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Dairy Guidelines

Dairy Crossbreeding: Why and How

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Interest in crossbreeding plants and animals is nearly as old as the science of genetics, dating back to the early 1900s. Many dairy cattle in the U.S. today descend from crosses of purebred bulls on a population of less specialized cattle that were clearly not purebred. The primary genetic interest in crossbreeding is in whether animals with genes from different parent breeds perform differently (better) in combination than the average of their parent breeds. The term for crossbred performance relative to the parent average is hybrid vigor or heterosis.

Formal research on dairy crossbreeding in this country traces back to a USDA project that began in 1939. It was followed by a series of crossbreeding experiments conducted by universities and research institutions in the 1950s and 1960s. The crosses involved Holstein, Guernsey, some Brown Swiss and Ayrshire, and a few Jersey animals. The general conclusions were that purebred Holstein cows almost always gave more milk in a single 305-day period than any cross studied, although there was evidence of heterosis for milk and fat yields, livability, growth, and reproduction. One or two crosses were more profitable than Holsteins across their lifetimes, but only marginally so. Dairy producers likely looked at the results and concluded that the purebred Holstein cow was close enough to the best choice to eliminate crossbreeding as an option.

Why consider crossbreeding now?

Some things have changed in the last 50-plus years.

- Direct payments are made for fat and protein in many parts of the country.
- Intensive selection for higher yields and better type has changed all the breeds of dairy cattle. Fifty-year-old results may no longer be valid.
- Inbreeding is increasing in purebred populations.
- Fertility has declined in U.S. purebred dairy populations as a correlated response to selection and/or from inbreeding depression.
- The U.S. Holstein is a large animal and calving difficulty is a problem.
- Organic or low input dairy production may favor crossbreds if hybrid vigor reduces the need for medical intervention, or if crossbreds prove more adaptable to grazing conditions.

Dairy producers are aware of these conditions. A 2003 survey by Weigel and Barlass of U.S. dairy producers already practicing crossbreeding showed that the respondents desired improvements in fertility, calving ease, longevity, and milk component percentages.

Crossbreeding is more widely practiced by dairy producers every year. A crossbreeding program should be seen as a long-term proposition. It is much easier to start a crossbreeding program than it is to return to a purebred. Knowledge of the breed resources available and the strengths and weaknesses of each breed should guide decisions of what breeds to use in a crossbreeding program.

Heterosis alone will not guarantee success in a crossbreeding program. Much of the success from crossbreeding will result from selection on PTAs of sires for different traits. The genetic merit of purebreds and of the animals within those breeds for economically impor-

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tant traits need to be known and utilized to the producer's advantage. With proper information, including the "all-breed" animal model genetic evaluations published by the USDA, dairy producers can predict the probable performance of the crossbred animals compared to purebreds. We don't yet have complete answers to several important questions surrounding dairy crossbreeding, but we can use what we do know and be aware of work in progress to give us further direction.

What are the breed resources?

Table 1 includes seven of the most promising breeds for crossbreeding programs. It includes reasonable estimates of breed averages for production traits, but not for fitness, fertility, or type. We know the most about production for these breeds, but need to increase our knowledge of those other traits as well. Population size, young-sire sampling efforts, and production characteristics are important when choosing breeds. Many other factors, such as body size of mature animals, fertility, calving ease, somatic cell scores, and availability of frozen semen from many bulls with accurate genetic evaluations also influence breed choices.

Large, well-run young-sire sampling programs generate more proven bulls. Choices enable greater selectivity for desirable combinations of traits, thereby increasing genetic progress for lifetime economic merit. A very large progeny testing program places the Holstein breed in a formidable position. No other dairy breed can match Holsteins for genetic resources to improve lowly heritable traits like fertility, longevity, and calving ease. The Jersey breed is in second place for number of bulls sampled, while the remaining breeds have smaller programs. However, sampling programs for each of the breeds in Table 1 are ample to identify genetic material of potential interest in crossbreeding programs.

Dairy producers must be concerned about many traits besides milk yield in a single lactation. Components – fat and protein – matter, as does health and fertility, calving ease, calf survival, longevity, and other functional traits. The lifetime performance of dairy cows for all traits of economic value should be the ultimate comparison for purebred and crossbred systems. We know less than we need to know about some of the breeds in Table 1 for these characteristics, but are learning fast as first crosses of Normande, Montebeliarde, and the Scandinavian breeds appear in U.S. dairy herds. This knowledge will be important to help dairy producers decide which breeds would be most useful in a crossbreeding program. However, knowledge of breed strengths – also called breed additive genetic merit – is only one piece in the crossbreeding puzzle.

