calving up to greenup.

Much less feed would be required if the cows were condition score 4 or higher just prior to calving. Ideally condition would hold up from the fall without more than a supplement containing PEP fed at 3-4 lb/head daily, 1 month prior to calving and up to greenup.

Mature cows, age 2 or more in the fall.

Fall condition score should be 5 or greater.

Generally extended feeding of the cow herd should not be necessary except for unusual years where summer/fall range growth and quality is limited by drought. An evaluation of the condition of the cows and of the quantity of forage available in the fall should help you to anticipate potential fertility problems the next spring. A minimum supplement of 1-2 lb. daily may be required if the range is primarily grass. Supplements should be fed based upon cow condition and nutrient content of the range forage.

Generally: cows will not gain weight or condition in the winter. Therefore, fall condition evaluation will identify potential problems and culling/supplementation decisions made accordingly.

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CROSSBREEDING SYSTEMS FOR ARIZONA RANGELANDS

Jim Sprinkle[1]

INTRODUCTION

Thirty years ago, price discounts were applied to ranchers' calves resulting from crossbreeding. Beginning in the 1970s, crossbreeding became popular with many different breeds being imported into the United States over the next fifteen years. Research and ranch records have shown an increase in production through the use of crossbred cows. The use of crossbred cows has been shown to increase overall lifetime production by 25%. At Clay Center, Nebraska, 50% of crossbred cows have been shown to be still in production at age 7. Clay Center also reported that the crossbred cow stays in the herd 1.3 years longer than the straightbred cow.

The establishment of any new breed of livestock is always accompanied by a certain amount of inbreeding depression which reduces conception and survival. Properly managed (no large breed sires on small framed, young cattle), crossbreeding restores to cattle populations some of the fitness which was lost during breed development. The largest advantage seen with crossbreeding is with less heritable traits such as reproduction and cow longevity. Little advantage will be seen with highly heritable carcass traits. The advantage expressed by crossbred cattle over the average of both parents is referred to as hybrid vigor or heterosis. For example, assume Hereford (H) calves weigh 450 lbs. at weaning and Angus (A) calves weigh 400 lbs. The F1 cross calves weigh 440 lbs. for Angus x Hereford (AH) and 450 lbs. for Hereford x Angus (HA). Heterosis for the above example is 5%, using the formulas below from the 1988 publication *Crossbreeding Beef Cattle for Western Range Environments TB-88-1* (Kress and Nelson, 1988).

Amount of heterosis =

$$\frac{AH + HA}{2} - \frac{A + H}{2}$$

or

445 lbs. - 425 lbs. = 20 lbs.

Percent of heterosis =

$$\frac{\text{amount of heterosis}}{\frac{A + H}{2}} \cdot 100$$

or

$$\frac{20}{425} \cdot 100 = 5\%$$

As Kress and Nelson mention, "heterosis can be positive or negative and there can be positive heterosis even when one of the parental breeds performs better than the average of crossbreds."

MATCHING THE ENVIRONMENT

There are three major areas in which one would wish to utilize heterosis: maternal traits, growth traits, and carcass traits. Maternal traits are those which relate to milking ability, conception, and mothering ability. Growth traits include average daily gain, which in turn influences yearling weight. Carcass traits are related to lean product yield and quality grade. Commercial cattle ranchers commonly seek maternal heterosis by using the crossbred cow with her increase in total lifetime production. As mentioned above, carcass heterosis is not large (0 to 5%), but is commonly practiced by utilizing lean muscle breeds such as Limousin and Charolais in terminal sire breeding programs. These fast growing, heavily muscled sires are used with smaller adapted females that are 4 years old or older and all offspring are sold. Also, carcass heterosis is sometimes sought

Table 1. Breed Comparisons in the Germplasm Evaluation Program at Meat Animal Research Center (MARC)

