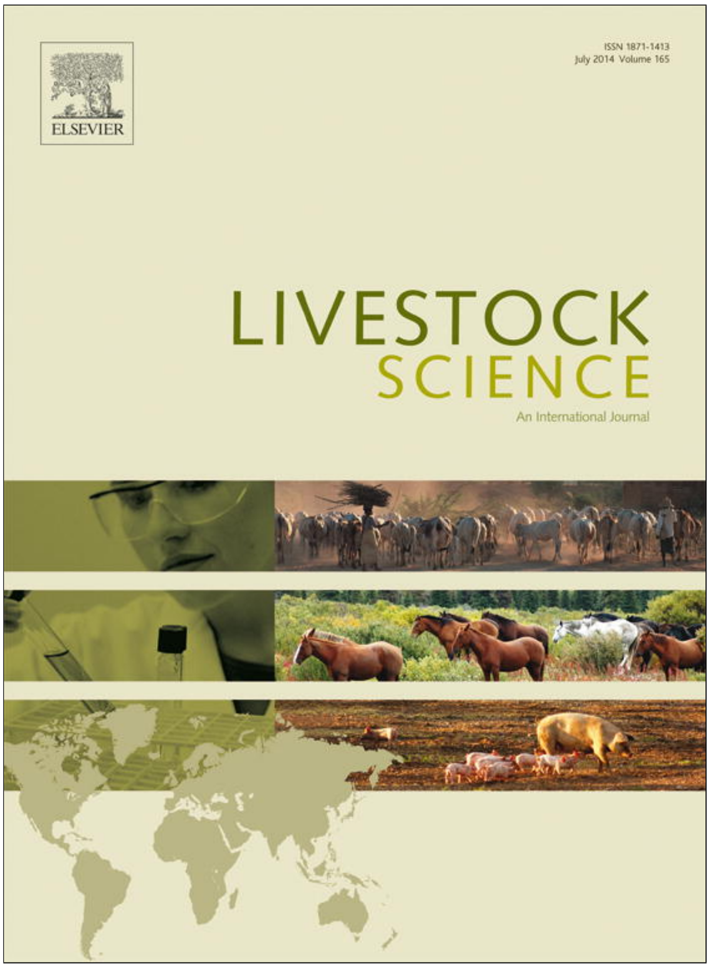
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Short communication

Productive and reproductive performance of first lactation purebred Holstein versus Swedish red & white × Holstein in central Argentina

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ABSTRACT

The aim of this work was to compare productive and reproductive performance between pure Holstein (H) and Swedish Red & White × Holstein crossbred (SRB/H) in first lactation dairy cows from the central region of Argentina. This study included 450 lactations from a commercial dairy of central-southern Argentina. The differences in mean daily milk yield, days to first breeding (DFB) and number of services per pregnancy (NS/P) between genotypes were evaluated. A Cox proportional hazard regression model was fitted to evaluate the breed effects on days open (DO) and adjusting by calving season and calving year. Days open were estimated trough survival curves for H breed and SRB/H crossbred using Kaplan–Meier method. Finally, average lactation curves were modeled for each genotype using a non-linear mixed model. Daily milk yield was not significantly different between genotypes. However, the cumulative 305-d yield and peak milk yield for pure H was higher than for SRB/H. Days to first breeding was lower for SRB/H than pure H. The NS/P was higher for pure H than for SRB/H. Regarding DO, SRB/H breed had 1.00–1.71 higher likelihood to become pregnant than pure H. Days open of 50% of pure H was 30 d higher than for SRB/H. The results showed that SRB/H crossbred were superior to pure H in terms of reproductive performance but inferior in terms of productive performance. Further studies may help to determine if the economics of dairying justifies the use of crossbreeding as a herd fertility enhancing tool.

1. Introduction

A decrease in fertility over time has been reported for Holstein cows (de Vries and Risco, 2005), being associated with an increase in milk production (Pryce and Harris, 2004). Hansen (2000) concluded that improvements in milk production through continuous genetic selection have a negative effect on reproduction and suggested that different management practices should be strengthened, with crossbreeding being a viable alternative that is routinely used in other food-producing species. Lucy (2001) suggested that high production, larger herd size, reduced cow health and increased inbreeding might be

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contributing to declining reproductive performance in Holsteins.

