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REGULAR ARTICLES

Reproductive performance and survival of Holstein and Holstein × Simmental crossbred cows

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Abstract Crossbreed dairy breeds, such as Holstein × dairy type of Simmental, have been generally used to improve fertility, udder health, and longevity of dairy herds. The aim was to compare the reproductive performance and survival of Holstein and Holstein × Simmental crossbred cows. Data from two farms were used as follows: one located in Bom Retiro, in the state of Santa Catarina, Brazil. and another in Carambeí, Paraná state. Information concerning birth, inseminations, and parity date were obtained from the management software of the farms, generating information regarding the calving interval, days between calving to first service, conception rate, and age at first calving. At one of the farms, calving was monitoring to quantify dystocia. Live weight as well as body condition score (BCS) of cows and information of culling were obtained to determine the survival rate. Data were analyzed by variance analysis and by logistic regression. Crossbred Holstein × Simmental cows had better reproductive performance than the Holstein cows, characterized by lower calving interval (381 vs. 445 days), higher conception rate (37.3 vs. 33.6 %), and shorter calving to first service interval (65 vs. 89 days). These results were related to a higher BCS in crossbred cows (3.63 vs. 2.94 points). Crossbred Holstein × Simmental cows had higher survival rate than Holstein cows on the second parity (83 vs. 92 %). No differences between genetic groups were observed ($P > 0.05$) for body weight and dystocia. In conclusion, Holstein × Simmental crossbred cows have better reproductive performance and higher survival rate than Holstein cows.

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Introduction

Genetic selection for milk yield, together with improved management and nutrition, has doubled the milk yield of cows in the last 40 years. In contrast, traits such as fertility, health, and longevity are negatively correlated with milk yield (Abe et al. 2009), so by increasing productivity, cows tend to have more reproductive disorders and diseases, which decrease longevity.

An alternative to improve fertility and longevity of cows is the cross between dairy breeds. This practice aims through complementarity between breeds and heterosis, to improve milk quality, fertility, and productive life of dairy cows. Most researches on crosses between dairy breeds are carried out with Holsten and Holstein × Jersey cows. Some studies have shown higher economic return (Lopez-villalobos et al. 2000), fewer days open (Heins et al. 2008), and higher pregnancy rate (Auldist et al. 2007) in the crossbred cows. Other studies show greater production of solids in milk (Thaler Neto et al. 2013), as well as higher fertility and uterine health (Felippe 2013).

The crossbreed between Simmental (dairy type) and Holstein breeds has been made for several years, mostly in Europe, especially Germany. Comparing the performance of Holstein cows and crossbred of Holstein with Simmental or Montebeliarde breeds, crossbreds demonstrate increased solids in milk, improved fertility, longevity, somatic cell score (Schwaiger 2008; Brähmig 2011; Heins and Hansen 2012;

Mendonça et al. 2014), conception rate (Heins and Hansen 2012; Hazel et al. 2014; Malchiodi et al. 2014), and calving to first service interval (Malchiodi et al. 2014; Walsh et al. 2008).

So, the aim was to evaluate the reproductive performance and survival of Holstein animals compared to Holstein × Simmental crossbred cows.

Methodology

The study was carried out in two dairy farms, located in Bom Retiro, in the state of Santa Catarina, Brazil (27° 47′ 50″ South; 49° 29′ 21″ West; altitude of 890 m), and Carambeí, in the state of Paraná (24° 44′ 04″ South, 50° 05′ 49″ West; altitude 1038 m); both are located in a region of humid subtropical climate, Cfb according to the Köppen classification. Both farms have Holstein and F1 Holstein × Simmental crossbred cows arising from the insemination of pure Holstein cows with semen of Simmental bulls, with breeding values estimated for dairy traits, imported from Germany. Simmental is a dual purpose breed; on this farms, the semen used was from the dairy type, as a specialized dairy breed.

