Short communication: Jersey × Holstein crossbreds compared with pure Holsteins for production, mastitis, and body measurements during the first 3 lactations

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ABSTRACT

Jersey (JE) × Holstein (HO) crossbred cows ($n = 76$) were compared with pure HO cows ($n = 73$) for 305-d milk, fat, and protein production, somatic cell score (SCS), clinical mastitis, lifetime production, and body measurements during their first 3 lactations. Cows were in 2 research herds at the University of Minnesota and calved from September 2003 to June 2008. Best prediction was used to determine actual production for 305-d lactations as well as lifetime production (to 1,220 d in the herd after first calving) from test-day observations. During first lactation, JE × HO cows and pure HO cows were not significantly different for fat plus protein production; however, JE × HO cows had significantly lower fat plus protein production during second (-25 kg) and third (-51 kg) lactation than pure HO cows. Nevertheless, JE × HO cows were not significantly different from pure HO cows for lifetime production or lifetime SCS. The JE × HO cows were not significantly different from pure HO cows for SCS and clinical mastitis during first and second lactations; however, JE × HO cows tended to have higher SCS (3.79) than pure HO cows (3.40), but significantly lower (-23.4%) clinical mastitis during third lactation. The JE × HO cows had significantly less hip height, smaller heart girth, less thurl width, and less pin width than pure HO cows during the first 3 lactations. Furthermore, JE × HO cows had significantly less udder clearance from the ground and significantly greater distance between the front teats than pure HO cows during their first 3 lactations.

Key words: crossbreeding, mastitis, somatic cell

Crossbreeding of dairy cattle is a topic of growing interest around the world because of dairy producer concerns regarding calf survival, cow fertility, and cow health of pure Holstein (HO) cattle (Funk, 2006). Over the past decade, Jersey (JE) was often the first breed

of choice for crossbreeding with the HO breed in the United States because the JE breed has the second largest number of cows in the country after the HO breed (VanRaden et al., 2007). Furthermore, many dairy producers have strategically mated JE bulls to HO virgin heifers to reduce calving difficulty and lower stillbirth rates (Weigel and Barlass, 2003).

Heins et al. (2008) reported on the production, SCS, and body and udder measurements of JE × HO cows compared with pure HO cows during only first lactations in experimental herds at the University of Minnesota. The present study compares the same JE × HO crossbred and pure HO cows during second and third lactation, and assesses the development of the 2 genetic groups of cows beyond first lactation. Specifically, the objectives of this study were to determine differences between JE × HO cows and pure HO cows during their first 3 lactations and for lifetimes for 305-d milk, fat, and protein production, and SCS. Additionally, incidence of clinical mastitis and body and udder measurements were compared.

The research dairy on the St. Paul campus of the University of Minnesota has 90 tiestalls and a 40-head compost barn, and the West Central Research and Outreach Center in Morris, Minnesota, has a 150-head, low-input grazing system. The 2 research herds have shared a crossbreeding design since 2000. To initiate crossbreeding, pure HO heifers and cows were randomly assigned to either the crossbred or pure HO lines at both locations. All JE × HO crossbred heifers and cows, which were born from 2001 to 2003, were mated to Montbeliarde AI bulls during their lifetime. The design of the experiment was thoroughly reviewed and genetic levels for sires of cows and the number of daughters of sires was provided in Heins et al. (2008). All AI bulls were greater than the 90th percentile for net merit within breed at the time of selection; however, the JE × HO cows were somewhat disadvantaged compared with pure HO cows for rank of sires for net merit respective to breed at the conclusion of the study. Furthermore, Heins et al. (2008) provided a detailed description of heifers born and raised, and number of

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cows calving a first time, and reported results only for first lactation. The current study analyzed data for the first 3 lactations up to 1,220 d after first calving for 76 JE × HO cows and 73 pure HO cows. All cows in the study were allowed to calve at least 3 times and had at least a partial third lactation; subsequently, some cows were voluntarily culled for dairy purposes. Therefore, performance only during the first 3 lactations of cows was compared.

Cows at both St. Paul and Morris calved seasonally, and all heifers from both locations were reared and mated at Morris. At St. Paul, calvings were mostly in the fall, whereas at Morris, calvings were mostly in the spring. Season of calving was defined as spring (March to July) or fall (September to February). Seasons containing fewer than 5 calvings for each breed group were combined (fall season with following spring season) at Morris.

Standard edits were applied to test-day observations for production and SCS; the edits were similar to those used by the USDA for routine genetic evaluation and are described in Heins et al. (2006). All cows in the study were milked twice daily. Actual milk, fat, and protein production and SCS for 305-d lactations were calculated with best prediction (Cole et al., 2009), which was implemented by the USDA in February 1999 for national genetic evaluation in the United States (VanRaden, 1997). Lactation records were adjusted for age at calving, and lactations less than 305 d were projected to 305 d. Best prediction was applied separately to each of the 2 herds in this study to calculate 305-d actual lactations for production. Incidence of clinical mastitis was recorded in a binary manner as treated (1) or not treated (0) during a lactation.

