January 2016

Comparison of Montbeliarde × Holstein and Viking Red × Holstein crossbreds with pure Holstein cows during first lactation in 8 commercial dairies in Minnesota

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A 10-year designed study on crossbreeding is ongoing with 8 large-scale and high-performance dairy herds in Minnesota. The end of 2015 marked the conclusion of the 8th year of the 10-year study. The interest in, and use of, crossbreeding by dairy producers served as the motivation for this research. Dairy producers often express disappointment with the health, fertility, and survival of their pure Holstein (**HO**) cows. Also, owners/managers of the 8 dairy herds participating in this study were aware of the greater profitability for 2-breed crossbreds of HO with the Montbeliarde and Viking Red breeds compared to pure HO cows from a previous field study in California.

The Viking Red breed is the result of combining the genetic improvement programs of the previously separate Swedish Red, Finnish Ayrshire, and Danish Red populations. The objective of the study is to assess the profitability of crossbreds from a 3-breed rotation using the HO, Montbeliarde, and Viking Red breeds (ProCROSS) compared to pure HO females.

However, this report provides results for only the first-lactation performance of 2-breed crossbreds compared to their pure HO herdmates. ProCROSS dairy cattle result from a 3-breed rotation, so the results in this report are for just the first generation of a mating system that will eventually provide ProCROSS dairy cattle. Also, because only first-lactation performance is reviewed in this report, an analysis of health treatments was not undertaken or reported. Differences in health treatments for crossbreds versus pure HO cows are anticipated to be much more substantial for cows in their second and later lactations. Therefore, analysis of health treatments will follow in the future when cows have had the opportunity to complete at least three lactations in the 8 dairy herds.

Study Design

Pure HO females (3,550 virgin heifers and cows) in 8 dairy herds were enrolled by the University of Minnesota as "foundation" females during 2008. Two additional herds were initially enrolled in the study but subsequently discontinued participation – one herd decided to implement a crossbreeding program of its own design and the other herd preferred working with only pure HO cows.

The 8 dairy herds are located throughout Minnesota and are elite herds for milk production in the state. Collectively, these herds currently have average production from milk recording of 30,410 lbs. of milk, 1,115 lbs. of fat, and 943 lbs. of protein with 3-times daily milking. All of the herd owners/managers had positive previous experiences from milking some crossbred cows alongside pure HO cows in their herds, and their previous success with crossbred cows sparked

their interest in participating in the study. The 8 dairy herds range in size from 275 to 1,940 cows.

The mating design is the first of its kind for a genetic study with cooperating herds – it's absolutely unique. Producers offered primarily virgin heifers and first-lactation or second-lactation pure HO cows to serve as "foundation" pure HO females for the study. University of Minnesota researchers then assigned these foundation females to one of 2 genetic groups – crossbred or pure HO. Foundation heifers and cows were paired and assigned to the 2 genetic groups based on age (for heifers), lactation number (for cows), sire, and production level. Across the 8 herds, approximately 56% of the foundation pure HO females were mated to either Montbeliarde or Viking Red A.I. bulls with exactly one half to bulls from each of the two breeds during the first generation to initiate a 3-breed rotation. The other approximately 44% of the foundation pure HO were bred to Holstein A.I. bulls, as were the subsequent generations of descendants across the years of the study.

Only proven A.I. bulls (those with daughter performance) with very high genetic merit from all 3 breeds were mated to heifers and cows. Producers chose the service sires for each breed in consultation with 2 genetic advisors employed by Minnesota Select Sires Co-op, Inc. For Montbeliarde and Viking Red, all semen was imported into the U.S. by Creative Genetics of California. The bulls ranked highly among those that were available in the U.S. for the French ISU index and the Nordic Total Merit index, which are the national indices for the Montbeliarde and Viking Red breeds, respectively. For pure HO bulls, proven A.I. bulls marketed by Select Sires, Inc. were used, and dairy producers were asked to select bulls that ranked among the top 10% of available bulls for the Net Merit index.

Heifers and cows were mated individually to A.I. bulls by the 2 genetic advisors, and females in each breed group were correctively mated for conformation. Additionally, inbreeding protection was provided for the pure HO matings. Some of the herds mated cows on 5th and later services to unproven A.I. bulls or natural service bulls, but none of the resulting progeny were included in the study.

Data Analysis

During the first 8 years of the 10-year study, more than 6,000 heifer calves have been born within the study and each herd currently contains a cross-section of first, second, third, and fourth generations of 3-breed rotational crossbred females alongside their pure HO herdmates. The complete cohort of 2-breed crossbreds and their pure HO herdmates have now had the opportunity to complete the first 305 days of first lactation.

