

*Dairy Grazing***Genetics of the Grazing Cow**

**T**he commodity produced on a dairy farm is milk. The production unit is the cow. For a pasture-based dairy to maximize profits, the cow needs to be able to efficiently convert grazed forages into milk. Maximizing profits is most easily accomplished with the right type of cow — one genetically designed to efficiently convert grazed forages into milk.

**The ideal pasture-based cow**

No single ideal pasture-based cow exists. Dairies that use grazing do so differently; therefore, the ideal cow will not be the same for all dairies. Dairy producers who call themselves graziers operate systems ranging from low-input seasonal operations that use grazed forage as the primary feedstuff to conventional operations that use pasture only seasonally or to a lesser degree. The ideal cow for these different systems is probably not the same animal.

Conventional dairy production has stressed individual cow yield as a high-priority trait. Generations of selection have made noticeable strides toward attaining higher-producing cows. High production can come at a cost, though. Over the years, reproductive efficiency has slowly declined in the U.S. dairy herd, resulting in a lengthening of the average calving interval. This trend does not present an insurmountable problem for conventional dairies because modern cows also tend to be persistent producers and this persistency and fewer dry days (as a percentage of total productive days) make up for the longer calving intervals. By contrast, in pasture-based systems, particularly seasonal dairies that use “batch” or “window” calving, lowered reproduction efficiency can be a major problem. In these systems, it is imperative that a high percentage of cows in the herd return to estrous cyclicity and breed back within a time that will keep them on the desired seasonal calving schedule. Thus, the relative economic importance of yield and reproduction in these two systems is not the same.

Another trait considered important by many pasture-based producers is body size. Traditional cows tend to be moderate to large in size. This is particularly true of Holsteins. Many pasture-based producers prefer smaller cows that tend to do less damage to grass paddocks, especially during wetter weather. Some producers also

**Dairy grazing publication series**

This publication is one in a series about operating and managing a pasture-based dairy. Although these publications often refer to conditions in Missouri, many of the principles and concepts described may apply to operations throughout the United States. A list of the publications in this series is available online at <http://extension.missouri.edu/m168>.

believe smaller cows are more mobile and suffer less from heat stress than larger cows. Other traits, including good udder health (somatic cell score), productive life, feet, legs and udders, are important to the functionality of dairy cows regardless of the production system.

Most importantly, the cow should be suited to the environment in which it is expected to perform. Thus, the first step to determining the type of cow that would fit a given operation is to establish goals for the farm's production system.

**Sources of genetics for breeding pasture-based cows**

Nearly every dairy breed has been used on pasture-based operations; and each breed has its strengths and weaknesses, which can be different even among various strains or populations of the same breed. Using breeds with larger populations and more sire selection options will generally result in the most genetic progress. This is true when producing purebreds as well as crossbreds. This guide discusses some of the sources of genetics most commonly used in pasture-based systems.

**Holstein**

Holsteins are by far the most popular breed in the United States. On a per-cow basis, U.S. Holsteins are unsurpassed for milk production and are favored in most conventional dairy operations. They typically are larger cows with a lot of capacity. Largely due to their will to milk, U.S. Holsteins generally take longer to replenish body condition and to return to estrus after calving compared to some other breeds or even to Holstein/Friesian populations in some other countries. Also, Holsteins may be more vulnerable to heat stress than some smaller breeds. Purebred Holsteins can be used in pasture-based systems and are preferred by some producers. They may, however, present a challenge

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for seasonal operations where cows must calve on a 12-month interval. They are a more logical choice for nonseasonal operations and operations in cooler climates. Use of North American Holstein genetics in seasonal operations would likely benefit from strict selection for sires with high daughter pregnancy rate predicted transmitting abilities (PTAs).

The Holstein cow is popular not only in the United States but worldwide. Holstein populations in many foreign countries are genetically similar to the U.S. population. A notable exception is the New Zealand Friesian. New Zealand Friesians have undergone generations of selection in an environment that stresses low inputs, low levels of concentrate feeding and seasonal calving. These cows are smaller and tend to gain body condition more easily than their U.S. counterparts.<sup>1</sup> They also have good reproductive performance. Cows from genetics of New Zealand origin have demonstrated higher pregnancy rates than cows of North American genetic origin.<sup>2</sup> These attributes have increased interest in the use of New Zealand genetics in domestic pasture-based herds. However, milk marketing realities in New Zealand have led to selection for milk solids content and against fluid volume. This factor should be considered when deciding whether to use New Zealand genetics for a breeding program. In general, New Zealand genetics would best be used by seasonal, low-input operations or in component markets. Selection within the population for sires with higher milk PTAs would benefit most U.S. milk markets.

