Crossbreeding Trials in California

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TAKE HOME MESSAGES

- Crossbreeding results in hybrid vigor, which is the opposite of inbreeding depression.
- Hybrid vigor is a bonus that dairy producers can expect on top of the individual gene effects from the use of top A.I. sires within breed.
- The bonus from hybrid vigor should be at least 5% for production and at least 10% for fertility, health, and survival of dairy cows.
- Crossbreeding Holsteins with Montbeliarde sires resulted in fewer stillborn calves, as well as cows with more calving ease, improved conception rates, fewer days open, and improved survival compared to pure Holstein herdmates, with little loss of production.
- Crossbreeding is NOT genetic improvement.
- Continuous use of top progeny-tested A.I. sires is essential for genetic improvement.
- Crossbreeding systems with dairy cattle should use <u>three</u> breeds to capitalize adequately on the benefits of hybrid vigor.

CIRCUMSTANCES HAVE CHANGED

Interest in crossbreeding is perhaps at an all-time high among commercial dairy producers internationally. Over the past 50 years, North American Holsteins have steadily increased as a percentage of the national dairy herd in most countries. Generally speaking, however, circumstances have changed regarding the historical superiority of pure Holsteins compared to crossbreds. Economically, milk pricing in most markets has placed greater emphasis on the solids in milk rather than the fluid carrier, which gives the Holstein breed less of a competitive advantage compared to other breeds.

Biologically, the reproductive decline of Holsteins, on both an observed and a genetic basis, has been clearly documented in most countries of the world. Furthermore, postpartum complications of Holsteins have become more pronounced in recent years in most environments. All dairy breeds in the world likely have fewer problems than the Holstein breed for the direct and maternal effects of calving difficulty. Frequently, Holstein cows have become too large for optimum longevity in many facilities, because they have difficulty fitting in stalls that are inadequate in size. The combined effect of these factors is fewer calvings during the lifetimes of pure Holstein cows at this time than in the past.

Inbreeding

The global Holstein population is becoming more inbred over time. As expected, relationships continue to mount within the Holstein breed because of highly effective selection programs. As relationships between individuals rise, it becomes more and more likely that bulls and cows that are mated to one other will be closely related. Most consequences of inbreeding are masked and not readily noticeable. Inbreeding robs dairy producers of income by increasing stillbirths, hampering growth rates of heifers, reducing cow fertility, and reducing disease resistance. A major negative consequence of inbreeding should be reduced cow fertility, because highly inbred embryos are more likely to be non-viable and sloughed.

Table 1 has the relationship in 2005 of individual sires of high impact to the USA Holstein population. These relationships were estimated by USDA with a base year of 1960, so relationships prior to that year were ignored. Two bulls born in the 1960s – Elevation and Chief – together make up about 30% of the Holstein breed today. All of the other bulls in Table 1 are descendants of at least one of these two stalwarts of the breed. Blackstar is a relatively "young" ancestor with a birth year of 1983, yet he already has a relationship of 15.8% to the Holstein breed. Many of Blackstar's sons (Emory, Juror, Lord Lily, Duster, Patron) and grandsons (Mtoto, Tugolo, Outside) have begun to have their impact on the breed. Historically, no bull has surpassed 16% relationship to the Holstein breed, but Blackstar should be the first bull to do so. Globally, the "narrowing of the genetic base" is almost as severe as in the USA, because North American Holstein genetics have replaced native breeding stock internationally.

Table 1. Relationships of individual sires to the Holstein breed in the USA.

Sire	Pedigree	Birth year	Relationship (%)
Blackstar	Traces twice to Elevation and twice to Chief	1983	15.8
Elevation		1965	15.2
Chief		1962	14.8
Emory	Son of Blackstar and dam is sired by a double grandson of Chief	1989	14.2
Valiant	Son of Chief	1973	13.6
Mark	Son of Chief	1978	13.2
Starbuck	Son of Elevation	1979	12.2

Four Holstein bulls (Blackstar, Rudolph, Manfred, and Elton) currently dominate the pedigrees of sires and dams of progeny-test young bulls entering A.I., because their descendants tend to rank highly for cow fertility and survival. Elton's relationship to the breed in 2005 is 11.6%, but will likely increase substantially through his sons (Durham and Convincer) and especially his grandsons (O-Man, BW Marshall, Addison, Jesther, and Machoman).

Table 2 has the average inbreeding of Holstein females in the USA from milk recording by birth year. The estimates are conservative, because many cows lack parts of their pedigree and because pedigrees go back to only 1960. Knowledge of relationships prior to 1960 suggests that 2% should be added to all current estimates of inbreeding with the 1960 base for pedigrees.