For analysis, 548 Montbeliarde × Holstein (**M×H**), 583 Viking Red × Holstein (**V×H**), and 1,134 pure HO cows calved for the first time between December 2010 and April 2014. All had the opportunity to milk 305 days into their first lactation. For all traits, cows were excluded if their lactation began with an abortion, and this removed 9 M×H, 17 V×H, and 33 pure HO cows.

Sires of cows in this analysis were selected for use from 2008 to 2011, which is 5 to 8 years ago. The following list of bulls had at least 45 daughters analyzed for production for the

Montbeliarde, Viking Red, and HO breeds, and their daughters comprised 78% of the Montbeliarde-sired cows, 79% of the Viking Red-sired cows, and 44% of the pure HO cows. The most frequent sires of M×H cows were Plumitif (112), Patinage (93), Micmac (75), Papayou (66), and Redon (53). The most frequent sires of V×H cows were Orraryd (95), B Jurist (91), O Brolin (74), Peterslund (67), Sörby (56), and Gunnarstorp (46). The most frequent sires of pure HO cows were Michael (117), Million (97), Moscow (74), Elias (52), Plato (47), and Colby (45). The average birth year for the sires of cows by breed group was 1999 for both the M×H and V×H crossbreds, but was 4 years younger (2003) for the pure HO cows. Therefore, the sires of the pure HO females in this study likely had an advantage for genetic level respective to breed.

For the analysis of 305-day production for first lactations, production was calculated from monthly test day records from milk recording, and reported on an **actual** basis (not as mature equivalent). Cows milking longer than 305 days were limited to the first 305 days. Some cows became pregnant quickly after calving, which resulted in lactation length shorter than 305 days, or they left the herd prior to 305 days in milk. Production for these cows was projected to 305 days. All 8 herds routinely milk most of their cows 3 times daily; however, 4% of test-day observations were for cows milked 2 times per day on specific test days. The breed groups did not differ for percentage of observations that were from 2-time or 3-time daily test-days. All cows were required to have observations from at least 2 test days to be included in the production analysis.

Cows bred to bulls that did not follow the rotational mating design were excluded for the analysis of calving traits and fertility. Also, cows sold for dairy purposes during first lactation were removed from the survival analysis. Days open were assigned a maximum of 250 days, which is commonly done so extremely long calving intervals for a small number of cows do not unfairly impact results. Three seasons of calving were defined as January to April, May to August, and September to December within each herd. Cows that calved during seasons within a herd with fewer than 3 crossbred and 3 pure HO cows were removed from the analysis for each trait. Number of cows analyzed varied somewhat for the individual traits.

All traits were analyzed using statistical models that accounted for effects of herd-year-season in which each cow calved, as well as the breed group of cow (M×H, V×H, or pure HO). Also, the statistical model accounted for sire effects within breed. Sex of calf was included only for the calving traits. Effect of service sire was included for the calving and fertility traits.

Statistical analysis provides probability values, which measure the likelihood that differences reported are large enough to be taken seriously. In the tables that follow, the probability of $P < 0.05$ (symbolized with 1 asterisk) indicates an observed difference has 95% certainty of being real rather than due to chance. Similarly, a $P < 0.01$ (symbolized with 2 asterisks) indicates an observed difference has 99% certainty of being real rather than due to chance. No asterisk indicates that differences may be due to chance only.

Results

Production

Breed groups were essentially identical for age at first calving (Table 1). Production of fluid volume of milk was not statistically different for M×H and pure HO cows. However, M×H cows had significantly more protein (+3%) and fat + protein production (+3%) than pure HO cows. The V×H cows had significantly less fluid volume production than pure HO cows. However, although numerically higher, V×H cows (1,651 lb) were statistically similar to their pure HO herdmates (1,633 lb) for fat + protein production, which was due to their higher percentages of fat and protein in their milk.

The majority of U.S. dairy herds are paid for the solids in milk rather than the fluid carrier of those solids. To repeat, the M×H crossbreds produced significantly higher milk solids (lbs.) than their pure HO herdmates in this study, and the V×H cows had no loss of solids (lbs.) than their pure HO herdmates during the first 305 days of first lactation. Somatic cell score did not differ significantly for the breed groups; however, problems with mastitis are more common for cows during second and later lactations than during first lactation.

Table 1. Production (*actual* and not mature equivalent) during the first 305 days of first lactation for M×H and V×H crossbreds compared to pure HO cows.