Several studies have documented the potential of using crossbreeding in the dairy industry (Touchberry, 1992; McAllister et al., 1994). The benefits of using crossbreds over purebreds would result in shorter breeding period, fewer days open, larger proportion of cows that complete one or more lactations, and higher conception rates. Weigel and Barlass (2003) found fertility, calving ease and milk composition as further advantages of crossbreeding. Heins et al. (2006b) concluded that inbreeding depression has a direct effect on fertility rates, health and survival, also stating that the use of heterosis through crossbreeding should result in a 6.5% bonus for production and at least 10% for fertility, disease resistance, and survival in dairy cows. Swalve (2007) documented longer productive life and higher fertility with Swedish Red & White/Holstein crossbred and Brown Swiss/Holstein than with pure Holsteins. The Swedish Red breed is evaluated by the Nordic total merit (NTM) index since 1972. Breeding decisions based on the NTM Index aims for a high genetic capacity for yield, health, fertility and conformation resulting in productive and long-lasting cows. The aim of this work was to compare productive and reproductive performance between pure Holstein (H) and Swedish Red & White/Holstein crossbred (SRB/H) cows.

2. Materials and methods

2.1. Data

The data set used included 450 first lactations from a commercial dairy collected in three years (2008–2010) from central-southern Argentina. Of the 450 lactations, 352 corresponded to pure Holstein breed (H) and the remaining first lactations to SRB/H F1 crossbred. There were five SRB bulls involved in the crossbreeding. Regarding calving season, lactations that started between September and February (spring + summer) were classified as belonging to hot seasons and lactations that started between March and August (autumn + winter) were classified as belonging to cool seasons. It was not possible to control the voluntary waiting period; hence, performance was evaluated for each genotype through days to first breeding (DFB) and number of services per pregnancy.

All animals received continuous service system, with a single suspension window of 45 d (March 15 to May 1) to avoid calving in January, the month of maximum heat stress. Estrus is monitored routinely twice a day using visual observation and tail painting (Ce-Lamark®). Palpations or ultrasounds are performed to all cows to determine uterus and ovarian conditions. Cows who had not been bred are treated with prostaglandin for estrus synchronization. Cows are selected for fixed-time artificial insemination (FTAI) protocols.

2.2. Statistical analysis

A Cox proportional hazard regression model was fitted using PROC PHREG in SAS (SAS Institute, 2003) to compare the genotypes regarding days open (DO) adjusting by calving season and calving year. The assumption that hazards are proportional over time was confirmed using SAS PROC LIFEREG. Survival curves with Kaplan–Meier method for each genotype were also obtained for comparison of time to event, DO, at a given proportion of pregnant cows. The log rank test was used to test the equality of the survival functions between genotypes. In both the Cox proportional hazards and survival analyses, animal were regarded at risk of becoming pregnant after calving. In this work, the last day of data collection was December on 31, 2010 (defined as "*t*" time). If an animal became pregnant during data collection and did not have records of abortion before "*t*" time, it was not censored. This means that a censored observation refers to an animal that failed to become pregnant before "t" time or that was no longer observed because the data collection period had finished. Also, cows were not included in the study if they were no longer eligible for services, died during the study or were being selected for sale. A very important censorship case in this study was cows that became pregnant but then had an abortion and did not become pregnant again before "*t*" time. Thus, DO were measured as days from calving until the cow was censored or until it became pregnant and did not have a recorded abortion during the observation or data collection period. After the variable DO was obtained, a stepwise procedure was used to select the most significant variables affecting DO ($P<0.05$). Finally, population average lactation curves were modeled using the MilkBot model (Ehrlich, 2011) for each genotype, considering as random the subject-specific effect given by the cow. SAS PROC NLMIXED was used to fit lactation curves and to estimate total 305-d milk yield and peak milk yield.

$$Y(t)=a\left(1-\frac{\exp^{\frac{c-t}{b}}}{2}\right)\exp^{-dt}$$

The MilkBot Model (above) predicts daily milk yield, $Y(t)$ as a function of time (t). Four parameters, a (scale), b (ramp), c (offset), and d (decay), control the shape of the curve. Parameter "a" is the scale parameter. It is a simple multiplier, which determines the overall magnitude of milk production. Parameter "b" is the ramp parameter, controlling the rate of rise in milk production in early lactation. Parameter "c" is the offset parameter, and has relatively minor influence on the model. It represents the offset in time between calving and maximal growth rate of productive capacity. Parameter "d" is the decay parameter, controlling the loss of productive capacity, and analogous to the first-order decay constant common in pharmacokinetics.