Holstein, Jersey, Brown Swiss, and Ayrshire cattle have established reputations for type, which is worth noting here as long as interpretation allows for variation within breeds. Holsteins are the most numerous breed and have benefited from improvement in type through selection over the past 40 years. This highest producing dairy breed has made important progress in strength of udder attachments, teat size and placement, and in foot and leg structure. Holsteins deserve the reputation as being good uddered cattle. Jersey cattle are very dairy, highly productive animals, with quite a bit of udder for their body size, especially compared to Holsteins. Results from recent crosses of Holsteins and Jerseys suggest a need for extra attention to udder conforma-

Table 1. Population sizes and production of potential breed resources for crossbreeding programs. Management conditions are not the same for all breeds and could affect production comparisons.

Breed	Worldwide population	Bulls sampled per year	Average milk (lbs)	Fat %	Protein %
Ayrshire	100,000	150	17,900	3.9%	3.1%
Holstein	25,000,000	4,000	23,300	3.6%	3.0%
Jersey	1,200,000	630	17,600	4.6%	3.6%
Brown Swiss	7,000,000	80	20,700	4.0%	3.3%
Normande	300,000	160	16,000	4.4%	3.6%
Montbeliarde	330,000	170	18,000	3.8%	3.4%
Swedish Red	205,000	100	20,000	4.2%	3.5%

Source: *Dairy Herd Management*, April 2005 tion because of the high productivity of the resulting crosses. Brown Swiss cows have the best reputation of U.S. dairy breeds for feet and legs, with especially deep heels and well-formed feet. They are also reputed to live a long time, but perhaps to mature a bit more slowly than other breeds. Ayrshires have long been known for good udders and for overall health and vitality. The Ayrshire breed played an important role in the establishment of the Swedish Red breed in Table 1.

What issues should be considered in crossbreeding?

Crossbreeding programs are long-term decisions. Producers should plan crossbreeding strategies carefully and have reasonable expectations of the process. First crosses, the F1s, may involve easy decisions for many producers, but another decision is needed when first-cross calves reach sexual maturity. What breed of service sire will be used on the F1s? Two years later, the next generation of crossbred female will be reaching breeding age and another decision must be made.

Performance of the first crosses will probably please most producers because

- Producers typically use their second favorite breed on their first favorite breed to produce F1s, and
- F1s display full hybrid vigor and have uniform breed composition.

However, a third breed or a backcross to a parent breed of the F1 must follow the first cross. A third breed may be a hard choice or even a big compromise if no third breed interests a particular producer. Maintaining semen inventories for three purebred breeds is a necessary part of rotational crossbreeding programs. Herds composed of combinations of purebreds and two- and three-breed crosses will vary in size, rates of maturity, and perhaps in important management requirements. Finally, backcross matings reduce hybrid vigor to half that of F1s. For traits showing large amounts of hybrid vigor, backcross performance may decline enough to disappoint producers.

Factors to consider

Following are key issues to consider when designing a crossbreeding program.

- *Breed additive merit:* Breeds used in crossing programs need to function well as dairy cows. If a producer does not like a particular breed as a purebred, it is likely that the breed will not be suitable in crossbred combinations either.
- *Breed complementation:* Strengths of one breed can be used to offset or compliment the weaknesses of another. Example: if a producer considers large size a disadvantage, Holstein – Jersey (HJ or JH combinations with breed of sire first) crosses are complimentary, that is, more desirable than HH animals. If small size is considered to be a disadvantage, H and J crosses are favorable relative to JJ animals, but less favorable relative to HH.
- *Within-breed selection:* The ability to pick and choose parents is just as important for crossbreeding programs as it is in purebred herds. Large population sizes (to provide choices among bulls) and readily available genetic evaluations are essential to rapid genetic progress. Unique breeds or strains such as Scottish Highland or Dutch Belted cattle may intrigue some breeders, but there will be very few choices among service sires. There may be no genetic evaluations to guide the selection process at all. These are serious limitations to the utility of such breeds for commercial milk production.
- *Heterosis:* As defined earlier, heterosis is the difference in performance of crossbred animals from the average merit of the two parent breeds for each trait. It can be positive or negative, large or small, and may be considered to be favorable or unfavorable, depending on economic value of the difference. Heterosis for a trait is specific for the two breeds involved in the cross. For example, heterosis for fertility may not be the same in Holstein-Jersey and Holstein-Brown Swiss crosses.
- *Program objective:* Is the goal to develop top-quality crossbreds or to ensure the survivability of the dam? Some herds practice crossbreeding by using Jersey bulls in natural service on Holstein heifers for calving ease. Such a program is not designed to produce the best crossbred animals possible. It is intended to deliver healthy Holstein heifers into the milking herd. Crossbred calves are a by-product. However, selecting a proven AI Jersey bull of superior genetic merit will still improve calving ease while also increasing the genetic potential of crossbred calves produced.

