Crossbreeding: Why the Interest? What to Expect

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Summary:

- Crossbreeding is the opposite of inbreeding depression.
- Inbreeding depression and hybrid vigor should be greatest for cow fertility in dairy cattle.
- Crossbreeding is NOT genetic improvement.
- Continuous use of top progeny-tested A.I. sires is essential for genetic improvement.
- 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 about 6.5% for production and at least 10% for fertility, health, and survival of dairy cows.
- Crossbreeding systems should use three breeds to allow for an adequate level of hybrid vigor, without the complication involved with using more breeds.

CIRCUMSTANCES HAVE CHANGED

Interest in crossbreeding is at perhaps 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. However, circumstances have changed regarding the historical superiority of pure Holsteins compared to crossbreds. In recent years, milk pricing in most markets has continued to place an increasing emphasis on solids in milk rather than the fluid carrier. The reproductive decline of Holsteins, on both an observed and a genetic basis, has been clearly documented in most countries of the world including the U.S. Post-partum complications of Holsteins have become more pronounced in recent years in most environments. The typical Holstein cow has become too large for optimum longevity, and sometimes she has difficulty fitting in stalls that are inadequate in size.

Perhaps, most importantly, Holsteins have become more inbred over time. At this time, two bulls (Chief and Elevation) make up about 30% of the gene pool of U.S. Holsteins. Globally, the problem with the “narrowing of the genetic base” is almost as severe as in the U.S., because U.S. Holstein genetics has replaced native breeding stock internationally. As an example, one bull (Starbuck – a son of Elevation out of an Astronaut – both American) has a 20% relationship to Canadian Holsteins. Inbreeding is increasing at a constant rate of about 0.1% per year for U.S. 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 Holsteins surpass the 6.25% threshold. The first negative consequence of inbreeding should be reduced cow fertility, because an inbred embryo is more likely to be non-viable and sloughed.

INTRODUCTION

The perceived decline in fertility and survival of pure Holsteins led owners of seven large dairies in California to mate Holstein heifers and cows with imported semen of the Normande and Montbeliarde breeds from France and of the Norwegian Red and Swedish Red breeds. Because the Swedish Red (SRB) and Norwegian Red (NRF) share similar Ayrshire ancestry and exchange some sires of sons, we have regarded the two breeds collectively as "Scandinavian Red". Crossbred cows began calving in June 2002, and all early crossbreds were Normande-Holstein. Montbeliarde-Holstein and Scandinavian Red-Holstein crossbreds began calving about one year later than the Normande-Holstein crossbreds. Some cows in the seven California dairies remained pure Holstein, which has permitted comparison of pure Holsteins and crossbreds.

PRODUCTION

All cows calved from June 2002 to December 2004 for a study of the production of crossbreds versus pure Holsteins. Sires of all cows were A.I. sires with assigned sire codes. Furthermore, the Holstein maternal grandsires of all cows (both purebred and crossbred) were likewise required to be A.I. sires with assigned sire codes. This edit removed all cows from the study that had natural service Holstein sires or maternal grandsires and provided for fairer comparisons. Test days for cows with 3X milking were pre-adjusted to 2X milking.

The analysis of daily production data from milk recording included adjustment for stage of lactation within breed (five 30-day intervals from calving to 150 days postpartum), age at calving, herd-year-season of calving (3-month seasons), and transmitting ability (PTA) of each cow's Holstein maternal grandsire. Effects of breed composition, sire, and cow (within breed and sire) were key factors in the statistical analysis. Table 1 has a summary of the number of daily observations from milk recording, cows, and sires represented in the production data.

Table 1. Number of observations for production.

Breed	Milk recording observations	Cows	Sires
Holstein	1,855	419	73
Normande-Holstein	1,033	231	24
Montebeliarde-Holstein	2,034	468	22
Scandinavian Red-Holstein	1,356	305	13

Results for production during the first 150 days of lactation of first lactation cows are provided in Table 2. Only results for the first 150 days of lactation are reported to date, because 305-day lactational production of cows will need to be adjusted for differences in reproductive status. 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. Results for 305-day production adjusted for days open will be available later in 2005.

Table 2. Average daily production (2X basis) for the first 150 days of first lactation.

