REPRODUCTION OF HOLSTEIN AND BROWN SWISS COWS AND OF THEIR F1 RECIPROCAL CROSSES RAISED IN A MEXICAN SUBTROPICAL ENVIRONMENT

R. C. Calderón-Robles;A. Ríos-Utrera[*], V. E. Vega-Murillo[*], M. Montaño-Bermúdez[**], G. Martínez-Velázquez[***], S. I. Román-Ponce[**], R. Calderón-Chagoya[****]

Sitio Experimental Las Margaritas, INIFAP, Hueytamalco, Puebla, México.
[*]Campo Experimental La Posta, INIFAP, Medellín, Veracruz, México.
[**]CENID Fisiología y Mejoramiento Animal, INIFAP, Ajuchitlán, Querétaro, México.
[***]Campo Experimental Santiago Ixcuintla, INIFAP, Santiago Ixcuintla, Nayarit, México.
[****]Universidad Nacional Autónoma de México, Distrito Federal, México.
Correspondingauthor e-mail: rios.angel@inifap.gob.mx

ABSTRACT

The aim was to assess differences among Brown Swiss (BS), Holstein (HO), BS x HO and HO x BS cows. Age (AFC) and weight at first calving (WFC) were analyzed with a simple model that included sire within breed group (SIRE) as a random effect, and breed group (BG), calving year (CY) and calving season (CS)as fixed effects. Days to first heat, days to first service, days open, calving interval, pregnancy rate at first service (PR), and services per conception (SPC) were analyzed with a repeated measures model that included SIRE (except for SPC and PR), BG, CY, CS, and lactation number. In addition, for PR, the model included stage of lactation (Stage 1: 1 to 50 d; Stage 2: 51 to 100 d; Stage 3: 101 to 150 d; Stage 4: ≥151 d postpartum).Repeated measures model for each trait was fitted testing different covariance structures in order to provide the best fit to the data.The selection of the appropriate covariance structure was based on Akaike's, second order, Schwarz's Bayesian and quasilikelihood information criteria fit statistics. Differences among breed groupswere foundonlyfor AFC and SPC. Holstein and HO x BS cows were younger at first calving ($P<0.05$) than BS cows ($P<0.05$). Brown Swiss and BS x HO cows required fewer SPC ($P<0.05$) than HOcows. Cows in Stage 4 of lactation had higher PR ($P<0.05$) than cows in Stages 1 and 2 of lactation (63% versus 44% and 50%). Results suggest absence of heterosis effects.

Keywords: Age at first calving, Calving interval, Crossbreeding, Dairy cattle, Pregnancy rate, Subtropics.

INTRODUCTION

Even though the large advantage of the Holstein breed for additive genetic merit for lactation milk yield, several dairy cattle crossbreeding experimentsinvolving this breed along with Brown Swiss, Jersey, Normande and Montbeliardehave been performedto answer the question if crossbreds excel Holsteins in reproduction, health and survival.Sorensen et al. (2008) stated that the two main reasons for applying crossbreeding are: 1) to utilize the different additive genetic levels between breeds to generate offspring with better economic ability caused by new combinations of additive genetic components, and 2) make use of heterosis. Numerous previous experiments had indicated a better reproductive performance of crossbred over purebred cows. For instance, Walsh et al. (2008) noted that F1 Montbeliarde x Holstein cows had shorter intervals from calving to first service than pure Holstein cows.Heins et al. (2008) reported that F1 Holstein x Jersey cows had fewer days open (127 d versus 150 d) and a greater percentage of cows pregnant by 150 d postpartum (75% versus 59%) than pure Holstein cows.In North Carolina, Mullen et al. (2015) found that crossbred cows had higher 90-d pregnancy rates in a study involving Holsteins, Jerseys, and crosses with various percentages of these two breeds. In Mexico, studies related to crossbreeding among dairy cattle(*Bostaurus*)breeds are very scarce.Up to now, it seems that the sole investigation on this topicis the one carried out by Lammoglia et al. (2013), whoreportedthat pure Holstein cows had moredays open and longer calving intervals than Holstein x Jersey, Holstein x Montbeliarde and ¼ Holstein x ¼ Jersey x ½ Swedish Red crossbreed cows.However, there are noMexicanstudies comparing the reproductive performance of pure Holstein and Brown Swiss cows with their F1 reciprocal crosses. Based on these antecedents, the objective of the present investigation was to evaluate differences in reproductive performance among pure Holstein and Brown Swiss cows and Holstein x Brown Swiss and Brown Swiss x Holstein crossbred cows in a pasture-based system under subtropical conditions of Mexico.