3. Results

Table 1 shows the number of lactation records, mean daily milk yield, median number of days to first service, and median number of services per pregnancy for H breed and SRB/H crossbred. Mean daily yield was not statistically different between genotypes: 20.8 L for pure H and 20.0 L for SRB/H crossbred. DFB was statistically different between genotypes, being 80 d for pure H vs. 73 d for SRB/H crossbred. The number of services per pregnancy was also statistically different between genotypes: 2 for pure H vs. 1 for SRB/H crossbred (Table 1).

Mean daily milk yield during hot and cool seasons was not statistically different between genotypes. DFB during hot season was also not statistically different between genotypes, whereas DFB during cool season was statistically different, being 73 d for pure H vs. 65 d for SRB/H crossbred. The number of services per pregnancy was statistically different in hot and cool seasons between genotypes: 2 for pure H and 1 for SRB/H crossbred in both seasons (Table 2).

Genotype effects, as well as calving season resulted statistically significant (Table 3).

Regarding genotype, the coefficient for pure H with respect to SRB/H crossbred was statistically significant and negative, suggesting that animals of pure H have lower risk of pregnancy than SRB/H throughout the observation period (Table 4). The hazard ratio for SRB/H compared with H was 1.31 (95%CI=1.00–1.72), indicating that SRB/H had 1.31 increased likelihood of pregnancy during the observation period (Table 5). Our results suggest that calving season affected the risk of pregnancy (Table 4). The hazard ratio was 1.32 times higher (95%CI=1.06; 1.64) for those calving during cool seasons than for those calving during the hot seasons (Table 5).

Table 1
Milk yield (MY), days to first breeding (DFB) and number of services per pregnancy (NS/P) for pure Holstein (H) and Swedish Red & White/Holstein crossbred (SRB/H).

Breed	MY [daily yield] Mean ± SE[b]	DFB [d] Median ± SE	NS/P [number] Median ± SE
H (n=1183)	20.8 ± 0.2[a]	80 ± 2.7[a]	2 ± 0.1[a]
SRB/H (n=157)	20.0 ± 0.4[a]	73 ± 3.0[a]	1 ± 0.1[a]

[a] Means within a column with different superscripts differ ($P<0.05$).
[b] SE=standard error.

Table 2
Milk yield (MY), days to first breeding (DFB) and number of services per pregnancy (NS/P) for pure Holstein (H) and Swedish Red & White/Holstein crossbred (SRB/H) by calving season.

Calving season	Breed	MY [daily yield] Mean ± SE[b]	DFB [d] Median ± SE	NS/P [number] Median ± SE
Hot	H	20.9 ± 0.3[a]	88 ± 5.1[a]	2 ± 0.2[a]
	SRB/H	19.8 ± 0.9[a]	89 ± 6.2[a]	1 ± 0.3[a]
Cool	H	20.6 ± 0.3[a]	73 ± 2.9[a]	2 ± 0.1[a]
	SRB/H	20.1 ± 0.5[a]	65 ± 3.1[a]	1 ± 0.2[a]

[a] Means within a column with different superscripts differ ($P<0.05$).
[b] SE=standard error.

Table 3
Likelihood ratio test (LRT) for each factor analyzed in the Cox proportional hazards regression to model days open.

Factor	LRT	P-value
Breed	3.88.	0.0423*
Calving season (CS)	6.30	0.0121*
Year	0.89	0.6383

* $P<0.05$.

Table 4
Parameters estimated for the explanatory variables in the Cox proportional hazards regression model of days open.

Explanatory variable[a]	Regression coefficient	Standard error	CI 95% lower limit	CI 95% upper limit
Breed				
Holstein (H)	−0.136	0.068	−0.267	−0.0007
Calving season (CS)				
Cool seasons	0.137	0.055	0.029	0.247
Calving year				
2008	0.023	0.072	−0.119	0.166
2009	0.052	0.076	−0.099	0.201

[a] The explanatory variable category that has no values for the parameters estimated is the reference category used for the statistical comparisons.

Table 5
Hazard ratios and 95% coefficient interval of risk to get pregnant (LL: lower Limit and UL: Upper Limit) for each breed, calving season (CS), and calving year.