Trait	Holstein	Montbeliarde × Holstein	Viking Red × Holstein
Number of cows	978	513	540
Age at calving (months)	23.9	23.8	23.7
Milk (lb)	24,185	24,150	23,229**
Fat (lb)	900	920	910
% Fat	3.74	3.83	3.93**
Protein (lb)	733	756**	740
% Protein	3.05	3.14**	3.19**
Fat + Protein (lb)	1,633	1,676*	1,651
Somatic cell score	2.1	2.2	2.1

***** Significant difference ($P < 0.05$) from pure Holsteins.

****** Significant difference ($P < 0.01$) from pure Holsteins.

It's important to note the analysis for production did not adjust for differences in pregnancy status (fertility) between the breed groups and, on average, the crossbred cows calved sooner with their second calves than did the pure HO cows. Because of this advantage for fertility, the crossbred cows also returned to peak production more quickly with second calving than did their pure HO herdmates.

Calving traits

First lactation cows tend to have low twinning rates compared to older cows, and no difference was detected between breed groups for twinning rate in this study (Table 2). Gestation length

was significantly longer for both M×H cows (bred to Viking Red A.I. bulls) and V×H cows (bred to Montbeliarde A.I. bulls) than pure HO cows. This result was expected because gestation length is a determined by the genetics of the calf, and the 3-breed crossbred calves had either 25% or 50% Montbeliarde content. The Montbeliarde breed (like its "cousin" breeds of Brown Swiss and Fleckvieh) averages 7 days longer for gestation length than the other major breeds of dairy cattle.

Calving difficulty was subjectively scored within herds from 1 to 5, with 1 as "no assistance" and 5 as "extremely difficult." Calving difficulty was significantly greater (+0.2) for V×H cows giving birth to Montbeliarde-sired calves, but the difference resulted from the greater difficulty for bull calves because heifer calves born from V×H cows had least calving difficulty, numerically, among all breed groups.

Table 2. Twinning rate, gestation length, calving difficulty score (1-5 scale), and stillbirth rate during first lactation for M×H and V×H crossbreds compared to pure HO cows.

Trait	Holstein (HO service sire)	Montbeliarde × Holstein (VR service sire)	Viking Red × Holstein (MO service sire)
Number of cows	971	496	508
Twinning rate (%)	1.0	0.6	0.8
Number of cows	961	493	504
Gestation length (days)	276	279**	280**
Calving difficulty-All	1.5	1.6	1.7*
Calving difficulty-Females	1.4	1.4	1.3
Calving difficulty-Males	1.6	1.7	2.1**
Stillbirth rate-All (%)	9	4*	5†
Stillbirth rate-Females (%)	6	2*	3
Stillbirth rate-Males (%)	11	7	8

† Tendency for significant difference ($P < 0.10$) from pure Holsteins.

* Significant difference ($P < 0.05$) from pure Holsteins.

** Significant difference ($P < 0.01$) from pure Holsteins.

As expected, bull calves had greater stillbirth rates than heifer calves for each of the breed groups. Both crossbred groups had lower stillbirth rates compared to the pure HO cows. Despite greater calving difficulty compared to pure HO calves, the Montbeliarde × (V×H) bull calves (8%) were not higher for stillbirth rate than the pure HO bull calves (11%). Clearly, the greater calving difficulty of these crossbred bull calves did not negatively impact stillbirth rate. This result was not anticipated, because calving difficulty typically has a positive relationship with stillbirth rate within breeds. The possible explanations for what seems like conflicting results for calving difficulty and stillbirth rate are: a) workers may have provided calving assistance too quickly based on perceived size of calf (i.e., circumference of exposed calf feet), b) higher calving difficulty scores may have been subjectively assigned to larger calves after birth

regardless of actual difficulty, and c) the Montbeliarde × (V×H) crossbred calves have genetic superiority for livability compared to pure HO calves.

Dairy producers are accustomed to stillbirth rates in excess of 8% for pure HO calves. Applying a fixed value of $500 to all live calves, the advantage of 4% to 5% more live calves for the crossbreds equates to more than $22,000 additional profit from the 997 crossbred calves in this study. Also, in most instances, crossbred bull calves sell for a premium price compared to pure HO bull calves.

Body condition and conformation

Body condition and conformation traits (Table 3) were scored once between 2 and 110 days after calving (average of 32 days) during first lactation. Both crossbred groups maintained significantly more body condition than the pure HO cows and, as expected, the difference was greater for the M×H cows. Previous research has documented an increase in body condition of crossbred cows compared to pure HO cows provides advantages for fertility. Both crossbred groups also had significantly less stature than pure HO cows as well as less body depth, which may lead to fewer health complications. Many dairy producers are unpleased with the continuous trend with time of taller stature of pure HO cows. Deep-bodied cows are documented to have greater frequency of displaced abomasum than shallow-bodied cows. Also, the M×H crossbreds had significantly more strength than both the V×H and pure HO cows.