On the farm situated in Bom Retiro, SC (herd 1), cows were managed in semi-confinement system, maintained in pasture of oats + rye grass in winter and sorghum in summer and supplemented with corn silage, grass silage, and concentrates twice daily. Approximately 170 cows were milked twice a day, of them 110 Holstein and 60 crossbred Holstein × Simmental. On the farm situated in Carambeí, PR (herd 2), cows were managed on a free-stall, receiving a total mixed ration, based on corn silage, grass silage, and concentrates. Approximately 150 dairy cows were milked twice daily, 100 Holstein and 50 crossbred Holstein × Simmental.

Data from management software (Prodap GP Professional software, ProdapTech in the herd 1, and DairyPlan, GEA Farm Technologies, in the herd 2), from 2008 to 2014, were available, regarding births, inseminations, productive traits, and culling dates of the cows. From this data set, age at first calving, calving to first service interval, calving interval, and conception rate were calculated. Both farms adopted a voluntary waiting period after calving of 40 days and used artificial insemination. Heifers were inseminated with approximately 350 kg, around 15 months of age in both genetic groups.

For the evaluation of survival rate of cows, a data set of the herd 1, from 2007 to 2014, with information about culling dates was used. The percentage of cows of both genetic groups that ended the first, second, and third lactations was calculated. In this same herd, dystocia was evaluated in 2012 and 2013 with a 1 to 5 scale with 1 = no assistance, 2 = slight problem but required no assistance, 3 = required assistance, 4 = considerable force, and 5 = extreme difficulty, as proposed by Olson et al. (2009). For statistics analysis, dystocia scores of 1 or 2 were coded as unassisted, and scores of 3 to 5 were coded as assisted. Still in the herd 1, body condition score (BCS) was assessed and cows were weighed in intervals of 60 to 90 days, from April 2013 to April 2014. The evaluation of the BCS was carried out using the scale from 1 (extremely thin) to 5 (very fat).

For the statistical analysis, 361 data of age at first calving, 211 of dystocia, 2897 of conception rate, 801 for calving to first-service interval, 436 to calving interval, and 328 data of calving and culling of animals to determine the survival rate were available.

Data for continuous dependent variables of reproductive performance were submitted to ANOVA using the MIXED procedure of SAS (SAS 2002) statistical package, having previously been tested for normality of residuals. The model was composed by the explanatory variables genetic group, parity, herd, season, year, and the interaction between parity and genetic group. It was estimated BCS curve according to days in milk (DIM) throughout non-linear regression technique with the Wood model, which is described by Y = Atb e-ct where Y = BCS; A, B, and C are constants, where A = theoretical initial BCS, b = increased rate, c = decrease rate, and t = DIM.

Binary variables, such as conception rate, dystocia, and survival rate, were analyzed with a generalized linear model with binomial distribution (logistic regression) using the GENMOD procedure of SAS, with a statistical model analogous to that described above. For the analysis of dystocia, the variables sex of the calf and type of semen (conventional or sexed) nestled on herd were included in the model. For conception rate, the variable type of semen nested in the herd, as well as the interaction between genetic group and herd, was added to the model.

Results

Holstein × Simmental crossbred cows have lower ($P < 0.001$) calving interval (CI) than pure Holstein cows (Table 1). The difference represented 64 days less CI than Holstein cows, demonstrating better reproductive efficiency. The lower calving interval in crossbred cows was accompanied by shorter calving to first service interval ($P < 0.0001$) to the crossbred cows, showing that after calving, crossbred cows return to cyclicity earlier than Holstein cows. Both variables were not affected by parity, with no interaction between genetic group and parity, with different averages in the herds (Table 1).

Another indicator of fertility evaluated was conception rate, which was higher ($P < 0.05$) in crossbred Holstein × Simmental cows (Table 2). There was interaction between genetic group and the number of inseminations ($P = 0.0126$), with no differences in the first insemination and higher conception rate in crossbred cows inseminated more times ($P = 0.0749$). There was also interaction between genetic group and type of semen used ($P < 0.0001$), and the Simmental × Holstein crossbred

Table 1 Number of observations, adjusted average (days) ± standard error of the mean (SEM) for calving interval and calving to first service interval according to the genetic group and parity