MATERIALS AND METHODS

Location features: The present study was carried out at Las Margaritas research station of the National Institute for Forestry, Agriculture and Livestock Research (INIFAP). The research station is located in the Municipality of Hueytamalco, State of Puebla, Mexico, at 450 m above sea level. The climate is classified as subtropical humid (García, 1988). Average annual temperature is 20.8°C, the minimum temperature is 15.3°C in winter, and the maximum temperature is 24.2°C in summer. The region is characterized by abundant rainfall from July to October and a low temperature period with drizzle from November to the end of February. From March to June, high temperatures combined with low humidity and solar radiation generates stressful conditions.

Livestock: Data were obtained from an experimental dairy herd integrated by purebred Holstein (n=99) and Brown Swiss (n=110) cows and by F1 Holstein x Brown Swiss (n=20) and Brown Swiss x Holstein (n=27) crossbred cows, born from 1996 to 2010. Lactations followed from 2000 to 2013. The Holstein and Holstein x Brown Swiss cows were the progeny of 74 Holstein sires, while the Brown Swiss and Brown Swiss x Holstein cows were the progeny of 62 Brown Swiss sires. The same sires were used to produce pure and crossbred females.

Breeding management: Heifers were first bred when they reached about 350 kg. Heat detection was performed one hour in the morning (from 06:00 to 07:00) and one hour in the afternoon (from 17:00 to 18:00), with the help of a bull with achin-ball marker. Breeding of cows was in the following manner: those coming on oestrus in the morning were served in the afternoon, and those coming on oestrus in the afternoon were served the following day in the morning, approximately 12 hours after visual observation of oestrus. Cowswere mated to sires mainly through AI, but there was also somenatural mating.Cows were confirmed pregnant by rectal palpation after 45 days of last service.

Feeding management: Cows were kept in an intensive rotational grazing system in which the principal feed was Star grass (*Cynodonplectostachyus*). Grazing and non-grazing periods for each pasture (1-2 hectares each) lasted 2-3 and 35-40 days, respectively, depending on the season of the year (climate conditions). Stocking rate averaged 2.5 animal units per hectare per year throughout the study. During the cold season (November to February), each cow received 20-30 kg of fresh, chopped Japanese cane (*Saccharumsinense*) per day. Also, each lactating cow received 1.75 kg of a commercial supplement (16% crude protein and 70% total digestible nutrients) per milking (twice a day), while non-lactating cows received 2 kg of the same supplement per day.

Milking management: Calves were taken away from their dams three days after calving. Cows were managed according to the following groups: 1) lactating cows from calving to the fifth month of lactation, 2) lactating cows from the sixth month of lactation to drying-off, and 3) dry-off cows. Milking of cows initiated four days after calving. Cows were milked twice daily, by machine, between 05:00 and 07:00 hours and between 15:00 and 17:00 hours. Measurement of the individual cow's milk yield was carried out automatically during each milking with Waikato type proportional flow meters. Total milk yield per day was calculated adding the milk yield of the first milking to the milk yield of the second milking. Lactating cows were dried off when they were seven months pregnant or when their milk yield was less than 2 kg per day.