For statistical analysis of 305-d milk, fat, and protein production, fat plus protein production, SCS, and clinical mastitis, independent variables were effects of herd, calving season nested within herd, breed group, and parity nested within breed group, along with cow nested within breed group as a random effect. The MIXED procedure of SAS (SAS Institute, 2008) was used to obtain solutions and conduct the ANOVA. The GLIMMIX procedure of SAS was used to determine the statistical significance for clinical mastitis because it is a binary trait. Preliminary analysis for the production traits indicated interaction of herd and breed group was not significant ($P > 0.05$), so the interaction was removed from the models for production.

Best prediction may provide daily production from test-day observations up to 999 DIM for any lactation of a cow (Cole et al., 2009); therefore, best prediction was also used to predict production on each day of lactation, and daily production was summed across lactations to determine lifetime production. Lifetime

Table 1. Number of observations, least squares means, and standard errors of means for 305-d actual production, SCS, and incidence of mastitis during the first 3 lactations for pure Holstein (HO) versus Jersey (JE) × Holstein crossbred cows

Trait	First lactation			Second lactation			Third lactation		
	Pure HO (n = 73)		Mean difference	JE × HO (n = 76) ¹		SE	Pure HO (n = 55)		Mean difference
	Mean	SE		Mean	SE		Mean	SE	
Milk, kg	7,905	195		9,421	143		9,803	203	
Fat, kg	279	7	–544**	336	5		357	7	–1,273**
Protein, kg	247	6	–10*	294	4		302	6	–21**
Fat plus protein, kg	526	12	–8	630	9		660	12	–29**
SCS	2.91	0.21	0.14	2.87	0.15		3.40	0.22	–51**
Mastitis incidence, %	27.7	9.5	3.4	59.7	7.1		71.6	10.0	0.39†
									–23.4*

¹Least squares means for Jersey × Holstein crossbred cows are expressed as a difference from pure Holsteins.

† $P < 0.10$; * $P < 0.05$; ** $P < 0.01$ for difference from pure Holsteins.

Table 2. Number of observations, least squares means, and standard errors of means for lifetime production and SCS during the first 3 lactations for pure Holstein versus Jersey × Holstein crossbred cows

Trait	Pure Holstein (n = 73)		Jersey × Holstein (n = 76) ¹	
	Mean	SE	Mean difference	SE
Lifetime milk, kg	21,447	1,021	−2,253	1,001
Lifetime fat, kg	775	38	−37	37
Lifetime protein, kg	680	33	−57	32
Lifetime fat + protein, kg	1,455	71	−94	69
Lifetime SCS	3.10	0.09	0.16	0.08

¹Least squares means for Jersey × Holstein crossbred cows are expressed as a difference from pure Holsteins. Mean lifetime days for pure Holstein cows was 866; mean lifetime days for Jersey × Holstein cows was 898.

was defined as the time from the date of first calving up to 1,220 d (3.34 yr) in the herd after first calving. For lifetime production, cows with lactations shorter than 305 d were not projected to 305 d and all production beyond 305 d in lactation was included. Milk, fat, and protein production was summed across lactations for each cow, and mean SCS for all test days of cows was defined as lifetime SCS. Most cows in this study remained at either St. Paul or Morris for their lifetimes; however, 11 JE × HO cows and 12 HO and were moved from Morris to St. Paul to facilitate other research studies. Therefore, a covariable was used for percentage of lifetime at St. Paul. The mean lifetime was 898 d for JE × HO crossbred cows and 866 d for pure HO cows.

For statistical analysis of lifetime milk, fat, protein, and fat plus protein production and SCS, the independent variables were effects of breed group and the covariable for percentage of lifetime at St. Paul. The general linear model procedure of SAS (SAS Institute, 2008) was used to obtain solutions and conduct the ANOVA. Preliminary analysis indicated season effect of first calving was not significant ($P > 0.05$), so it was removed from the model.

Body measurements were hip height, heart girth, thurl width, pin width, rump angle, foot angle, foot length, rear udder height, rear udder width, udder clearance from the ground, front teat width, and front teat length. Body measurements were recorded on cows between 6 and 343 d postpartum. For statistical analysis of all body measurements the independent variables were the fixed effects of herd, season nested within herd, breed group, and parity nested within breed group, with DIM at time of measurement as a covariable. Cow nested within breed group was a random effect and the MIXED procedure of SAS (SAS Institute, 2008) was used to obtain solutions and conduct the ANOVA. Preliminary models for analysis of each body measurement included the quadratic effect of DIM and the interaction effect of herd and breed group; however, neither effect was

significant ($P > 0.05$), hence both effects were removed from the models.