Breeds Grouped into Biological Types for Four Criteria[a]				
Breed Group	Growth Rate and Mature Size	Lean to Fat ratio	Age at Puberty	Milk Production
Jersey (J)	X	X	X	XXXXX
Longhorn (Lh)	X	XXX	XXX	XX
Hereford-Angus (Hax)	XXX	XX	XXX	XX
Red Poll (R)	XX	XX	XX	XXX
Devon (D)	XX	XX	XXX	XX
Shorthorn (Sh)	XXX	XX	XXX	XXX
Galloway (Gw)	XX	XXX	XXX	XX
South Devon (Sd)	XXX	XXX	XX	XXX
Tarentaise (T)	XXX	XXX	XX	XXX
Pinzgauer (P)	XXX	XXX	XX	XXX
Brangus (Bn)	XXX	XX	XXXX	XX
Santa Gertrudis (Sg)	XXX	XX	XXXX	XX
Sahiwal (Sw)	XX	XXX	XXXXX	XXX
Brahman (Bm)	XXXX	XXX	XXXXX	XXX
Nellore (N)	XXXX	XXX	XXXXX	XXX
Braunvieh (B)	XXXX	XXXX	XX	XXXX
Gelbvieh (G)	XXXX	XXXX	XX	XXXX
Holstein (Ho)	XXXX	XXXX	XX	XXXXX
Simmental (S)	XXXXX	XXXX	XXX	XXXX
Maine Anjou (M)	XXXXX	XXXX	XXX	XXX
Salers (Sa)	XXXXX	XXXX	XXX	XXX
Piedmontese (Pm)	XXX	XXXXXX	XX	XX
Limousin (L)	XXX	XXXXX	XXXX	X
Charolais (C)	XXXXX	XXXXX	XXXX	X
Chianina (Ci)	XXXXX	XXXXX	XXXX	X

[a]Increasing number of Xs indicate relatively higher values. For example, XXXXXX is greatest milk production or oldest age at puberty and X is lowest growth rate and youngest age at puberty. Available at http://www.ansi.okstate.edu/breeds/research/table2.htm.

by breeding a cow herd with less ability to have intramuscular marbling (such as high percentage of Brahman or continental breeding) to sires known to have the ability to deposit marbling (such as British breeds like Angus). The practice of combining the strengths and weaknesses of different breeds to meet marketing goals or to better match a harsh range environment is called complementarity.

It must also be remembered that desirable genetic traits are often correlated with other less desirable traits. For example, accelerated average daily gain and increased carcass yield are usually correlated with large birth weights.

It is possible to exceed the range environment available to the cowherd when designing crossbreeding systems. For example, milk production can become excessive for the amount of feed produced by most rangeland (less than 20 inches rainfall). Milk production for most beef breeds peaks at 60 to 70 days at around 18 to 20 lbs. per day. Heavier milking, dual-purpose breed crosses have peak lactations of 22 to 26 lbs. per day. Each additional lb. of milk production requires approximately .52 lbs. of additional forage intake each day. Another example of exceeding a range environment is by utilizing large breeds in the development of the crossbred cow for an arid environment. An environment characterized by abundant, high quality summer forage and ample winter feed resources can use a large frame size, heavy-milking crossbred cow. Most western rangeland requires the use of intermediate or small framed cattle with moderate milk production. As winter feed resources or available forage for grazing decrease, cow size and milk production need to decrease also. At Havre, Montana in the Bear Paw Mountains (20 in. annual precipitation) Simmental x Hereford cows had superior weaning weight/cow exposed averages when compared to Angus x Hereford cows. When the same type of cows were compared at Miles City, Montana (10 to 12 in. annual precipitation), Angus x Hereford cattle excelled in calf weaning weight/cow exposed.

DESIGNING A CROSSBREEDING SYSTEM

Unlike the dairy industry, there is no particular breed which excels in beef production in the United States. Variation among environments requires the use of different breed combinations. In the Gulf Coast region, use of a heat tolerant breed is needed, while North Dakota would require the opposite. Ranchers should outline production goals for the ranch and then look at possible biological types of cattle to help achieve those goals. Limitations which may influence the success of using different biological types of cattle or different crossbreeding systems should also be considered. Possible limitations include feed and forage resources, labor, rainfall, ability to supplement cattle, number of pastures, size of the herd, herd replacement strategy, temperament desired, adequacy of corral facilities, and commitment to management.

Tables 1 and 2 categorize different biological types of cattle and crossbreeding systems, respectively. In Table 1, cattle are separated into four major traits by biological type. Some traits desired will conflict with production goals. For example, if retaining offspring to slaughter, increased lean to fat ratio may be important. However, for range cows it is particularly important for cows to have the ability to store fat during times of nutritional plenty so they can use it during nutritional deprivation (less lean to fat ratio). If you would like to use a breed in your environment that has a particular trait you would like to be present in the herd (e.g., increased growth rate) but that may also conflict with environment adaptability (e.g., mature size), limit that particular breed to 25% or less of the crossbred cow or consider using the breed as a terminal sire.