Female traits: Reproductive records,age at first calving, weight at first calving, days to first heat after calving, days to first service after calving, days open, calving interval, number of services per conception, and pregnancy rate at first service were collected and analyzed. Traits were defined as follows:

Age at first calving-Difference between date of first calving and birth date.

Weight at first calving-Live body weight at first calving.

Days to first heat after calving-Difference between date of first heat after calving and corresponding calving date. This measureis an indicator of the female's ability to restartcyclicity and express estrus.

Days to first service after calving- Difference between date of first service after calving and corresponding calving date.

Daysopen-Difference between conception date after calving and corresponding calving date.This trait reflects both pregnancy rate and the female's capability to cycle and express estrus.

Calving interval- Difference between calving date and previous calving date.

Pregnancy rate at first service- This trait was defined as a binary variable; therefore, if the female became pregnant after first service,a value of 1 was assigned; otherwise, a value of 0 was assigned.

Characteristics of the data for all reproductive traits aresummarizedin Table 1.Means of age at first calving, weight at first calving, days to first heat, days to first service, days open, calving interval, pregnancy rate at first service and number of services per conception were:33.9 months,454.4 kg, 125.4 d,126.6 d, 167.8 d, 456.7 d,53% and1.9 services, respectively.

Table 1.Descriptivestatistics[a] for reproductive traits.

Trait	N	Mean	Min	Max	SD	CV (%)
Age at first calving, months	222	33.9	22.0	60.3	6.9	20.4
Weight at first calving, kg	209	454.4	300.0	618.0	60.4	13.3
Days to first heat after calving	827	125.4	8.0	614.0	100.2	79.9
Days to first service after calving	827	126.6	19.0	614.0	99.9	78.9
Days open	755	167.8	23	637	111.6	66.5
Calving interval, d	701	456.7	259	980	113.9	24.9
Number of services per conception	787	1.9	1.0	11.0	1.3	68.4
Pregnancy rate at first service	748	0.53	0.0	1.0	0.49	92.5

[a]N=number of records, Min= minimum value, Max=maximum value, SD=standard deviation, CV=coefficient of variation.

Statistical Analyses: Age and weight at first calving were analyzedwith the GLM procedure of SAS (SAS Institute Inc., 2011)with a simple model that included sire nested within breed group as a random effect, and breed group, year of calving and season of calvingas fixed effects. Remaining traits were analyzed with a repeated measures model that included sire nested within breed group as a random effect, except for number of services per conception and pregnancy rate at first service, and breed group, year of calving, season of calving and lactation number as fixed effects. In addition, for pregnancy rate at first service, the statistical model included stage of lactation (Stage 1:from 1 to 50 d; Stage 2:from 51 to 100 d; Stage 3:from 101 to 150 d; and Stage 4:≥151 d postpartum). Days to first heat after calving, days to first service after calving, days open and calving interval were analyzed with the MIXED procedure of SAS (SAS Institute Inc., 2011). Number of services per conception and pregnancy rate at first servicewere analyzed with the GENMOD procedure of the same software. For number of services per conception, a Poisson distribution was specified in the model statement (Poisson regression analysis). On the other hand, abinomial distribution was specifiedand a logit link function was usedin the analysis of pregnancy rate at first service (logistic regression analysis). The model to analyze days to first heat after calving, days to first service after calving, days open and calving interval waspreliminarily fitted testing different covariance structures in order to provide the best fit to the data. The covariance structures tested to analyze number of services per conception and pregnancy rate at first service werefirst-order autoregressive, compound symmetry, independent, Toeplitz, and unstructured. The selection of the appropriate covariance structure for days to first heat after calving, days to first service after calving, days open and calving interval was based on Akaike's, second order, and Schwarz's Bayesian information criteria fit statistics. For number of services per conception and pregnancy rate at first service, the appropriate covariance structure was selected based on the quasilikelihoodcriterion fit statistic.