### Jersey

The Jersey breed is popular among pasture-based producers. Many of the qualities graziers seek in a cow are inherent to the breed. Jerseys are smaller and have shown evidence of greater heat stress resistance in reproductive performance than Holsteins.<sup>3</sup> In the U.S., they are second to Holsteins in population size and offer a large enough genetic pool to allow an adequate level of sire selection pressure. Jerseys are popular among graziers both as purebreds and in crossbreeding programs.

As with Holsteins, New Zealand Jerseys offer specialized grazing genetics. Difference in body size tends to be less noticeable between U.S. and New Zealand Jersey populations than between Holstein populations. Otherwise, New Zealand Jersey genetics tend to show strengths for the same traits as Friesians — adaptation to low-input and seasonal systems.

### Other Breeds

Holsteins, Jerseys and crossbreds containing Holstein blood, Jersey blood or both are by far the most common cows found on pasture-based dairies. Other breeds have been used, however, and all have their proponents. The greatest interest in other breeds generally comes from producers who use crossbreeding, specifically a three-way rotational crossing program. With this breeding scheme, a third breed for mating to F1 offspring (the first filial generation) must be identified.

If tapping into another source of genetics becomes necessary, several factors need to be considered when choosing among alternative breeds. First, does the breed being considered offer a large enough population to facilitate a reasonable level of sire selection pressure? Second, does the breed offer strength in traits that complement herd breeding goals? Additional factors to consider are discussed in the *Crossbreeding* section.

## Sire selection

### Natural service vs. artificial insemination

A discussion on sire selection would not be complete without comparing the relative values of artificial insemination (AI) and natural service. The advantages of AI have been emphasized virtually since the technology was first made commercially available in 1938 but need to be reviewed periodically.

**Genetic performance** of AI sires either individually or as a group can be fairly accurately predicted. In contrast, individual natural service sires are a relatively unknown commodity and, collectively, they are genetically inferior to proven AI sires. In the April 2012 sire evaluations (Table 1), active AI Holstein and Jersey sire genetic merit (expressed as net merit, or NM\$) is clearly superior to that of non-AI bulls. With the application of some selection pressure, the difference is magnified. Notice the advantage in genetic worth of proven sires selected at the level of the 90th percentile.

**Table 1. Average PTAs, April 2012 U.S. Department of Agriculture Sire Evaluations.**

	Net Merit \$		
	AI Average	AI 90th pct.	Non-AI
<b>Holstein</b>	293	495	64
<b>Jersey</b>	263	459	53

**Cost** is a factor cited by many in favor of using herd bulls. When considering only direct costs, expenses associated with a bull (purchase price, feed, health, etc.) may be lower than expenses associated with AI (semen, supplies, labor). However, when the value realized from the use of AI (increased genetic gain, improved profitability, increased replacement value, etc.) is properly assessed, cost concerns are seen differently.

**Breeding success** is often thought to be greater with natural service than with AI. However, accurate analysis will show this to rarely be the case as long as heat detection is adequate. AI actually offers an advantage in that semen quality has been screened, thus eliminating problems arising from bull infertility, injury or lack of libido. If heat detection is a problem, implementation of a timed-breeding protocol can be used to alleviate those shortcomings. See MU Extension publication M178, *Dairy Grazing: Reproduction*, for more information.

**Health** concerns are decreased with the use of AI. Danger of spread of most sexually transmitted diseases is eliminated or greatly reduced.

**Safety** is always a concern when dealing with herd bulls. Bulls pose one of the greatest health risks on dairy farms. The safest bull is one that stays in your semen tank.

**Crossbreeding** programs are more easily executed with AI than with natural service. At any time, the herd will have animals that require service sires of different breeds. Providing this variety with natural service would be possible only if a herd is divided into more than one group.

### Selection tools

Lots of information is available to help dairy producers make genetic decisions. Predicted transmitting abilities (PTAs) are calculated for various yield, health, type and convenience traits for dairy cattle. These PTAs are derived from evaluations primarily of animals managed in traditional confinement systems. The ability of these evaluations to accurately predict animal performance in pasture-based environments has been questioned. However, a Purdue University study showed a high genetic correlation for traits in grazing versus confinement management systems and only a small tendency toward reranking of sires between the two systems.<sup>4</sup> Researchers there concluded that available genetic evaluations for dairy sires can be used adequately and successfully by pasture-based producers.