For Table 1, much of Arizona can be characterized by these general assumptions:

1. Keep milk production for replacements at XX or XXX (Table 1).

2. Keep age at puberty at XX or XXX.

3. For the cow herd, keep lean to fat ratio (ability to store fat) at XX or XXX. For terminal sires, it doesn't matter.

4. For mature size, keep the cow herd at XX or XXX. For terminal sires, use common sense when combining different breeds (i.e., don't use a XXXXX sire on X or XX mature size cows due to calving problems).

5. For conflicting traits, lean towards cow herd adaptability by following the 25% or terminal sire rule above.

Once biological types are identified for developing a crossbred system (Table 1), constraints may be necessary to achieve uniformity among calves (Table 2). For example, rotational or composite crossbreeding systems require the use of similar biological types to prevent excessive variation among cow generations due to gene recombination. An extreme example would be a rotational cross breeding system utilizing one breed with 2 Xs for growth and another breed with 5 Xs for growth. Cow size and necessary nutritional management would fluctuate wildly from one generation to another, depending upon the current sire being used. If the rancher were to purchase replacement females each year (such as Braford F1 cattle for use in South Texas), fluctuation problems could be avoided. Another constraint inherent with crossbreeding systems is additional management requirements. Cattle have to be separated and maintained by breed or age during breeding for rotational and terminal sire

Table 2. Resource Constraints and Advantages and Disadvantages of Different Breeding Systems

System	% Heterosis	Advantage	Disadvantage	Pastures Needed
Straightbred	0	Easy to manage	No heterosis, no breed complementarity.	1
Periodic Rotation (rotate breeds in herd over 2-4 years)				
	12	Some heterosis with limited additional management constraints. Increased production with crossbred cow.	Limited breed complementarity. Fluctuation among cow types by generation requires use of similar biological types.	1
	16	"	"	1
Rotation				
2 breed	16	Added heterosis with additional management. Increased production with crossbred cows.	Must sort cows by sire and run 2 herds on 2 or more pastures. Limited breed complementarity. Fluctuation among cow types requires use of similar biological types.	2
	20	"	"	3
	22	"	"	4
Composite (4 breed)	17	Once herd is developed, only 1 pasture is required. Can obtain similar heterosis to rotational crossbreeding systems with less hassle. Suitable for small operators. Less generation to generation varability than with rotational systems.	If developing your own, requires large numbers of animals (400 or more) or use of crossbred bulls on crossbred cows. Otherwise, must purchase initial composite cows. At this time, it is not possible to obtain reliable EPDs for composite cattle, limiting selection ability for cows or purchased bulls. As for rotational crossbreds, similar breeds should be used for development of composite breed.	1
Terminal Sire on:				
	9	Some complementarity; individual heterosis on F1 calves. Can change quickly for changing market.	Must separate cow herds into 4 years and older and under 4 years old. Older cows are bred to terminal sires. Younger cows (40% to 45% of herd) generate replacements. Can't select replacements from best old cows.	2
	21	Maximizes breed complementarity for older cows. Can fit changing market	"	3
3-breed rotation	24	"	"	4
	21	More heterosis, less mgmt.	"	2

Heterosis is in weaning weight/cow exposed.
Adapted from: *Crossbreeding Beef Cattle for Western Range Environments* TB-88-1, 1988, D.D. Kress and T.C. Nelson, NV Agricultural Expt. Sta., University of NV-Reno and Table 2, “Make Crossbreeding Work on Your Place,” Part 1, Michael MacNeil, 3/2/96, *Western Beef Producer*.

breeding systems, respectively. This requires the use of additional breeding pastures (Table 2), which may be difficult for some public lands grazing allotments. Alternative crossbreeding systems for smaller herds or those with fewer management capabilities are the periodic rotation or composite systems. When using simplified crossbreeding systems, it is still important to carefully plan which biological types will be used to achieve production goals. Haphazard breeding programs lead to haphazard results.

EXAMPLE CROSSBREEDING SYSTEM

Note: This example is for discussion only to show how a rancher might design a crossbreeding system to fit his particular ranch and production goals. It is not meant to be a blueprint for all ranches in Arizona!