Varable	Category	Calving interval			Calving to first service interval		
		N	Average ± SEM	*P*	*N*	Average ± SEM	*P*
Genetic Group	Holstein	289	445 ± 5.7	<0.0001	519	89 ± 2.5	<0.0001
	Holstein × Simmental	147	381 ± 8.7		282	65 ± 3.2	
Parity	1	198	422 ± 6.4	0.1710	294	79 ± 2.7	0.3002
	2	133	416 ± 8.4		232	74 ± 3.1	
	≥3	105	400 ± 10.7		273	79 ± 3.7	
Herd	1	294	427 ± 5.8	0.0101	497	66 ± 2.8	<0.0001
	2	143	399 ± 9.2		304	88 ± 2.9	

only overcame the Holstein cows when conventional semen was used (Table 2). The reduction of fertility using sexed semen in both genetic groups ($P < 0.05$) is noteworthy. There was no interaction between genetic group and parity, and the crossbred cows had 3 to 4 percentage points higher conception rate in all parities. However, there was a decrease in the conception rate by increasing the parity for both genetic groups, indicating the reduced fertility in multiparous cows.

There was no difference in age at first calving ($P > 0.05$) between Holstein and crossbred Holstein × Simmental heifers (28.27 ± 0.21 and 0.29 ± 28.23 months, respectively), as well as in dystocia ($P = 0.7382$; 39.34 × 37.08 % respectively), with no effect of calf sex ($P = 0.4992$). Higher survival rate of cows was observed for Holstein × Simmental cows ($P < 0.05$), especially on the second parity (Table 3). On average, the percentage of cows that ended the first, second, and third lactation was higher for crossbred cows than for Holstein cows.

There was no difference in body weight of the cows in both genetic groups ($P < 0.005$) with an average weight of 640.6 and 651.7 kg for Holstein and crossbred Holstein × Simmental cows, respectively. However, Holstein × Simmental cows had higher BCS than Holstein cows ($P < 0.0001$), with average values of 3.63 vs. 2.94 points, during the whole lactation (Fig. 1). In crossbred cows, no reduction in BCS at the peak of lactation was observed, and the curve was ascendant, with an average score of 3.3 points at calving, reaching approximately 3.8 points at 305 days of lactation. Already, the Holstein cows had approximate score of 3.2 points at calving, decreasing to 2.8 points approximately 60 days after parity, and until 305 days of lactation, these cows did not recover the BCS.

Discussion

The results presented in Tables 1 and 2 clearly demonstrate that crossbred cows (Holstein × Simmental) had better reproductive performance than Holstein cows. These results may reflect the heterosis and complementarity between the breeds of this crossbreed (Sørensen et al. 2008). This allowed the crossbred Holstein × Simmental cows to return to cyclicity postpartum earlier than the Holstein cows, even in similar milk yield conditions. The increase in milk yield negatively affects the reproductive performance of dairy cows (Abe et al. 2009). However, this does not seem to be the reason of greater fertility of crossbred cows, whereas in another study with data of the cows from herd 1, crossbred cows had higher milk yield than the Holstein cows (31.8 vs. 30.5 l/day, respectively;

Table 2 Conception rate (%) according to the genetic group, the number of inseminations, parity, and type of semen

Variable	Category	Holstein		Holstein × Simmental		*P*
		N	%	*N*	%	
Insemination	First	848	31.2	420	34	0.3155
	Others	1134	35.4	495	40.1	0.0749
Parity	Heifers	393	52.7	240	48.7	<0.0001
	1	597	31.5	303	35.6	
	2	447	28.9	201	31.8	
	≥3	546	26.1	170	30.6	
Semen type	Conventional	1211	37	566	44.0	0.0049
	Sexed	767	27.9	345	25.8	0.4661
Average			33.6		37.3	0.0485

Table 3 Survival rate (%) according to genetic group

Variable		Genetic group		P
		Holstein	Holstein × Simmental	
Parity	First	92.1	94.0	0.6129
	N	101	68	
	Second	68.0	91.2	0.0025
	N	50	57	
	Third	75.0	90.6	0.1287
	N	20	32	

N number of observations

$P < 0.05$; data not published). Simmental × Jersey cows also showed higher reproductive performance than Jersey cows throughout heterosis and complementarity between breeds (Goni et al. 2015).