The seemingly endless collection of genetic data available on AI sires can make sire selection seem like an overwhelming task, but several indexing tools exist to simplify the job. An index provided by the U.S. Department of Agriculture (USDA) and widely used in the dairy industry is net merit (NM\$). Variations of NM\$ include cheese merit (CM\$) and fluid merit (FM\$). The traits used to calculate each of these indexes are the same, but the weights given to some traits vary between indexes. These variations provide selection tools tailored to different milk-pricing situations. NM\$ is the index to use for producers who are paid solely on protein and butterfat sold. CM\$ works best if milk is priced on a cheese yield formula. FM\$ is the appropriate index when payment is based on fluid volume and butterfat content.

Ten traits of primary economic importance have been identified and incorporated into the merit indexes. These traits are milk yield, butterfat yield, protein yield, productive life, somatic cell count score, udder composite, feet and leg composite, body size, daughter pregnancy rate and calving ability. Calving ability consists of a combination of calving ease and stillbirth evaluations. Table 2 lists the relative weights assigned to each trait for each of the three merit indexes in the Holstein breed. Relative rates used to calculate indexes for other breeds are adjusted slightly upward since not all breeds collect the data used to compute calving ability.

Generally, the relative emphases placed on the traits comprising net merit make this index a good basic sire-selection tool for pasture-based herds. Net merit

**Table 2. Relative economic values of traits included in net merit (NM\$), cheese merit (CM\$) and fluid merit (FM\$) (2010 formula).**

Trait	Units	Relative value (%) Holstein		
		NM\$	CM\$	FM\$
Protein	Pounds	16	25	0
Fat	Pounds	19	13	20
Milk	Pounds	0	-15	19
Productive life	Months	22	15	22
Somatic cell score	Log	-10	-9	-5
Udder	Composite	7	5	7
Feet/Legs	Composite	4	3	4
Body size	Composite	-6	-4	-6
Daughter pregnancy rate	Percent	11	8	12
Calving ability	Dollars	5	3	5

offers a balanced approach for improving yield, length of productive life, udder health, reproductive efficiency and important type traits. All these traits are of value in pasture-based systems. Note that the formula selects against large body size and in favor of higher daughter pregnancy rate. These emphases fit very well with the objectives of most graziers. If necessary, further selection pressure can be placed on specific traits to meet individual herd breeding goals.

### Special considerations on international genetics

International dairy genetics have generated considerable interest among U.S. producers in recent years. Many graziers have expressed particular interest in pasture-based genetics from New Zealand. Genetic selection from the New Zealand sire population necessitates an understanding of that country's genetic evaluations and how they differ from those of the United States. The New Zealand dairy industry uses an economic index referred to as breeding worth (BW). The formula for calculating BW incorporates many of the same traits as the U.S.'s net merit index but also has some important differences. Positive selection is made for protein yield, butterfat yield and fertility using BW. Additionally, BW selection is negative for milk yield (similar to the U.S. CM\$), body weight (same as U.S. indexes) and somatic cell score (same as in the U.S.). Feet, legs and udders are not considered in BW.

BW equals the sum of each trait's breeding value (BV) multiplied by the trait's economic value (EV) as shown below.

$$\begin{aligned} \text{Breeding worth} = & (\text{Milkfat BV} \times \$\text{EV}) + \\ & (\text{Protein BV} \times \$\text{EV}) + \\ & (\text{Milk BV} \times \$\text{EV}) + \\ & (\text{Liveweight BV} \times \$\text{EV}) + \\ & (\text{Fertility BV} \times \$\text{EV}) + \\ & (\text{Somatic cell BV} \times \$\text{EV}) + \\ & (\text{Residual survival BV} \times \$\text{EV}) \end{aligned}$$

Table 3 lists the relative weights assigned to each trait included in the breeding worth index formula.

**Table 3. Traits and weightings included in New Zealand breeding worth (BW) 2012.**

Trait	Economic values
Protein	\$8.685
Milkfat	\$1.920
Milk volume	-\$0.094
Liveweight	-\$1.480
Fertility	\$3.118
Residual survival*	\$0.048
Somatic cell	-\$31.460

\*Residual survival is defined as herd-life after accounting for the genetic effects of production, liveweight, milk somatic cells and fertility on herd-life. It measures the expected ability of a cow to resist culling for reasons other than traits included directly in the BW index.