John Smith of the Lazy Upside Down U desires to initiate a crossbreeding system to reap the benefits of both individual (crossbred calves) and maternal (crossbred cows) heterosis. He has a herd consisting of 200 straightbred Hereford cows which graze a USFS allotment (elevation 6200 to 7500 ft.) from June 1 to October 15. From October 15 to May 31, cattle graze BLM or Arizona State Land Dept. pasture (elevation 2700 to 5000 ft.). Calving season is from March 1 to May 15 (unassisted) and bulls run with cows on the USFS permit from June 1 to August 15 at a 1:33 bull:cow ratio. The current allotment management plan on the USFS allotment allows for the cow herd to be split into two herds. Cattle are supplemented with protein once a week (14 lbs. cottonseed meal cake per cow) for January and February only. All calves are weaned on the mountain and sold at weaning except for 40 replacement heifers, of which 20 to 30 will be retained and the remainder sold as yearlings. John’s family desires to increase weaning rate while maintaining weaning weights. Although weaning weights have been adequate (403 lbs. for heifers, 458 lbs. for steers), John and his family have had problems maintaining cow body condition during the winter without supplementation during January and February. Calving rate is around 80% and weaning rate is 75%. Mature cows weigh 1100 lbs. and replacement heifers calve at 2 years of age. Everyone agrees that while the nutritional quality of the forage available is generally excellent on the mountain, the forage quality of the winter forage is limiting (when tested over 2 years, hairy grama was 5.5% crude protein and 48% TDN). The family desires to limit supplementation to the current time period. The Smiths have 40 acres private ground of which 12 acres are irrigated hay, the balance being in non-irrigated pasture. Five horses are kept year round on the private ground and there is enough hay left over to keep 40 mature cows for 30 days at headquarters. Weaned replacement heifers are kept at headquarters and fed hay for 1 week and then graze hay stubble for 1 week. Following this, they are put out on a pasture near headquarters until the first of January. For January and February, replacement heifers are brought back to headquarters and fed hay. After this time, they are put out with the cow herd.

Let's look at the constraints that John has with his operation. First, he is limited to two breeding pastures during the summer. Secondly, he must maintain or increase fleshing ability of the cowherd (no more than two Xs from lean to fat ratio for biological types listed in Table 1). The second constraint would imply that John not increase milk production to any extent and that he maintain cow size or decrease it slightly (no more than three Xs for mature size and no more than two Xs for milk production).

When the family reviewed their options, they decided they would like to keep the disposition and “rustling ability” of the Hereford cows. With the two pasture limitation, they decided to implement a two stage crossbreeding program by first developing a herd of F1 females and then crossing the 4-year-old and older crossbred cows to a smaller framed terminal sire (no calving assistance rendered). The sire breeds which fitted the family's criteria were Angus for the initial sires to produce F1 females and Limousin for the terminal sire. Red Poll was considered briefly for the initial sire breed due to the smaller size and younger age at puberty and then eliminated due to the difficulty in obtaining bulls and the possibility of increased milk production. It was felt that the Angus sires would reduce age at puberty slightly (Clay Center has adjusted age at puberty at 359 days for Red Poll, 393 days for Angus, and 411 days for Hereford) and sires with low birth weight EPDs are readily available. The stages in implementing the cross-breeding program are as follows:

Stage 1: Replace all Hereford bulls with Angus with low EPDs for birth weight, yearling weight, and maternal milk. Keep as many of the replacements as possible, allowing for a more rapid turnover to F1 cows. For two years, breed all cows to Angus bulls. From the first calf crop on, start selecting cross-bred bulls prospects from the herd at weaning. From weaning until the spring of their yearling year, test bulls in home feedlot and pasture for performance on a roughage based diet. Cull bulls according to performance and breeding soundness examinations. Bull to cow ratio for F1 bulls is 1:15 or 1:20 as yearlings and 1:33 as 2-year-olds.

Stage 2: At the beginning of the third breeding season, a proportion of the bull battery is replaced with F1 bulls. All F1 females over 4 years old will be bred to the terminal sires. When the herd stabilizes at 100% F1 females, 45% of the herd (younger cows) will be bred to F1 bulls for replacements and 55% (older cows) will be bred to the terminal sires in a different pasture with all these calves being sold.

The possibility of inbreeding from retained crossbreed bulls after their third and final breeding season is (on the high side) about 6.5% if the herd stayed in a simple F1 breeding system and about 3% for the combination F1/terminal sire crossbreeding program. In the future, some of this can be alleviated by (a) buying crossbred bulls as they become more popular or (b) by estrus synchronizing the cow herd for 1 heat cycle and using mass AI with F1 AI sires as they become more available.

OTHER INFORMATION

Other information on crossbreeding systems is available from the following publications:

Crossbreeding Beef Cattle for Western Range Environments TB-88-1. 1988. D.D. Kress and T.C. Nelson. Nevada Agricultural Experiment Station, College of Agriculture, University of Nevada-Reno.