RESULTS AND DISCUSSION

Fit statistics for Akaike's (AIC), second order (AICC), Schwarz's Bayesian (BIC) and quasilikelihood (QIC) information criteria are presented in Table 2. These values indicate that the best covariance structures, used in the final model, were: first-order autoregressive for days to first heat after calving and days to first service after calving; compound symmetry for days open, calving interval and pregnancy rate at first service; and independent for number of services per conception. Previously mentioned covariance structures that do not appear in Table 2 were not estimable.

Table 3 presents least square means and their standard errors for reproductive traits by breed group. Holstein, Brown Swiss, Holstein x Brown Swiss and Brown Swiss x Holstein cows had similar weight at first calving, days to first heat after calving, days to first service after calving, days open, calving interval and pregnancy rate at first service. These results indicate that heterosis effects are not important for these reproductive traits.

	Fit statistic[a]			
Trait/Covariance structure	AIC	AICC	BIC	QIC
Days to first heat after calving				
First-order autoregressive	**8992.4**	**8992.4**	**9001.3**	-
Compound symmetry	8993.0	8993.0	9002.0	-
Simple	9000.1	9000.1	9006.1	-
Days to first service after calving				
First-order autoregressive	**8994.3**	**8994.3**	**9003.2**	-
Compound symmetry	8995.4	8995.4	9004.3	-

Simple	9002.6	9002.6	9008.6	-
Days open				
First-order autoregressive	8481.1	8481.2	8490.1	-
Compound symmetry	**8479.7**	**8479.7**	8488.7	-
Simple	8480.2	8480.2	**8486.2**	-
Calving interval				
First-order autoregressive	8367.5	8367.5	8376.4	-
Compound symmetry	**8364.2**	**8364.3**	**8370.2**	-
Simple	8365.7	8365.7	8371.7	-
Number of services per conception				
First-order autoregressive	-	-	-	1168.07
Compound symmetry	-	-	-	1168.23
Independent	-	-	-	**1167.56**
Toeplitz	-	-	-	1168.08
Pregnancy rate at first service				
First-order autoregressive	-	-	-	1039.29
Compound symmetry	-	-	-	**1039.23**
Independent	-	-	-	1039.29
Toeplitz	-	-	-	1039.29

Table 3. Least square means and their standard errors for age at first calving (AFC; months), weight at first calving (WFC; kg), days to first heat after calving (DFH), days to first service after calving (DFS), days open (DO), calving interval (CI; days), number of services per conception (NSC) and pregnancy rate at first service (PRF; %), by breed group.

	Trait[a]							
Breed[c]	AFC	WFC	DFH	DFS	DO	CI	NSC	PRF
H	32.7±0.8[a]	457±5.4[a]	157±8.8[a]	157±8.7[a]	205±9.1[a]	479±8.3[a]	2.1±0.11[a]	49±3.5[a]
S	36.2±0.9[b]	437±6.1[a]	156±8.8[a]	158±8.7[a]	197±8.6[a]	461±7.9[a]	1.7±0.07[b]	56±3.7[a]
HxS	32.3±1.7[a]	458±12.9[a]	165±14.9[a]	164±14.8[a]	192±14.9[a]	470±12.9[a]	1.8±0.13[ab]	52±5.7[a]
SxH	32.8±1.5[ab]	444±10.5[a]	138±14.7[a]	138±14.6[a]	166±13.8[a]	452±11.0[a]	1.7±0.10[b]	56±4.1[a]

[a,b]Means with different superscript within trait are different ($p<0.05$).
[c]H= Holstein, S= Brown Swiss, HxS= Holstein x Brown Swiss, SxH= Brown Swiss x Holstein.