Least squares means and standard errors of means for 305-d production, SCS, and clinical mastitis for JE × HO cows compared with pure HO cows during their first 3 lactations are given in Table 1. Milk volume was significantly ($P < 0.01$) lower for JE × HO cows during all 3 lactations compared with pure HO cows. The JE × HO cows had significantly lower fat production than pure HO cows only during third lactation, and the JE × HO cows had significantly lower protein production during all 3 lactations than pure HO cows. For fat plus protein production, JE × HO cows and pure HO cows were not significantly different ($P = 0.42$) for fat plus protein production during first lactation. On the other hand, JE × HO cows had significantly lower fat plus protein production in second lactation (−25 kg) and significantly lower fat plus protein production in third lactation (−51 kg) than pure HO cows.

Least squares means for SCS were not significantly different for JE × HO cows compared with pure HO cows during first and second lactation. However, JE × HO cows tended ($P = 0.09$) to have higher SCS (3.79 versus 3.40) during third lactation than pure HO cows. During first and second lactation, JE × HO cows and pure HO cows were not significantly different for clinical mastitis; however, during third lactation, JE × HO cows had significantly less clinical mastitis (48.2% vs. 71.6%) than pure HO cows. Heterosis from crossbreeding should improve the health of cows; however, JE × HO cows and pure HO cows were significantly different for clinical mastitis only during third lactation.

In what appears to be a contradiction, third-lactation JE × HO cows in this study tended to have higher SCS but less clinical mastitis than pure HO cows. The explanation for higher SCS but lower clinical mastitis is unknown; however, JE cattle have a higher breed average for SCS than HO in the United States, which likely contributed to the increase in SCS of the JE × HO

Table 3. Number of observations, least squares means, and standard errors of means for body measurements during the first 3 lactations for pure Holstein (HO) versus Jersey (JE) × Holstein crossbred cows

Trait	Direction of positive	First lactation				Second lactation				Third lactation			
		Pure HO (n = 71)		JE × HO (n = 74) ¹		Pure HO (n = 54)		JE × HO (n = 61) ¹		Pure HO (n = 35)		JE × HO (n = 49) ¹	
		Mean	SE	Mean difference	SE	Mean	SE	Mean difference	SE	Mean	SE	Mean difference	SE
Hip height, cm	Taller	142.2	0.8	−8.8**	0.8	144.5	0.5	−9.4**	0.5	144.9	0.8	−9.1**	0.7
Heart girth, cm	Larger	190.4	1.5	−9.5**	1.5	196.9	1.0	−9.9**	1.0	202.4	1.4	−11.4**	1.4
Thurl width, cm	Wider	50.3	0.4	−3.9**	0.4	52.3	0.3	−3.7**	0.3	53.7	0.4	−4.1**	0.4
Pin width, cm	Wider	12.3	0.3	−1.2**	0.3	12.4	0.2	−1.3**	0.2	12.7	0.3	−1.8**	0.3
Rump angle, cm	Sloped	3.3	0.6	0.4	0.6	2.3	0.4	1.5**	0.4	2.6	0.6	1.5*	0.6
Foot angle, °	Steeper	46.4	0.9	−1.8*	0.8	42.1	0.7	−1.4	0.6	40.7	0.9	−1.3	0.9
Foot length, cm	Longer	7.2	0.1	0.2	0.1	7.9	0.1	−0.1	0.1	8.3	0.1	−0.6**	0.1

¹Least squares means for Jersey × Holstein crossbred cows are expressed as a difference from pure Holsteins.

* $P < 0.05$; ** $P < 0.01$ for difference from pure Holsteins.

Table 4. Number of observations, least squares means, and standard errors of means for udder measurements during the first 3 lactations for pure Holstein (HO) cows versus Jersey (JE) × Holstein crossbred cows

Trait	Direction of positive	First lactation				Second lactation				Third lactation			
		Pure HO (n = 71)		JE × HO (n = 74) ¹		Pure HO (n = 54)		JE × HO (n = 61) ¹		Pure HO (n = 35)		JE × HO (n = 49) ¹	
		Mean	SE	Mean difference	SE	Mean	SE	Mean difference	SE	Mean	SE	Mean difference	SE
Rear udder height, cm	Lower	13.9	0.6	0.0	0.6	14.5	0.4	0.5	0.4	16.1	0.6	0.3	0.6
Rear udder width, cm	Wider	11.2	0.4	−0.4	0.4	12.3	0.3	−0.2	0.3	12.5	0.4	−0.8†	0.4
Udder clearance, cm	Shallower	54.8	0.9	−7.0**	0.9	51.4	0.6	−9.0**	0.6	48.9	0.9	−8.5**	0.8
Front teat width, cm	Wider	14.0	0.8	1.7**	0.8	14.7	0.6	2.3**	0.5	15.6	0.8	2.1**	0.7
Teat length, cm	Longer	4.4	0.2	0.1	0.1	4.6	0.1	0.2	0.1	5.0	0.2	0.1	0.2

¹Least squares means for Jersey × Holstein crossbred cows are expressed as a difference from pure Holsteins.