Table 2. Average inbreeding of Holstein females in the USA.

Birth year	Inbreeding (%)
1994	3.5
1996	3.9
1998	4.2
2000	4.5
2002	4.8
2004	5.0

Inbreeding is increasing at a constant rate of 0.1% per year for USA Holsteins, and heifers born in 2004 had an average inbreeding of 5.0%. The recommendation for commercial milk production is that inbreeding shouldn't surpass 6.25%. With an average of 5.0%, many individual Holstein matings surpass the 6.25% threshold. What does the 6.25% mean? Cows have two genes at every location on their chromosomes – one from each parent. The inbreeding coefficient measures the percentage of those two genes (on all chromosomes) that are identical because they trace to the same ancestor. As the inbreeding % goes up, the likelihood of doubling up on genetic recessives (most of them of minor consequence) becomes greater.

Most dairy producers are probably unaware that individual cows in their herd have inbreeding % higher than what is recommended. With increased relationships among Holsteins, inspection of pedigrees is essential when mating individual bulls to individual cows. The corrective mating programs offered by A.I. organizations can assist to avoid the mating of A.I. sires with cows that will result in unacceptable inbreeding. However, pedigrees of cows must be provided for the mating programs, and the mating programs must go deeply into pedigrees to pick up bulls like Elevation and Chief, which often appear many, many times in the pedigrees of current bulls and cows. A major hurdle for avoiding inbreeding by pedigree inspection is misidentification of sires of cows, which was recently estimated to be at least 25% of cows in the USA.

CROSSBREEDING

Concerns about inbreeding can be eliminated by crossbreeding. The effects of crossbreeding are the exact opposite of the effects of inbreeding. At each location on pairs of chromosomes, the two genes are much less likely to be identical with crossbreeding than with same-breed matings. Therefore, genetic recessives of both major and minor consequence are not expressed. Old research has indicated that hybrid vigor from crossbreeding is greatest for traits related to fertility, health, and survival. Currently, routine crossbreeding of Holsteins and Jerseys in New Zealand has resulted in phenomenal increases in survival of crossbreds compared to purebreds.

Crossbreeding should be of the most benefit when environments are limited and when dairy producers are unable or resistant to keep reliable records on parentage of cows in their herds. New research is underway to help uncover the potential value of crossbreeding for commercial milk production. However, the commercial pig, beef cattle, and sheep production have relied on crossbreeding to improve reproduction, growth, and disease resistance for about half a century.

Background

The decline in fertility and survival of pure Holsteins led the managers of seven large dairies in California to mate Holstein heifers and cows with imported semen of the Montbeliarde breed from France. Crossbred cows began calving in June 2002. Some cows in the seven dairies continued to be pure Holstein, which permitted comparison of pure Holsteins and crossbreds.

Production

Crossbreds and pure Holsteins that calved for the first time from June 2002 to January 2005 were studied for production. Sires of all cows were A.I. sires, and all Holstein sires had NAAB-assigned sire codes. Furthermore, the Holstein maternal grandsires of all cows (both purebred and crossbred) were likewise required to be A.I. sires with NAAB-assigned sire codes. Therefore, cows were removed from the study that had natural service or unidentified Holstein sires or Holstein maternal grandsires.

Actual production (milk, fat, and protein) for 305-day lactations was calculated with the Best Prediction technique used by USDA for national genetic evaluation in the USA. Best Prediction was applied separately to each of the seven dairies and used herd-specific lactation curves rather than breed-specific lactation curves to calculate 305-day actual production. Adjustment was made for age at calving and milking frequency (test days with 3X were adjusted to 2X), and records less than 305 days in length were projected to 305 days. Herd-year-season of calving (4-month seasons) and genetic level of each cow's Holstein maternal grandsire were included in a statistical analysis of 305-day actual production of cows. Table 3 provides the number of cows analyzed for production and number of sires of the cows by breed group.

Table 3. Number of cows and sires of cows analyzed for production.

Breed	Cows	Sires
Holstein	380	69
Montbeliarde-Holstein	494	23

Results for 305-day actual production of first lactations are in Table 4. Fat (kg) plus protein (kg) was used to gauge the overall production of the pure Holsteins versus crossbreds. The Montbeliarde-Holstein crossbreds (-3.8%) were significantly lower than pure Holsteins for fat (kg) plus protein (kg).

Table 4. Actual 305-day production (2X milking) for first lactation.