Crossbreeding Beef Cattle C-714. 1990. D.D. Simms, K.O. Zoellner, R.R. Schalles. Kansas State University, Cooperative Extension Service, Manhattan, KS.

Detailed information on breed group averages for different traits at Clay Center, NB can be found on the Internet at

http://www.ansi.okstate.edu/breeds/research/marccomp.htm

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FROM:

Arizona Ranchers' Management Guide
Russell Tronstad, George Ruyle, and Jim Sprinkle, Editors.
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UNDERSTANDING EPDS

Jim Sprinkle[1]

Currently, most registered bulls have information available from their own performance records, progeny, or relatives which enables us to predict the performance of future offspring for various traits. An expected progeny difference or EPD is the difference in some trait (usually expressed as pounds, but sometimes as inches for carcass type traits) which one can expect when compared to other animals of the same breed. For example, if a bull's birth weight EPD is +5.0, then on an average his offspring should weigh 5 lbs. more at birth than does a bull with a birth weight EPD of 0. The actual difference you will realize within your herd for a particular trait will depend upon how your herd compares to the breed as a whole. For example, if weaning weights on a particular ranch are greater than the observed breed average, then it is conceivable that a bull's weaning weight EPD in this herd may be less than that listed for the breed.

The traits which are commonly available for sires include birth weight, weaning weight, yearling weight, milk or maternal milk, and total maternal. For all of these traits, an EPD is expressed in pounds deviation + or - from the breed base average of 0. (Note: The breed base average is often outdated by several years, so actual base averages for a given year often exceed 0.) It must be pointed out that milk EPD values are *not* pounds of milk, but the pounds of weaning weight in the offspring of daughters of a bull which can be expected due to milk production alone. In explanation, an EPD value of +12 for milk means that on average you can expect grandsons and granddaughters of calves from a bull's daughters to weigh 12 lbs. more at weaning due to the influence of milk production in the daughters. Total maternal EPD values in grandsons and granddaughters are total pounds of weaning weight expected due to the combined influence of milk production and growth genetics from dams.

Accuracy (often shown as ACC) is the amount of confidence one can place in the estimated EPD. This accuracy figure is related to the number of progeny of a particular bull for which records exist. An accuracy of .93 basically means you are 93% confident that the bull's EPD will be what the record says it is. An accuracy of .40 would be more unreliable. Young, unproven bulls have low accuracy figures.

The EPD values for a bull must be compared within a breed. A birth weight EPD of +5 for a Charolais bull would not have the same effect upon calving difficulty as a +5 for an Angus bull in a commercial crossbred herd because breed averages are different. The respective breed averages for a particular year can usually be obtained by contacting breed associations or reviewing breed sire summaries. Table 1 contains information from more than 4,000 offspring (from Angus x Hereford dams) along with 30 sires per breed. This data was collected in one environment only (Clay Center, Nebraska) and sires were adjusted for 1991 EPD breed averages. Some of the respective rankings may change as cattle move from one environment to another.

In order to utilize heterosis and combine complementary breeds in cow herds, crossbreeding is practiced. One may be concerned about matching cattle to the environment or in meeting a particular marketing niche. To aid in these decisions, EPDs across breeds can be estimated using Table 1 and the individual bull EPDs. The actual difference between bulls of different breeds can be estimated by adding the EPDs to the respective breed averages

Table 1. Breed Averages for Some Traits[a]

Breed	Birth Weight	Weaning Weight	Yearling Weight
Angus	77.8	441	810
Polled Hereford	80.3	450	806
Hereford	81.4	442	800
Shorthorn	83.5	461	832
Brahman	87.8	447	744
Simmental	86.0	471	860
Limousin	83.1	450	798
Charolais	86.0	458	819
Maine-Anjou	87.8	458	826
Gelbvieh	87.3	465	822
Pinzgauer	82.4	440	783
Salers	80.9	464	830

[a] Averages of offspring sired by bulls with EPDs in MARC's GPE project. Adjusted for 1991 EPD breed averages. From *Beef,* September 1993.