† $P < 0.10$; ** $P < 0.01$ for difference from pure Holsteins.

cows. Nonetheless, research has shown that pure JE cows may have a different immune response to clinical mastitis than pure HO cows (Bannerman et al., 2008), and several studies have indicated that pure JE cows have lower clinical mastitis incidence than pure HO cows (Morse et al., 1987; Washburn et al., 2002; Berry et al., 2007).

Percentage of time at St. Paul significantly explained variation for lifetime production of milk, fat, protein, and fat plus protein, but not lifetime SCS. As expected, the high-input management system at St. Paul resulted in higher production than the low-input management system at Morris. Least squares means and standard errors of means for JE × HO cows and pure HO cows for lifetime production are provided in Table 2. The JE × HO cows were not significantly ($P > 0.05$) different from pure HO cows for lifetime milk, lifetime fat, lifetime protein, or lifetime fat plus protein production, and JE × HO cows and pure HO cows were not significantly different ($P > 0.05$) for lifetime SCS. The lifetime production for JE × HO cows and pure HO cows in this study is lower than found on many commercial dairies in the United States (Kuhn et al., 2006) because 56% of the cows spent their total lifetime at Morris, which is a low-input production system.

Results for body measurements are given in Table 3; the JE × HO cows had significantly smaller hip height (about 9 cm) and significantly smaller heart girth during all 3 lactations than pure HO cows. Furthermore, JE × HO cows had significantly smaller thurl width than pure HO cows during first (−3.9 cm), second (−3.7 cm), and third (−4.1 cm) lactation, and significantly smaller pin width than pure HO cows during first (−1.2 cm), second (−1.3 cm), and third (−1.8 cm) lactation. Reduction in body size of cows may be a good strategy for dairies with small stall sizes; however, smaller body size may create problems with milking parlor efficiency and cleanliness of stalls in a commercial dairy designed for large-framed cattle.

For rump angle, JE × HO cows and pure HO cows were not significantly different during first lactation, but JE × HO cows had significantly greater rump angle (more slope) during second and third lactation compared with pure HO cows. Also, JE × HO cows had significantly less foot angle than pure HO cows during first lactation; however, JE × HO cows and pure HO cows were not significantly different during second and third lactation for foot angle. The JE × HO cows and pure HO cows were not significantly different in first and second lactation for foot length; however, JE × HO cows had significantly less foot length than pure HO cows during third lactation.

Least squares means for udder traits are given in Table 4; the JE × HO cows and pure HO cows had

significantly less udder clearance than the pure HO cows during first (−7.0 cm), second (−9.0 cm), and third (−8.5 cm) lactation. Moreover, JE × HO cows had significantly greater front teat width (about 2 cm) during the 3 lactations compared with pure HO cows; however, JE × HO cows and pure HO cows did not differ significantly for teat length. Significantly more ($P < 0.05$) of the JE × HO cows (6 of 76) versus HO cows (0 of the 73) were culled for udder conformation.

The JE × HO cows in some countries, especially New Zealand, have perceived advantages over pure HO cows for profitable dairying because of their smaller body size, higher milk fat and protein composition, superior fertility for seasonal calving, and enhanced foraging ability in pastoral settings. Furthermore, the reduced body size of cows containing JE influence should result in less damage to grass paddocks. With lower daily production in New Zealand, JE × HO cows may have fewer issues with udder conformation than the JE × HO cows in the experimental herds in this study or other dairies with higher daily production than in New Zealand.

Results of this study suggest numerous shortcomings of JE × HO cows, especially at medium to high production levels by global standards. The reduced production of fat plus protein during second and third lactations of JE × HO cows compared with HO cows would negatively affect dairying profitability. Furthermore, udders are important for functional milk production and, compared with other dairy cattle breeds, JE cows have proportionately larger udders in relation to their body size. The higher frequency of JE × HO cows than HO cows culled for udder conformation in this study would be unwelcome by dairy producers. Therefore, dairy producers must carefully choose a breed, multiple breeds, or crosses among breeds that are optimal for conditions unique to their dairy operations, considering climate, facility design, nutritional regimens, reproductive protocols, and low-input versus high-input management.

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