THE UNIVERSITY OF ARIZONA
Cooperative Extension

Crossbreeding Systems for Arizona Rangelands

Introduction

Thirty years ago, price discounts were applied to rancher's calves resulting from crossbreeding. In the 70's, crossbreeding became popular with many different breeds being imported into the US 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. They 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 survivability. Properly managed (no large breed sires on small framed, young cattle), crossbreeding restores some of the fitness to cattle populations which was lost during breed development. The largest advantage seen with crossbreeding is with lowly 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 , D.D. Kress and T.C. Nelson, Nevada Agricultural Expt. Sta., University of Nevada-Reno).

$$\text{Amount of heterosis} = \frac{AH + HA}{2} - \frac{A + H}{2}$$

or

445 lb. - 425 lb. = 20 lb.

$$\text{Percent of heterosis} = \frac{\text{amount of heterosis}}{\frac{A + H}{2}} \times 100$$

or

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

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. Heterosis for maternal traits or maternal heterosis is commonly gained through the use of crossbred cows. 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- year-old or older and all offspring are sold. Also, carcass heterosis is sometimes sought for 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. A good example of complementarity is the use of larger muscled sire breeds on older smaller framed cows.

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It must also be remembered that desirable genetic traits are often correlated with other less desirable traits, e.g. accelerated average daily gain and increased carcass yield is 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 (Kress, 1990, Journal of Animal Science 68:1910-1921). 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 (M. D. MacNeil, Miles City Montana USDA Ag. Res. Sta., unpublished data).

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 and 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. Performance in some of these traits may conflict with a rancher's 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 (meaning a lower lean to fat ratio is desired). If you would like to use a breed in your environment that excels in a trait (e.g., increased growth rate) but may also conflict with environment adaptability (i.e., 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 XXX or lower (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 since all females will be sold.

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 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 X's for growth and another breed with 5 X's for growth. Cow size and nutritional management necessary 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 breeding systems, respectively. This requires the use of addi-

tional breeding pastures (Table 2), which may be difficult for some public lands grazing allotments. Alternative crossbreeding systems for smaller herds or those with less 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 USFS allotment 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 two years of age. Everyone agrees that while the nutritional quality of the forage available is generally excellent on the USFS allotment, 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 feed 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.

Lets 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 X's 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 X's for mature size and no more than two X's 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 crossbreeding 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 crossbred 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 two-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 breed 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 artificial insemination 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 at the Internet site: <http://www.ansi.okstate.edu/breeds/research/marccomp.htm>

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

	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, XXXXX is greatest milk production or oldest age at puberty and X is lowest growth rate and youngest age at puberty.

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)				
2 breed	12	Some heterosis with limited additional mgmt. constraints. Increased production with Xbrd cow.	Limited breed complentarity. Fluctuation among cow types by generation requires use of similar biological types.	1
3 breed	16	"	"	1
Rotation				
2 breed	16	Added heterosis with addl. 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
3 breed	16	"	"	3
4 breed	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 variability than with rotation 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 crossbreeds, similar breeds should be used for development of composite breed.	1
Terminal Sire on:				
straightbred	9	Some complementarity; individual heterosis on F1 calves. Can change quickly for changing market.	Must separate cows herds into four years and older under 4 years old. Old cows are bred to terminal sires. Younger cows (40 to 45% of herd) generate replacements. Can't select replacements from best old cows.	2
2-brd rotation	21	Maximizes breed complementarity for older cows. Can fit changing market.	"	3
3-brd rotation	24	"	"	4
Composite	21	More heterosis, less mgmt.	"	2

Heterosis is in weaning weight/cow exposed.

Adapted from: *Crossbreeding Beef Cattle for Western Range Environments* TV-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.*