Table 3. Body condition score (1 to 5 scale) and conformation scores (1 to 9 scale) during first lactation for M×H and V×H crossbred cows compared to pure HO cows.

Trait	Holstein	Montbeliarde × Holstein	Viking Red × Holstein
Number of cows	956	502	538
Body Condition Score	3.20	3.70**	3.45**
Number of cows	983	510	541
Stature (9 = taller)	5.4	4.6**	3.8**
Body depth (9 = deeper)	5.2	4.2**	4.5**
Strength (9 = wider)	5.3	6.8**	5.2
Rump angle (9 = more slope)	6.1	7.0**	6.6**
Legs set (9 = more sickle)	5.6	4.6**	6.1**
Foot angle (9 = steeper)	5.6	6.6**	5.4
Udder depth (9 = shallower)	6.9	5.5**	6.2**
Front teat width (9 = closer)	5.5	4.5**	5.1*
Rear teat width (9 = closer)	6.5	5.4**	5.9**
Teat length (9 = longer)	3.9	4.6**	4.0

* Significant difference ($P < 0.05$) from pure Holsteins.

** Significant difference ($P < 0.01$) from pure Holsteins.

For legs and feet, the M×H cows had significantly less set to the hock than pure HO cows, and the V×H cows had significantly more set to the hock than pure HO cows. The V×H cows did not differ from the pure Holsteins for foot angle, but the M×H cows had significantly steeper foot angle than either V×H or pure HO cows. Also, both crossbred groups had more slope to their rump, which is generally associated with improved functionality.

Among the key udder traits, the M×H and V×H cows had significantly deeper udders than pure HO cows early in first lactation. The difference in udder depth score (1.4 points) between M×H and pure HO cows is equivalent to about 1.4 inches. Also, the M×H and V×H cows had wider rear teat placement than the pure HO cows, and the M×H cows had significantly longer teat length than pure HO cows during first lactation.

During recent years, dairy producers have identified close rear teats and very short teats as functional problems of pure HO cows, especially for robotic milking systems. Apparently, differences in udder characteristics between the breed groups of cows in these 8 dairy herds was not critical for functionality, because culling for udder conformation was not different ($P > 0.75$) for the breed groups.

Fertility

Not surprisingly, both crossbred groups were superior to the pure HO cows for fertility during first lactation (Table 4). The vast majority of cows during the years of the study were bred as a result of synchronized first services; therefore, there was little difference between the breed groups for days to first breeding. That said, the M×H cows were bred 2 days earlier than pure HO cows during first lactation.

Table 4. Fertility during first lactation for M×H and V×H crossbred cows compared to pure HO cows.

	Holstein		Montbeliarde × Holstein		Viking Red × Holstein	
Trait	n	Estimate	n	Estimate	n	Estimate
Days to first breeding	970	71	507	69*	539	70
First service conception rate (%)	948	38	499	43	528	47**
Overall conception rate (%)	950	38	499	46**	528	43†
Times bred (up to 5)	959	2.30	506	2.07**	537	2.15
Days open	901	125	480	113**	514	117*

n = Number of cows.

† Tendency for significant difference ($P < 0.10$) from pure Holsteins.

* Significant difference ($P < 0.05$) from pure Holsteins.

** Significant difference ($P < 0.01$) from pure Holsteins.

The V×H cows had significantly higher first service conception rate (+9%) than the pure HO cows. However, the M×H crossbreds had higher conception rates (46%) than the pure HO cows (38%) across the first 5 inseminations. Also, the M×H cows were inseminated significantly fewer times (2.07) than the pure HO cows (2.30). Lastly, both M×H and V×H crossbreds had

significantly fewer days open during first lactation than their pure HO herdmates with 12 fewer days open for the M×H cows and 8 fewer days for the V×H cows.

However, it is important to keep in mind that days open were not allowed to surpass 250 days for individual cows for this analysis; therefore, differences between breed groups for days open are conservative because a higher percentage of pure HO cows had days open greater than 250 days.

Survival

The survival of cows to 60 DIM was similarly high (96% to 97%) for all breed groups (Table 5) indicating, regardless of breed, the young cows transitioned well into first lactation in the well-managed herds in this study.