Table 2. Across Breed EPDs for Some Traits[a]

Breed	Birth Weight	Weaning Weight	Milk	Yearling Weight
Angus	0	0	0	0
Polled Hereford	5.9	11.3	-27.4	8.8
Hereford	6.1	6.4	-3.7	7.3
Shorthorn	8.7	25.2	11.9	31.9
Brahman	13.8	28.8	34.4	-21.1
Simmental	10.5	49.8	25.4	79.2
Limousin	6.6	28.8	-8.5	20.0
Charolais	9.7	37.2	3.7	52.4
Maine-Anjou	11.9	31.5	23.1	39.7
Gelbvieh	9.6	38.6	27.1	41.8
Pinzgauer	8.7	21.6	7.1	16.4
Tarentaise	4.4	22.3	20.1	10.5
Salers	6.8	30.8	11.9	31.7

[a] EPDs adjusted to a 1992 base with Angus EPDs set to zero in MARC's GPE project. From Barkhouse et. al., 1994. Proc. Beef Improvement Federation 26th Research Symposium and Annual Meeting, West Des Moines, Iowa. June 1-4, 1994.

and then comparing the resulting sums. For example, assume we wish to compare a Charolais bull with a birth weight EPD of +4 and an Angus bull with an EPD of +6. Using the breed averages from Table 1, progeny of the Charolais bull should be 6.4 lbs. heavier at birth than Angus progeny at Clay Center, Nebraska.

[(86 + 4) – (77.6 + 6)]
Charolais Angus

In this example, the Charolais bull is expected to sire calves with heavier birth weights than the Angus bull even though the birth weight EPD was greater for the Angus bull. While this method does not fully account for the effects of heterosis when combining males and females of two unlike breeds, it is a good starting point for planning breeding programs.

If you have an idea of what your herd averages are for various traits, Table 2 may be more useful to you. Table 2 allows comparison of EPDs across breeds with Angus EPD values being specified as 0 for all traits. For example, an Angus bull with a birth weight EPD of +5 should sire calves with birth weights 5 lbs. heavier than the average Angus bull. If you used a Limousin bull in your commercial herd with a birth weight EPD of +2, then you could expect him to sire calves weighing 8.6 lbs. (2 + 6.6) heavier than an average Angus bull. Table 2 information is also from Clay Center, Nebraska and will not completely account for changes in breed rankings with different environments.

Expected progeny differences can be used as a tool to predict future performance and to plan goals for genetic improvement in your cow herd. Available resources should be evaluated and genetic change should be planned to match these resources. In planning genetic trends in your herd, it should be remembered that one genetic trait is often correlated with another. For example, as yearling weight increases, so does birth weight and mature weight. An environment with 10 inches of rainfall may not be the place to use a sire with a yearling weight EPD of +70 unless all replacement heifers were purchased elsewhere. Otherwise, mature weight of the cows will increase. In arid western climates with limited forage availability, oftentimes the use of smaller cows is required to obtain acceptable conception rates. Bulls with low or negative birth weight EPDs should be used on first calf heifers. High milk production may be a liability in arid environments, so milk EPD values should be moderate. The American Angus Association reported the observations of a breeder who had evaluated EPDs in a range operation. He suggested that for Angus cattle under range conditions, an EPD for milk from -5 to +9 was adequate for calf growth and still allowed for rebreeding success.

In addition to using EPDs in charting genetic change, ranchers with commercial herds can predict genetic change in their herds with the formula below. When this value is divided by 2 (parents only contribute 1/2 of their genes to offspring), it approximates an EPD value on a herd-wide basis.

Genetic change/generation =
h2 • selection differential

The heritability (h2) of birth weight is around .35 to .50, for weaning weight it is around .25 to .30, and for yearling weight around .40

The selection differential is the difference between selected individuals for a specific trait (e.g. weaning weight) and the average for all animals by sex in the herd. For example, the selection differential would be 60 lbs. if heifers at weaning averaged 400 lbs. and selected heifers weighed 460 lbs. When calculating selection differentials, it is important for the animals being compared to have been treated similarly. In other words, if one group of selected heifers were grazed on irrigated pasture and another group was grazed on rangeland, it would not be appropriate to compare these groups without applying a weaning weight discount to the irrigated pasture group.

An example in calculating genetic change is shown below. Selected heifers weigh 60 lbs. more at weaning than the average of all heifers in the herd. The heritability of .25 is multiplied by .60 to give 15 lbs. genetic superiority.

60 lbs. • .25 = 15 lbs.

This must be divided by 2, since the heifers will only contribute 1/2 of the genes to offspring. Therefore, 7.5 lbs. will be added from the female side. A selected bull has a weaning weight EPD of +25 lbs. when used in your herd. Therefore, the predicted increase in weaning weight for the selected heifers and this bull would be 32.5 lbs.

The above example shows the response per year which can be expected for single trait selection. Selecting for more than one trait at a time usually reduces the genetic change expected in single trait selection.

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