	Holstein	Montbeliarde-Holstein
Milk (kg)	9757[a]	9161[b]
Fat (kg)	346.2[a]	333.8[b]
Protein (kg)	305.3[a]	293.0[b]
Fat (kg) + Protein (kg)	651.4[a]	626.8[b]
% of Holstein		-3.8%

[a,b] Different letters of superscripts indicate significant differences ($p<.05$)

Importantly, no adjustment was made to production for differences in days open (pregnancy status) of cows. It has been documented that cows with very short days open are penalized for 305-day production, and cows with long days open or do not become pregnant have inflated 305-day production. Production and reproduction must both be included, along with other important traits, in indexes to determine total economic merit of cows.

Averages of somatic cell score (as an indicator of mastitis) during first lactation were uniformly low compared to the entire USA, and crossbred group did not differ significantly from pure Holsteins, with averages of 2.4 for pure Holsteins, and 2.3 for Montbeliarde-Holstein crossbreds.

All cows in the study were sired by A.I. sires, and the seven California dairies historically used high-ranking Holstein A.I. sires. The weighted averages for estimated breeding value (May 2005) of the sires of the 380 pure Holstein cows in this study were +513 kg milk, +12 kg fat, +16 kg protein, which were relative to the USA's updated step-wise genetic base for 2005

Calving Difficulty and Stillbirths

Calving difficulty was measured on a 1 to 5 scale, with 1 representing a quick and easy birth without assistance and 5 representing an extremely difficult birth that required a mechanical puller. Scores of 1 to 3 were combined and regarded as no calving difficulty, and scores of 4 and 5 were combined and represented calving difficulty. Stillbirths were recorded as alive or dead within 24 hours of birth. Calving difficulty and stillbirth are traits of both the sire and the dam.

Breed of sire

To analyze effects of breed of sire, dams of calves were separated into first calving versus 2nd to 5th calving. Adjustments were made for sex of calf and herd-year-season (3-month seasons) of calving. Across breeds of sire for first-calf heifers, calving difficulty averaged 15.5% for bull calves and 7.3% for heifer calves, and stillbirth rates were 18.8% for bull calves and 5.6% for heifer calves. Clearly, the bulk of calving difficulty and stillbirth was for bull calves. Table 5 provides the number of births, calving difficulty rate, and stillbirth rate by breed of sire for first-calf pure Holstein dams.

Table 5. Calving difficulty and stillbirths for breed of sire for first-calf pure Holstein dams.

Breed of sire	Number of births	Calving difficulty	Stillbirth
		(%)	(%)
Holstein	371	16.0[a]	15.7[a]
Montbeliarde	158	12.0[a]	13.2[a]

[a,b] Different letters of superscripts indicate significant differences (p<.05)

Table 6 has number of births, calving difficulty rate, and stillbirth rate for pure Holstein cows calving for the 2nd to 5th time. Cows calving for the 2nd to 5th time had less calving difficulty and fewer stillbirths than first-calf heifers. However, bull calves again were more of a problem than heifer calves, with almost twice the rate of calving difficulty (7.9% versus 4.4%) and twice the rate of stillbirth (8.4% versus 4.3%).

Table 6. Calving difficulty and stillbirths for breed of sire when pure Holstein dams calved for the 2nd to 5th time.

Breed of sire	Number of births	Calving difficulty	Stillbirth
		(%)	(%)
Holstein	1,241	7.7[a]	11.8[a]
Montbeliarde	2,385	5.7[a]	4.4[b]

[a,b] Different letters of superscripts indicate significant differences (p<.05)

Montbeliarde sires had or tended to have fewer stillbirths than Holstein sires. Dams of all calves for the breed of sire analysis were pure Holsteins, so calves sired by Holstein sires were purebreds, whereas calves sired by bulls from the other breed were crossbreds. Therefore, inbreeding probably caused the much higher stillbirth rates for Holstein-sired calves, perhaps due to lethal genetic recessives that have not yet been uncovered.

Breed of dam

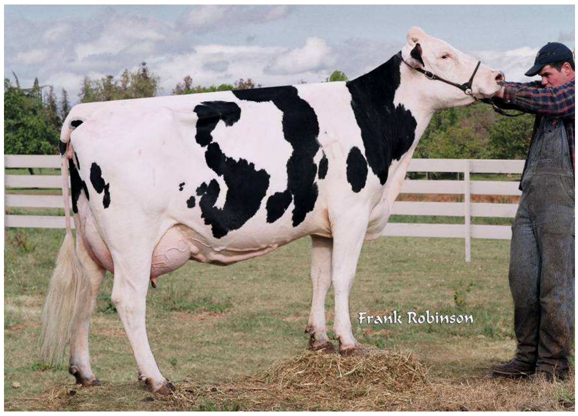
All births analyzed for effect of breed of dam were for crossbred calves. Adjustments were made for breed of sire, sex of calf, and herd-year-season of calving. Cows calving for the first time were analyzed separately. Across breed group of dam, calving difficulty rates were 11.4% for bull calves and 4.2% for heifer calves, and stillbirth rates were 13.6% for bull calves and 2.2% for heifer calves for cows calving the first time. Table 7 has number of births, calving difficulty rate, and stillbirth rate for first births of cows.