Variables	HR	LL 95%	UL 95%	P-value
BBreed [SRB/H vs. H]	1.31	1.00	1.71	0.0423*
CS [cool vs. hot]	1.32	1.06	1.64	0.0121*
Calving year [2008 vs. 2010]	1.10	0.84	1.44	0.4581
Calving year [2009 vs. 2010]	1.13	0.86	1.50	0.3612

* $P<0.05$.

Survival curves (Figs. 1 and 2) showed statistically significant differences between H and SRB/H. In addition, the time to pregnancy (DO) of 50% of the heifers was 129 d for H (95% CI=120; 139) and 99 d for SRB/H (95%IC=83; 108) (Table 6).

3.1. Lactation curves

The parameter 305-day milk yield estimated by the non-linear model was 6.468 L for H and 6.140 L for SRB/H. Peak milk yield estimated was 23 L for H and 22 L for SRB/H.

4. Discussion

4.1. Milk production

In our study, average daily milk yield was not statistically different between breeds at least in heifers. Weigel and Barlass (2003) evaluated the variable milk volume based on scores and found that the mean score varied between 2 for pure Jersey and 3.79 for pure H. The score for Brown Swiss cows was 2.40, a very similar value to the score obtained for F1 Holstein/Jersey (H/J) cows (2.52), whereas scores for F1 Brown Swiss × H cows (2.90) were similar to those of backcross H × H/J cows (3.00). Prendiville et al. (2010b) reported that daily milk production was greater in

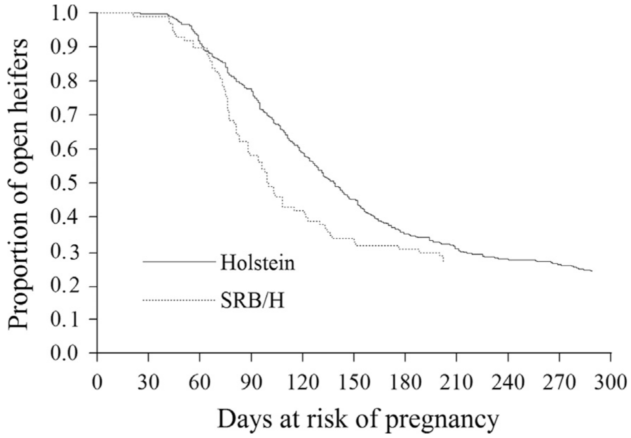

Fig. 1. Kaplan–Meier survival curves. Days in milk to pregnancy for lactations of pure Holstein and SRB/Holstein crossbreds ($\chi^2=5.0396$; $P=0.0248$).

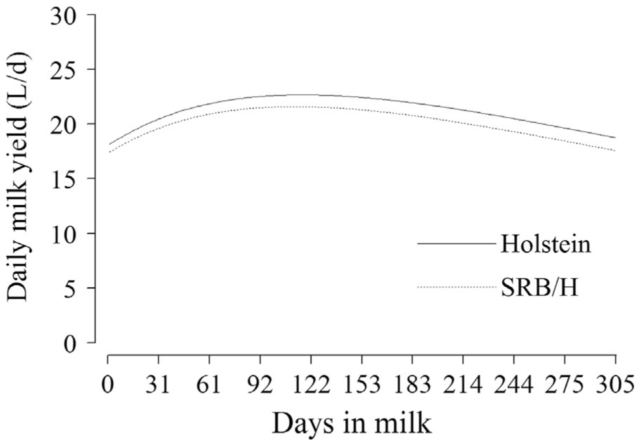

Fig. 2. Lactation curves for pure Holstein (H) (solid line) and Swedish Red & White/Holstein (SRB/H) crossbred (dotted line).

Table 6
Median time to pregnancy, 95% Confidence Interval and the 25 (P25) and 75 (P75) percentiles associated with each breed (pure Holstein=H; Swedish Red & White/Holstein crossbred=SRB/H).

Breed	Median time CI 95% (LL – UL)[a]	25% of Pregnant animals	75% of Pregnant animals
H	129 (120–139)	91	200
SRB/H	99 (83–108)	75	151

[a] LL: lower limit and UL: upper limit.