The reproductive parameters examined in this study may have been influenced by the energy balance of the animals, because of the higher BCS in crossbred Holstein × Simmental cows throughout the lactation (Fig. 1), confirming the results obtained by Hazel et al. (2014) and Mendonça et al. (2014), who compared crossbred Holstein × Monbelierde with Holstein cows. There is a negative correlation of BCS with energy balance and fertility (Banos and Coffey 2010; Bastin et al. 2010). Cows in negative energy balance have to metabolize body reserves to supply the demand of nutrients for milk production. Animals in a negative energy balance period show greater damage in follicular growth and development of the embryo. These animals tend to have delayed insemination and increased pregnancy loss, increasing the calving interval (Walsh et al. 2011). Besides the negative effects associated with follicular growth and ovulation, negative energy balance is characterized by the production of beta-hydroxybutyrate (BHBA) and non-esterified fatty acids (NEFA) that promote reduction of oocyte quality and change the luteal function. This results in low concentrations of uterine progesterone and inhospitable uterine ambient for the development of the embryo, which increases the embryonic mortality (Leroy et al. 2008).

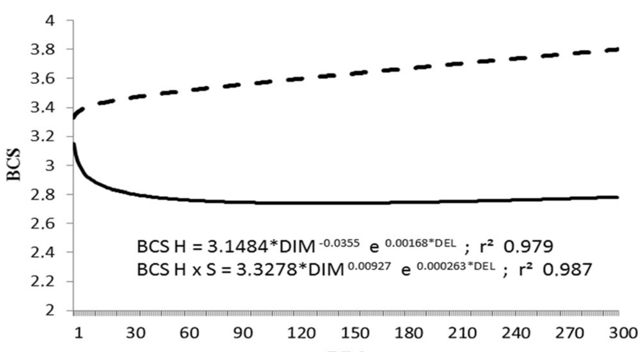

Fig. 1 Body corporal score (BCS) curve according to days in milk (DIM), for Holstein (H) cows (*solid line*) and Holstein × Simental (H × S) crossbred cows (*dash line*)

The lowest calving to first service interval (Table 1) may indicate that crossbred cows return to cyclicity earlier after calving. In a study with Holstein and Holstein × Montbeliarde crossbred cows, Mendonça et al. (2014) reported that the diagnosis of first postpartum corpus luteum happened earlier in crossbred cows than in Holstein cows (28.4 vs. 30.2 days, respectively). This report demonstrates that crossbred cows have an average first ovulation and therefore the first postpartum estrus earlier than the Holstein cows, helping to explain the shortest calving to first service interval observed in this study.

The lower conception rate in adult cows in relation to the heifers (Table 2) can be related to the fact that heifers are not affected by adverse effects of negative energy balance on reproduction. The lower conception rates in cows with three parities (approximately 5 % compared to primiparous cows in both experimental groups) can be related to higher milk yield in multiparous cows, as well as the increase in uterine postpartum diseases in oldest cows (Lee 2006). Lower reproductive performance with the use of sexed semen (Table 2) is linked to lower concentration of viable sperm per dose and to the sexing technique that can damage the sperm (Dejarnette et al. 2011).

The similarity between genetic groups for age at first calving is probably due to the breeds used in the crossing because both are large European breeds, with similar growth and sexual maturity. In addition, the criterion used for the first insemination of heifers from both genetic groups was the life weight, around 350 kg. This criterion is the same as conventionally used by farmers for the artificial insemination of Holstein heifers.

Higher survival rate of crossbred cows (Table 3) can be related to the higher fertility, since this is one of the main causes of culling in dairy herds (Ahlman et al. 2011; Hazel et al. 2014), as well as udder health, which is related to the high somatic cell score and clinical mastitis (Ahlman et al. 2011). Heins and Hansen (2012) observed lower somatic cell score in crossbred cows, which was also observed in a study in the herd 1, where the crossbred cows have lower somatic cell score than the Holstein cows (2.74 vs. 4.43, respectively, $P < 0.05$; data not published).

In conclusion, crossbred Holstein × Simmental cows have better reproductive performance than Holstein cows, demonstrating that the use of this crossing is a way to improve fertility in Holstein herds.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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