In an experiment with femalesof all possible two-breed combinationsamong Ayrshires, Brown Swiss, and Holsteins in comparison to contemporary purebreds, McDowell et al. (1970) found that average percentages of heterosis for calving to first estrus, first breeding to conception, days open, and percent pregnant by 95,120, and 145 days were not statistically significant. Blöttner et al. (2011) reported that Brown Swiss x Holstein crossbred cows were significantly heavier than pure Holstein cows during first lactation (621 kg versus 594 kg), finding that disagrees with present result. In a Canadian study, Schaeffer et al. (2011) found that Holstein and Brown Swiss x Holstein cows were not different for days to first service after calving.In another study carried out in Costa Rica, Mora (2004) found that Holstein, Brown Swiss and Holstein x Brown Swiss cows were similar for days from calving to first service, in accordance with current results.For days to first breeding during first lactation, Blöttneret al. (2011)reported that Brown Swiss x Holstein crossbred cows were not significantly different from pure Holstein cows(71 versus 75 d, respectively), in agreement with present results.However, Brown Swiss x Holstein crossbred cows started tore-bredearlier after calving ($P<0.001$) thanpure Holstein cows during second lactation(81 dversus 89 d), andthe crossbred cows tended to re-bred earlierafter calving ($P<0.10$) than pure Holstein cows duringthird lactation (85 versus 92 d).In accordance with present results, Brandt et al. (1974), for second-generation cows, and Rincon et al. (1982) reported that Holstein, Brown Swiss, Holstein x Brown Swiss and Brown Swiss x Holstein cows were similar in days open. Blöttne et al. (2011) reported that Brown Swiss x Holstein crossbred cows and pure Holstein cows were similar in days open during the first three lactations, finding that also agrees with present findings. On the contrary, Dechow et al.(2007) reported that Brown Swiss x Holsteincrossbreed cows had 20 fewer days openthan pure Holstein and Brown Swiss cows in lactation 1, but Brown Swiss x Holsteincrossbreedcows were not different from pure Holstein and Brown Swisscows in lactation 2, and lactation 3 and higher.More recently, Schaeffer et al. (2011) reported that Brown Swiss x Holstein crossbreds had significantly shorter intervals from first service to conception as heifers and cows than Holstein purebreds.Under subtropical environmental conditions of Egypt, Abdalla and El-Tarabany (2014) found that the calving interval of pure Brown Swiss and Brown Swiss x Holstein crossbreed cows were 28 and 19 days shorter than that of the pure Holstein cows, which is in disagreement with present results.

Holstein and Holstein x Brown Swiss cows were younger than Brown Swiss cowsat first calving (P<0.05), but Brown Swiss x Holstein cows did not differfrom cows of thesethree previously mentioned breed groupsin age at first calving.Schaeffer et al. (2011) found that pure Holstein and Brown Swiss x Holstein crossbred heifers had similar age at first service, in agreement with present result. In contrast, Rincon et al. (1982) reported that Holstein, Brown Swiss, Holstein x Brown Swiss and Brown Swiss x Holstein cows were not different in age at first calving.Brandt et al. (1974) found that first-generation Holstein, Brown Swiss, Holstein x Brown Swiss and Brown Swiss x Holstein cows had similar age at first calving, but second-generation Holstein and Brown Swiss x Holstein cows had smaller age at first calving than second-generation Brown Swiss cows. Dechow et al. (2007) noted that pure Holstein and Brown Swiss x Holstein crossbred cows had smaller least square means for age at first calving than Brown Swiss cows (P<0.05), finding that also was in partial agreement with present results.In Argentina, Vallone et al. (2014) found that F1 Brown Swiss x Holstein cows were five months younger at first calving than pure Holstein cows.