A U.S. producer wishing to use New Zealand genetics and who sells milk in a market that rewards fluid volume should be careful about making selections from among this population. Use of BW as the sole selection criterion will result in automatic selection against an economically important trait to that operation, namely milk volume. High BW sires that also have high milk-yield breeding values would be more appropriate for such a situation.

For several reasons, direct genetic comparisons cannot be made between U.S. and New Zealand sires using the data generated from their respective countries of origin. First, each country has its own unique genetic base from which evaluations are calculated. Second, New Zealand and U.S. sire evaluations are expressed in different genetic measures and different units of volume. New Zealand evaluations are expressed as estimated breeding values (EBVs) in kilograms for butter fat and protein and in liters for milk. U.S. sire evaluations are expressed as predicted transmitting abilities (PTAs) in pounds. To make a reasonable genetic comparison between New Zealand and U.S. sires, the New Zealand evaluations should be converted to a U.S. base. This service is provided by the International Bull Evaluation Service (Interbull).

Interbull develops and produces international genetic evaluations for dairy cattle. These evaluations are made available to the industry by the USDA for international dairy sires marketed in the U.S. This information and formulas used to make Interbull conversions are available on the USDA Animal Improvement Programs Laboratory (AIPL) website, <http://aipl.arsusda.gov>. The formulas are updated following the release of each USDA sire summary.

The Interbull formulas can be used to calculate approximate U.S. PTAs for New Zealand sires. These conversions are approximations and should be recalculated with each new sire summary to have any value.

## Crossbreeding

Producers have expressed increased interest in crossbreeding dairy cattle in recent years. Crossbreeding can offer benefits that are difficult to achieve with pure breeding — benefits realized from heterosis (hybrid vigor)



**Figure 1. Crossbred dairy cows offer several advantages to pasture-based operations, including improved reproduction and survival.**

as well as breed complementarity. Crossbreeding can be a particular advantage to pasture-based operations because many of the traits improved through heterosis are especially important in grazing systems (Figure 1). Four benefits that can be realized through a well-managed crossbreeding program are described below.

**Improved reproduction.** Traits with low heritability tend to be the traits that can be most easily and quickly improved by heterosis through crossbreeding. Fertility is one of these traits. Data from Minnesota indicates fewer days open for first lactation crossbreds compared to pure Holsteins.<sup>5</sup> Fertility benefits may represent one of the greatest advantages of crossbreeding for seasonal pasture-based herds.

**Moderation of body size.** As stated earlier, many pasture-based producers prefer small to moderate-sized cows to their larger herd mates. One of the easiest ways to reduce body size, particularly in Holstein herds, is to cross with a smaller breed.

**Increase milk solids content.** The value of this benefit varies depending on the pricing of butterfat and protein in various milk markets, but most producers will receive at least some increase in price with added solids.

**Improved survival.** Crossbreeding results in improved survival of F1s through first lactation and into second lactation compared to straight Holsteins.<sup>5</sup>

## Heterosis

Heterosis is defined as the increased expression of a trait or traits in offspring of two different parental lines compared to the difference that would be expected from purely additive effects. Heterosis is illustrated in Figure 2. Note that the performance of the F1 exceeds the average of the two parents.

One might wonder why the dairy industry has not traditionally used the benefits of heterosis through crossbreeding. For many years, selection efforts in dairy cattle primarily targeted yield traits, milk yield in particular. Heterosis is realized for both milk and solids yield through crossbreeding, but when one of the parent breeds is a high-yield breed such as Holstein, the milk yield achieved through crossbreeding generally does not surpass the yield

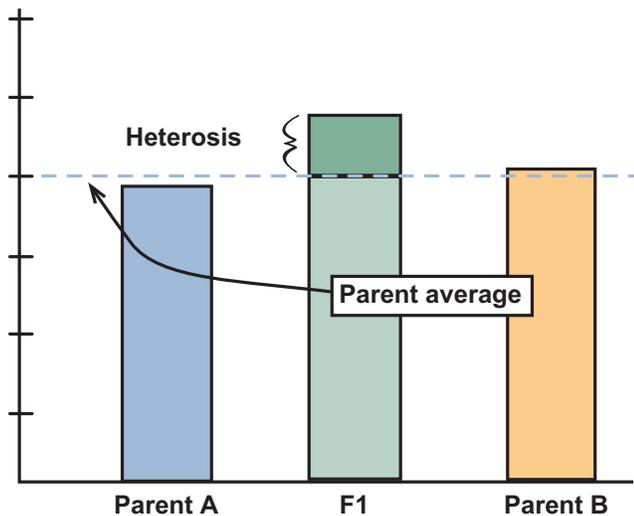


Figure 2. Expression of heterosis through crossbreeding.