	Holstein	Normande-Holstein	Montebeliarde-Holstein	Scandinavian Red-Holstein
Milk (lb)	66.0	58.4	63.4	65.6
Fat (lb)	2.32	2.16	2.29	2.37
Protein (lb)	2.02	1.88	1.99	2.06
Fat + Protein (lb)	4.34[a]	4.04[b]	4.28[a]	4.43[a]
% of Holstein		-7%	-1%	+2%

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

Production was gauged as fat plus protein (lb) on a daily basis. The Scandinavian Red-Holstein crossbreds (+2%) and Montbeliarde-Holstein crossbreds (-1%) were not significantly different from pure Holsteins for production; however, Normande-Holstein crossbreds had 7% less production than pure Holsteins. Some have questioned the genetic level of the sires of the pure Holsteins; however, these California dairy producers historically have used high-ranking Holstein A.I. sires. The current PTA (November 2004) of the sires of the pure Holstein cows in this study are +1224 lb milk, +34 lb fat, +40 lb protein, despite the fact that these cows were born several years ago.

CALVING DIFFICULTY and STILLBIRTHS

Number of observations for births was much greater than for production. 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. It is important to keep in mind that calving difficulty and stillbirth are traits of both the sire and the dam.

Breed of Sire

For analyzing effects of breed of sire, dams of calves were separated into first calving heifers versus cows calving for the 2nd to 5th time. Adjustments were made for sex of calf and herd-year-season of calving. Across breed 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 stillbirths were for bull calves. Table 3 provides the number of births, calving difficulty rate, and stillbirth rate by breed of sire. Inadequate numbers prevented the use of Normande sires. Scandinavian Red sires had significantly less calving difficulty and stillbirth than Holstein sires when dams of calves were first-calf pure Holsteins.

Table 3. Calving difficulty and stillbirths for breed of sire when pure Holstein dams calved for the first time.

Breed of sire	Number of births	Calving difficulty (%)	Stillbirth rate (%)
Holstein	371	16.0[a]	15.7[a]
Montebeliarde	158	12.0[a]	13.2[a,b]
Brown Swiss	224	11.9[a,b]	12.0[a,b]
Scandinavian Red	1,016	5.5[b]	7.9[b]

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

As expected, cows calving for the 2nd to 5th time had much lower rates of calving difficulty and stillbirth than first-calf heifers. Bull calves again were much more of a problem than heifer calves. Bull calves had almost twice the rate of calving difficulty (7.9% versus 4.4%) and twice the rate of stillbirth (8.4% versus 4.3%) as heifer calves. Table 4 has number of births, calving difficulty rate, and stillbirth rate for multiparous cows. Again, calves sired by Scandinavian Red sires had significantly less calving difficulty than Holstein-sired calves. Furthermore, Holstein-sired calves had significantly greater stillbirth than all other breeds of sire.

Table 4. Calving difficulty and stillbirths for breed of sire when pure Holstein dams calved from the 2nd to 5th time.

Breed of sire	Number of births	Calving difficulty (%)	Stillbirth rate (%)
Holstein	1,241	7.7[a,b]	11.8[a]
Normande	327	9.1[b]	6.5[b]
Montebeliarde	2,385	5.7[a]	4.4[b]
Brown Swiss	527	5.4[a,c]	4.9[b]
Scandinavian Red	516	2.6[c]	4.2[b]

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

All breeds of sire had (for first-calf heifers) or tended to have (for 2nd to 5th lactation cows) 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 breeds were crossbreds. Therefore, inbreeding probably caused the remarkably higher stillbirth rate for Holstein-sired calves.

Breed of Dam

To estimate differences in breed composition of dam for calving difficulty and stillbirths, breeds of sire were limited to Brown Swiss, Montbeliarde, and Scandinavian Red, because numbers of births by sires of other breeds were small and not well distributed across breed composition of dam. Therefore, all births analyzed for 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 composition 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 5 has number of births, calving difficulty rate, and stillbirth rate for 2,301 first births of cows.

Table 5. Calving difficulty and stillbirths for breed of dam at first calving.

Breed of dam	Number of births	Calving difficulty	Stillbirth rate
		(%)	(%)
Holstein	1,398	9.3[a]	11.8[a]
Normande-Holstein	269	9.2[a,b]	7.8[a,b]
Montebeliarde-Holstein	370	8.1[a,b]	7.1[a,b]
Scandinavian Red-Holstein	264	4.7[b]	4.9[b]

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

Scandinavian Red-Holstein crossbreds (4.7%) had significantly less calving difficulty than pure Holsteins (9.3%) at first calving. Stillbirth rates tended to follow the averages for calving difficulty respective to breed composition of dam, and Scandinavian Red-Holstein dams had a significantly lower stillbirth rate than pure Holstein dams at first calving.