Holstein–Friesian cows (16.9 kg/d) than in Jersey (12.8 kg/d), and stated that F1 obtained greater productions (15.7 kg/d; $P<0.05$) than the average values of their parent breeds. However, we observed that the cumulative 305-d yield, for H breed was higher than for SRB/H crossbred. These results are consistent with those reported by Heins et al. (2006a), who found that pure H breed was significantly superior for production (9757 kg) to the crossbreds of H with Normande (8530 kg), Montbeliarde (9161 kg), and Scandinavian Red (9281 kg). Our results are also in agreement with other findings (Touchberry, 1992; McAllister et al., 1994). In a study comparing milk production between H breed and H/J crossbred, Heins et al. (2008) concluded that pure H is significantly superior for milk production (7705 kg) to H/J (7147 kg) in its first lactation. In our analysis, peak milk yield were higher for H breed than for SRB/H crossbred. Lopez-Villalobos et al. (2000) stated that 25 years of crossbreeding and selection in New Zealand resulted in a higher rate of genetic gain in the entire herd, higher fat and protein production per hectare, higher stocking rate and lower milk production per hectare. Considering the current payment system, this should result in higher economic returns to the producer.

4.2. Reproductive indicators

DFB was lower for SRB/H than pure H. These results are similar to those reported by Heins et al. (2006b), who found 62 DFB for Normande/H crossbred, 65 DFB for Montbeliarde/H, 66 DFB for Scandinavian Red/H, whereas pure H had 69 DFB. Touchberry (1992) also reported that pure H had a greater DFB than Guernsey/H crossbreds, whereas Blottner et al. (2011) did not find differences between Brown Swiss/H and pure H during first lactation; however, they did find differences in the second lactation, with fewer days for Brown Swiss (81 d) than pure H (89 d). Blottner et al. (2011) found a trend in fewer DFB during the third lactation in crossbreds vs. pure H (85 d vs. 92 d).

The number of services per pregnancy was higher for H than for SRB/H (2 vs. 1, respectively). Partial results of an ongoing experimental work conducted in Germany showed that pure H breed had an average of 2.28 inseminations/pregnancy, whereas the SRB/H crossbred had 1.76 and Brown Swiss/H crossbred had 1.77 (Swalve 2007). In Blottner et al. (2011), the number of services per pregnancy for Brown Swiss/H versus pure H did not differ statistically in any lactation evaluated. This result is consistent with those of Walsh et al. (2008), who also did not find significant differences between Montbeliarde/Friesian H and Normande/Friesian H over pure breeds.

Regarding DO, the hazard ratio for SRB/H compared with H was 1.31, indicating that SRB/H had 1.31 increased likelihood of pregnancy during the observation period. Heins et al. (2008) found a 23 d delay of DO in pure H over H/Jersey crossbreds, whereas Dechow et al. (2007) found 12 d less for pure H compared to Brown Swiss/H crossbred heifers, but no differences in cows of these breeds. The median time (DO) to pregnancy of 50% of H heifers was 30 d higher than for SRB/H heifers (129 d versus 99 d, respectively). Therefore, SRB/H becomes pregnant faster than pure H breed. Heins et al. (2006b) reported an average of DO of 150 d for pure H, 123 d for Normande/H crossbred, 129 d for Red Scandinavian/H, and 131 d for Montbeliarde/H crossbreds. Preliminary results reported by Fischer et al. (2008) show significant differences in DO of primiparous cows between Brown Swiss/H (89.1 d) and pure H (106.8 d); however, for second-lactation cows they did not conclude the same (120.4 vs. 128.2 DO, respectively). Blottner et al. (2011) did not find statistically differences between Brown Swiss/H crossbred and pure H in terms of DO in the first three lactations, although numerically, the results favored Brown Swiss/H over pure H.

In the present study, calving season was clearly another factor impacting DO. The risk of becoming pregnant was 1.31 times higher for lactations started during cold seasons than for those started in the hot seasons suggesting that the calving season affects the risk of pregnancy. These results are expected, since cows calving in the latter seasons spend most or all of their first days in milk in the same seasons, and therefore, lower DO would be expected than if they calve during the cool season (Piccardi et al., 2013).

5. Conclusion

Crossbred (SRB/Holstein) was superior to pure Holstein breed in terms of reproductive performance, and inferior in terms of productive performance. So, further studies may help determine if the economics of dairying justifies the use of SRB breed to crossbreeding as a herd fertility enhancing tool.

Conflict of interest statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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