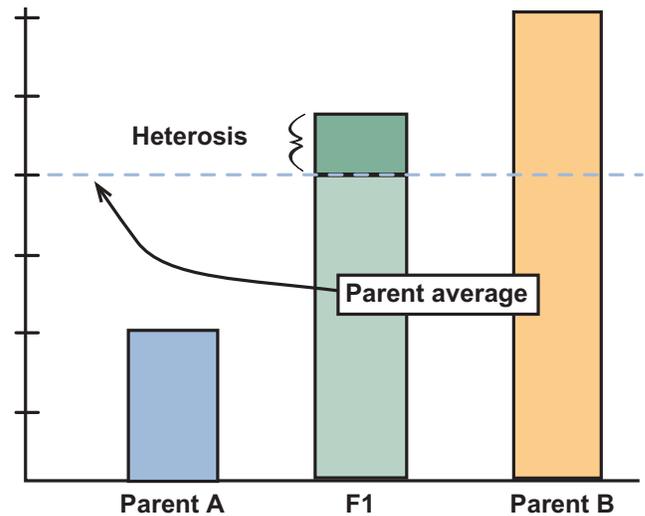


Figure 3. Expression of heterosis but without achieving trait superiority.

potential of straight Holsteins. Figure 3 illustrates this concept.

Contemporary interest in crossbreeding arises from a reordering of the relative importance of traits within some segments of the industry. For many producers, most pasture-based operators included, reproductive efficiency and fitness traits have risen to the top of the selection priority list. Differences among breeds for these traits are relatively small, thus heterosis for these traits is expressed similarly to the example in Figure 2.

### Crossbreeding systems

Most producers understand and appreciate the potential for improved performance from crossbred offspring produced by two purebred parents (F1s). Many, though, worry about how to mate F1s to continue the advantages of hybrid vigor into succeeding generations. Sustaining a successful crossbreeding program requires a plan and the commitment to follow it. Two crossbreeding systems most commonly used in dairy herds are the two-breed rotation and the three-breed rotation.

The **two-breed rotational crossbreeding system** uses two breeds on a continuous basis. In this system, F1 offspring are mated back to one of the original parent breeds, and mating sires for succeeding generations are alternated between the two breeds. After several generations, about two-thirds of each calf's genes will be from the breed of its sire and one-third will be from the other foundation breed. This system will sustain 67 percent of the hybrid vigor possessed by the original F1 generation. The two-breed rotation is one of the simplest systems to implement but still provides a reasonable level of hybrid vigor.

The **three-breed rotational crossbreeding system** uses three breeds. It starts with a two-breed F1 female, the same as the two-breed rotation, but mates the F1 to a third breed. The resulting offspring are 25 percent Breed A, 25 percent Breed B and 50 percent Breed C. The second generation females (F2s) are mated back to sires of one

of the original breeds. The third generation is mated to sires of the other original breed. The rotation continues, alternating among sires of the three breeds for each subsequent generation. Under this system, 86 percent of full heterosis will be maintained. The three-breed rotation takes a bit more management than does the two-breed system but offers a higher rate of heterosis.

In both the two-breed and three-breed systems, separate breeding groups must be maintained within the herd. Some cows will require mating to sires of each of the foundation breeds. Good animal identification is important to maintain the proper breed rotation.

Three factors should be carefully considered when choosing breeds for a crossbreeding program. First, the breeds used in the program need to complement each other and fit the breeding goals established for the herd. For example, if one herd goal is to produce cows of moderate to small body size, Holstein and Brown Swiss would not be complimentary, as both tend to sire larger animals. Jersey would be a more logical choice for crossing with a large breed. However, these three breeds may produce the desired results in a three-breed rotation. The Jersey influence coupled with careful selection of Holstein and Brown Swiss sires could make this combination workable.

Second, the breeds chosen need to offer large enough genetic pools to facilitate an adequate level of sire selection within each breed. In the U.S., the Holstein and Jersey breeds offer the largest populations and the largest number of bulls sampled per year. These are also the two breeds most widely used in crossbreeding programs. In a three-breed rotation, the third breed should be chosen based upon individual herd goals.

Finally, crossbreeding does not diminish the importance of good sire selection. Rather, crossbreeding should be viewed as a step toward enhancing the breeding value of highly selected sires. Matings to sires with marginal genetic merit will produce offspring with marginal genetic merit whether the animals are purebreds or crossbreds.

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