SURVIVAL

First-lactation cows in the seven California dairies that calved from June 2002 to October 2004 were compared for survival to 30 days postpartum, 50 days postpartum, and 305 days postpartum. Survival rates were adjusted for herd-year of calving. Table 6 has the survival rates for pure Holsteins and crossbreds. These survival rates are for 692 pure Holsteins and 1,554 crossbreds. Pure Holsteins left these dairies sooner than crossbreds, with 86% of pure Holsteins remaining 305 days postpartum compared to 92% to 93% of crossbreds.

Table 6. Survival during first lactation.

Breed	Number	30 days (%)	150 days (%)	305 days (%)
Holstein	692	95^{a}	91^{a}	86^{a}
Normande-Holstein	465	98^{b}	96^{b}	93^{b}
Montbeliarde-Holstein	655	98^{b}	96^{b}	92^{b}
Scandinavian Red-Holstein	434	98^{b}	96^{b}	93^{b}

$^{a,\,b}$ Different letters of superscripts indicate significant differences ($p<.05$)

Reason for disposal was recorded and 1.7% of pure Holsteins died by 30 days postpartum. Death percentage grew for Holsteins to 3.1% by 305 days postpartum and was more than double any of the crossbred combinations.

Normande-Holstein crossbreds (n = 118) were compared to pure Holsteins (n = 283) for percentage that calved a second time within 20 months of first calving. Only 66% of pure Holsteins re-calved within 20 months; however, 82% of Normande-Holstein crossbreds had a second calf within 20 months of first calving. This is a huge difference from an economic point of view, and likely easily compensates for the 7% lower production of Normande-Holstein crossbreds compared to pure Holsteins.

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 lactation, which means the Holsteins were a more highly selected group compared to the crossbreds, because a smaller percentage of them 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 520 pure Holsteins had average days open of 150 days (Table 7), and all of the crossbred groups had significantly fewer days open. The 375 Normande-Holstein crossbreds had average days open of 123, which is a difference of 27 days from the pure Holsteins. A difference of this magnitude for fertility, coupled with the difference for survival, certainly more than compensates, economically, for the somewhat lower production of Normande-Holstein crossbreds than pure Holsteins.

The distribution of days open for cows indicated 38% of the pure Holsteins versus 52% of the Normande-Holstein crossbreds, 43% of the Montbeliarde-Holstein crossbreds, and 44% of the Scandinavian Red-Holstein crossbreds had 35 to 99 days open. Furthermore, 21% of the pure Holsteins versus only 14% of the Normande-Holstein and the Scandinavian Red-Holstein crossbreds had at least 250 days open.

Table 7. 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]
Normande-Holstein	375	24	123[b]
Montbeliarde-Holstein	371	22	131[b]
Scandinavian Red-Holstein	257	10	129[b]

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

First service conception rate was 22% for pure Holsteins compared to 35% for the Normande-Holstein crossbreds, 31% for the Montbeliarde-Holstein crossbreds, and 30% for the Scandinavian Red-Holstein crossbreds. All three crossbred groups were significantly different from the pure Holsteins for first service conception rate.

CONCLUSIONS and RECOMMENDATIONS

Dairy producers must not regard crossbreeding as a genetic improvement program – it is not! Continuous use of high-ranking progeny tested A.I. sires within breeds is essential for genetic improvement. Unfortunately, some dairy producers have viewed crossbreeding as an excuse to turn to natural service. That would be an unfortunate consequence of renewed interest in crossbreeding.

Hybrid vigor is a bonus that dairy producers can expect on top of the individual gene effects acquired by the use of top A.I. sires within breed. The bonus from hybrid vigor should be about 6.5% for production and at least 10% for fertility, health, and survival of dairy cows. Therefore, the impact on profit could be substantial for commercial milk production. Research on crossbreeding has been initiated at many of the major agricultural universities in the U.S. and around the world. The rate of increase in inbreeding of U.S. Holsteins (+0.1% per year) might make crossbreeding almost essential at some point in the future.

Crossbreeding systems should make use of three breeds. Use of two breeds limits the long-term impact of hybrid vigor, and the use of four breeds limits the long-term contribution of any single breed to herd composition and makes the mating system more complex. The three breeds should be carefully chosen for the unique conditions (facilities, climate, nutritional regime, management system, and level of management) of a specific dairy operation to optimize a crossbreeding system.