Table 7. Calving difficulty and stillbirths for breed group of dam at first calving.

Breed of dam	Number of births	Calving difficulty (%)	Stillbirth (%)
Holstein	1,398	9.3[a]	11.8[a]
Montbeliarde-Holstein	370	8.1[a]	7.1[a]

[a,b] Different letters of superscripts indicate significant differences (p<.05)

Montbeliarde x Holstein
1-11 305d 9163 Milk, 304 Fat, 267 Protein



Montbeliarde x Holstein
2-3 305d 12,025 Milk, 469 Fat, 342 Protein

Survival

First-lactation cows that calved from June 2002 to October 2004 in the seven California dairies were compared for survival to 30 days, 150 days, and 305 days postpartum. Survival rates were adjusted for herd-year of calving. Table 8 has the survival rates for 692 pure Holsteins and 655 crossbreds. Pure Holsteins left these dairies sooner than crossbreds, with 86% of pure Holsteins surviving 305 days postpartum compared to 92% of crossbreds.

Reason for disposal was recorded, and 1.7% of pure Holsteins died by 30 days postpartum. Death rate grew for pure Holsteins to 3.1% by 305 days postpartum, and this was more than double the death rate of the crossbred group. However, all of these death rates are probably low based on death rates that have reported for other dairies in California.

Table 8. Survival rates during first lactation.

Breed	Number	30 days (%)	150 days (%)	305 days (%)
Holstein	692	95[a]	91[a]	86[a]
Montbeliarde-Holstein	655	98[b]	96[b]	92[b]

[a,b] Different letters of superscripts indicate significant differences (p<.05)

Fertility

Fertility of the pure Holsteins and crossbreds was measured as actual days open for cows that had a subsequent calving or had pregnancy status confirmed by a veterinarian. To be included in the analysis, cows were required to have at least 250 days in milk, which meant the pure Holsteins were a more highly-selected group compared to the crossbreds, because a smaller percentage of pure Holsteins than crossbreds survived to 250 days postpartum. Cows with more than 250 days open had days open set to 250. Adjustment was made for herd-year of calving.

The distribution of days open for cows indicated 38% of the pure Holsteins had 35 to 99 days open versus 43% of the Montbeliarde-Holstein crossbreds

The 520 pure Holsteins had average days open of 150 days (Table 9) during first lactation, and the crossbred group had significantly fewer days open than the pure Holsteins. The 371 Montbéliarde-Holstein crossbreds had average days open of 131, which was a difference of 19 days from the pure Holsteins.

Table 9. Days open during first lactation with a maximum of 250 days.

Breed	Number of cows	Number of sires	Days open
Holstein	520	76	150[a]
Montbeliarde-Holstein	371	22	131[b]

[a,b] Different letters of superscripts indicate significant differences (p<.05)

First service conception rate was 22% for pure Holsteins compared to 31% for the Montbeliarde-Holstein crossbreds. The crossbred group had significantly higher first service conception rate than the pure Holsteins.

RECOMMENDATIONS

Dairy producers should not consider crossbreeding to be genetic improvement – it is not! Continuous use of progeny-tested and highly-ranked A.I. sires is the key to genetic improvement. Some dairy producers have viewed crossbreeding as a justification to turn to natural service bulls rather than A.I. That would be an unfortunate consequence of the new interest in crossbreeding.

Hybrid vigor is a bonus that dairy producers can expect on top of the positive effects of individual genes obtained by using top A.I. sires within breed. The bonus from hybrid vigor should be at least 5% for production and at least 10% for fertility, health, and survival of dairy cows. Therefore, the impact of hybrid vigor on profit could be substantial for commercial milk production. However, some dairy producers might need to get beyond the notion that level of milk production is the only measure of profitability of dairy cows.

Research on crossbreeding has been initiated at many of the major agricultural universities in the USA and around the world. However, the rate of increase in inbreeding of Holsteins (+0.1% per year in the USA) might make crossbreeding almost essential at some point in time in the future for commercial milk production globally.

Crossbreeding systems should make use of **three** breeds. The use of two breeds limits the long-term impact of hybrid vigor. The use of four breeds limits the contribution of any single breed of especially high merit to herd composition and makes the mating system more complex. Individual dairy managers should carefully choose the three breeds that seem optimum for conditions that are unique to their dairy operation (facilities, climate, nutritional regime, reproductive status, and overall level of management).

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