Pure Brown Swiss and Brown Swiss x Holstein crossbred cows required 0.4 fewer services per conception than Holstein cows (P<0.05),but Holstein x Brown Swiss cows did not differfrom Holstein, Brown Swiss andBrown Swiss x Holstein cows in number of services (P>0.05).In agreement, Schaeffer et al. (2011) reported that Brown Swiss x Holstein cows and heifershad significantly lower numberof services per pregnancy than pure Holstein cows, but the difference was very small (around 0.1).Abdalla and El-Tarabany (2014) reported that the number of inseminations per parturition in pure Brown Swiss cows and Brown Swiss x Holstein crossbred cows (2.92 and 2.96, respectively) was significantly lower than in pure Holstein cows and Holstein x Brown Swiss crossbred cows (3.54 and 3.37, respectively), which partially agrees with present results.Blöttner et al. (2011), however, reported that Brown Swiss x Holstein crossbred cows and pure Holstein cows had similar number of services per conception during first (1.8 versus 2.1), second (1.8 versus 2.1) and third lactation (2.2 versus 1.8).The discrepancy may be due to the fact that in the present study the maximum number of services per conception in the actual data was 11 (Table 1), but in the study by Blöttner et al. (2011)the maximum value for this trait was set to 6.Vallone et al. (2014) reported that Holstein, Brown Swiss and F1 Brown Swiss x Holstein cows required the same number of services to become pregnant, in contrast with present results.

Table 4 presents least squares means and their standard errors for pregnancy rate at first service by stage of lactation.Cows in Stage 4 of lactation had higher pregnancy rates at first service (P<0.05) than cows in Stages 1 and 2 of lactation (62.8% versus 44.0 and 49.7%, respectively), and cows in Stage 3 of lactation were superior (P<0.05) to cows in Stage 1 of lactation (56.3% versus 44.0%). In lactating dairy females inseminated at a synchronized ovulation, Pursley et al. (1997) reported that cows that were >75 days postpartum had a greater (P <0.05) pregnancy rate per artificial insemination than did cows that were 60 to 75 days postpartum.

Table 4. Least squares means and their standard errors for pregnancy rate at first service by stage of lactation.

	Stage of lactation			
	1 to 50 d	51 to 100 d	101 to 150 d	≥151 d postpartum
Pregnancy rate at first service, %	44.0 ± 4.3^{c}	49.7 ± 4.2^{bc}	56.3 ± 5.0^{ab}	62.8 ± 3.7^{a}

[a,b]Means with different superscript are different (P<0.05).

Least squares means and their standard errors for reproductive traits by lactation number are in Table 5. First-lactation cows had more(P<0.05) days to first heat and days to first service than second- and third-lactation cows.Third-lactation cows had fewer (P<0.05) days open than first-lactation cows.There were no significant differences for calving interval, number of services per conception or pregnancy rate at first service.In contrast, Dechow et al. (2007), in a study involving Holstein and Brown Swiss purebred and Brown Swiss x Holstein crossbred cows, reported that first- and second-lactation cows had fewer (P<0.05) days open than third-lactation cows.Blöttner et al. (2011) found that first-, second- and third-lactation cows were not different in days open, also in disagreement with present finding.

Table 5. Least squares means and their standard errors for reproductive traits by lactation number.

	Lactation		
Reproductive trait	**1**	**2**	**3**
Days to first heat	170 ± 8.6^{a}	150 ± 8.8^{b}	142 ± 7.1^{b}
Days to first service	172 ± 8.5^{a}	150 ± 8.7^{b}	142 ± 7.0^{b}
Days open	205 ± 9.3^{a}	186 ± 9.9^{ab}	179 ± 7.5^{b}
Calving interval, d	473 ± 9.3^{a}	460 ± 9.5^{a}	464 ± 6.7^{a}
Number of services per conception	1.8 ± 0.09^{a}	1.9 ± 0.11^{a}	1.9 ± 0.07^{a}
Pregnancy rate at first service, %	54 ± 4.3^{a}	54 ± 4.5^{a}	56± 4.9^{a}

^{a,b}Means with different superscript within row are different ($P<0.05$).

In conclusion, purebred Holstein and Brown Swiss cows generally performed as well as their F1 Holstein x Brown Swiss and Brown Swiss x Holstein crossbreed contemporaries, since there was no substantialimprovement in reproductiveefficiency in crossbred cows, indicating absence of favorable effects of heterosis on fertility traits. Futureevaluation ofmilk, health, conformationand longevitytraits of these biological types of cowswould give a better picture of overall performance of them.

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