A significantly higher proportion of the crossbred cows calved again within 14 months after first calving (+9% and +7% for the M×H and V×H crossbreds, respectively) than the pure HO cows. In addition, significantly more of the M×H crossbreds (+7%) initiated a second lactation within 17 months after first calving compared with their pure HO herdmates. Therefore, the crossbred cows returned to peak milk production sooner after first calving than did their pure HO herdmates.

Table 5. Survival during first lactation for M×H and V×H crossbred cows compared to the pure HO cows.

	Holstein		Montbeliarde × Holstein		Viking Red × Holstein	
Trait	n	Estimate	n	Estimate	n	Estimate
Survival to 60 DIM (%)	1033	96	536	96	560	97
2nd calving within 14 months (%)	1021	63	530	72**	552	70*
2nd calving within 17 months (%)	1021	76	529	83**	551	81†
Survival to 2nd calving (%)	1014	80	529	84	551	83

n = Number of cows.

† Tendency for significant difference ($P < 0.10$) from pure Holsteins.

* Significant difference ($P < 0.05$) from pure Holsteins.

** Significant difference ($P < 0.01$) from pure Holsteins.

Additional cows in each breed calved after 17 months in first lactation and, when the 2-breed crossbreds were combined, a significantly greater proportion of combined crossbreds (84%) survived to a second calving compared with pure HO cows (80%).

Key conclusions

- M×H cows produced 3% more actual fat plus protein production (lbs.) during the first 305 days of their first lactations than their pure HO herdmates, and V×H cows were similar (+1% numerically) to pure HO cows for fat plus protein production (lbs.).

- No differences were detected between breed groups for SCS. Udder health problems tend to surface more during second and later lactations than during first lactation.

- Crossbred cows had 3 to 4 days longer gestation length, which was expected for a crossbreeding rotation that includes an "Alps breed," such as Montbeliarde.

- Calving difficulty of Viking Red-sired calves born to M×H cows was similar to pure HO calves; however, Montbeliarde-sired bull calves born to V×H cows scored +0.5 points higher for calving difficulty than pure HO bull calves.

- The 3-breed crossbred calves had a lower stillbirth rate (4% to 5%) compared to pure HO calves (9%) when born to first-lactation dams.

- The M×H and V×H cows had greater body condition (+0.50 and +0.25, respectively), shorter stature, and less body depth during early first lactation than the pure HO herdmates.

- Both crossbred groups had greater udder depth than their pure HO herdmates; however, M×H and V×H cows had more ideal rear teat placement than pure HO cows. The M×H cows also had longer teats than the pure HO cows. No difference was observed between breed groups for culling due to udder conformation during first lactation.

- All measures of fertility favored the two crossbred groups during first lactation, and the magnitude of the difference was 8 fewer days open (V×H cows) to 12 fewer days open (M×H cows) compared to the pure HO cows.

- Significantly more combined crossbred cows (+4%) survived to a second calving compared to their pure HO herdmates.

Discussion

The 2-breed crossbreds were competitive with their pure HO herdmates during first lactation and certainly met the performance expectations of these high-producing dairies in Minnesota. Economic return of the crossbreds versus the pure HO hasn't yet been assessed. In the future, the total profit over lifetimes of cows in the breeding groups, including costs of health treatments, will be compared. However, results from first lactation suggest the M×H and V×H cows should be more profitable than their pure HO herdmates because they gave birth to more live calves, required less reproductive cost, and had higher survival rates. Furthermore, the crossbreds produced at least as much milk solids (lbs.) as their pure HO herdmates and returned to peak production sooner for their second lactations.

The ProCROSS 3-breed rotational crossbreeding program should create a very stable herd because, over generations, cows will have the blended characteristics of the Holstein, Montbeliarde, and Viking Red breeds. Therefore, results for the 2-breed crossbred cows in this study represent a unique generation that dairy herds experience only once as a first step in their transition to the ProCROSS program. However, the performance of 2-breed crossbreds provides an indication of profitability for future generations of 3-breed ProCROSS dairy cattle. Therefore, future generations of crossbred cows that have a blended composition of the 3 breeds are needed to fully assess the merit of the ProCROSS program in these 8 herds.

Acknowledgements

The authors express gratitude to the owners/managers of the 8 dairies for their participation in this study and for providing data on the cows in their herds. The authors also wish to thank Minnesota Select Sires Co-op, Inc. for its contributions of mating individual heifers and cows with A.I. bulls and the scoring of conformation traits. Funding for this project was provided by Coopex Montbeliarde, France; Viking Genetics, Denmark; Creative Genetics of California; Select Sires, Inc., Ohio; and Minnesota Select Sires Co-op, Inc.