Three-breed rotational systems with purebred AI sires

Crossbreeding programs that rely on purebred sires in AI service from the major dairy breeds in Table 1 offer the important advantages of genetic evaluations and a wide choice of service sires. Programs including these breeds are strongly recommended. No alternative plans, such as use of unique dairy or dual-purpose breeds or crossbred sires, can offset the genetic improvement opportunities available through within-breed selection and the use of purebred sires in AI.

Table 2 shows breed composition and the retained hybrid vigor in nine generations of a three-breed rotational system starting from a Holstein base and utilizing Holstein, Jersey, and Swedish Red sire breeds. A three-breed system, at equilibrium, maintains 86 percent of full heterosis. The breed of the sire in any rotational system contributes the most genes to offspring. Breed choices can introduce large differences from one generation to the next in rate of maturity, mature body size, milk components, and associated nutritional requirements. One impact of the system chosen is on the value of dairy bull calves. Inclusion of a small breed like Jersey reduces the market value of bull calves, especially when Jersey is the sire breed. While this is a small part of the economic contribution of a crossbreeding program to a dairy business, it is a factor in the choice of breeds to include in the rotation.

Three-breed systems at maturity include 57 percent genes from the sire breed and 14 percent genes from the least used breed in each generation. Two-breed systems (not shown) include 67 percent genes from the sire breed and 33 percent from the other breed in the rotation. Further, two-breed rotational systems maintain only 67 percent of F1 heterosis.

The primary advantage of a two-breed system is simplicity, but both two- and three-breed systems are simple enough to manage, even in very large herds. Place a different color ear tag in the offspring of the different sire breeds. The tag will indicate the proper breed of service sire for the animal's lifetime. For instance, animals sired by Holstein bulls might always be bred to Jersey bulls. The resulting offspring might always be bred to Swedish Red sires and calves born to those matings would always be bred to Holstein bulls. When established, herds with such a program would have all three crosses at all ages, but decisions regarding the service sire would be driven by the color code of the ear tags carried by each animal. In Table 2, animals sired by Holstein bulls are always bred to Jersey bulls, while animals sired by Jersey bulls are always bred to Swedish Red bulls. Daughters of Swedish Red bulls are bred to Holstein sires.

Identification is important for crossbreds

Inbreeding can occur in crossbreeding programs through "backcrosses" to breeds previously used. If a crossbred cow is related, even remotely, to her purebred mate, some inbreeding will result in progeny. Accurate and complete identification of ancestry is recommended for all crossbred dairy animals. Properly

Table 2. Breed composition and retained heterosis of a three-breed rotational cross using Holstein, Jersey, and Swedish Red breeds for nine generations.

Generation	Breed of sire	% breed composition			% heterosis compared to F1
		Holstein	Jersey	Swedish Red	
Foundation	Holstein	100	0	0	0
1	Jersey	50	50	0	100
2	Swedish Red	25	25	50	100
3	Holstein	63	13	25	75
4	Jersey	31	56	13	88
5	Swedish Red	16	28	56	88
6	Holstein	58	14	28	84
7	Jersey	29	57	14	86
8	Swedish Red	14	29	57	86

Source: R.M. Bourdon, *Understanding Animal Breeding*, P 399.

identified crossbred animals have been used to calculate PTAs on their purebred sires since May 2007 in the USDA genetic evaluation system, the "all-breed" animal model. Genetic evaluations of crossbred cows are available provided performance is recorded though DHI testing programs and cows are identified by sire and dam. Thus, properly identified crossbred cows contribute to genetic evaluations of purebred bulls, which are so important to effective crossbreeding systems. Identification is just as important for crossbred calves as it is for purebred calves. Maintain tagging systems that associate written information with each heifer as she calves into the milking herd. Participate in production recording systems that contribute records to the national genetic evaluation program.

References

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