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Original

Reproductive analysis of Brown Swiss x Zebu and Simmental x Zebu cows in tropical conditions

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ABSTRACT

Objective. Compare the fertility of Brown Swiss x Zebu and Simmental x Zebu crossbred cows reared in a tropical environment. **Materials and methods**. Reproductive traits of 185 Brown Swiss x Zebu and Simmental x Zebu crossbred cows with diverse percentages of European breed were evaluated. Grazing of cows was rotational. The milking was twice daily with the help (suckling) of the calf, which was kept tied next to the dam while she was milked. Traits were evaluated fitting a repeated measures model (except for age at first calving). Calving interval, age at first calving, days open, interval from calving to first service, and weight at calving were analyzed with PROC MIXED of SAS. Pregnancy rate at first service and services per conception were analyzed with PROC GENMOD of the same software. **Results.** Simmental x Zebu cows started to re-bred 39 days earlier after calving ($p<0.05$) and had 47 fewer days open ($p<0.05$) than Brown Swiss x Zebu cows. The calving interval of the Simmental x Zebu cows was 45 days shorter ($p<0.05$) than that of the Brown Swiss x Zebu cows. Simmental x Zebu cows were 34 kg heavier at calving ($p<0.05$) than Brown Swiss x Zebu cows. **Conclusions.** Simmental x Zebu cows had better fertility than Brown Swiss x Zebu cows.

Keywords: Age at first calving, calving interval, crossbreeding, pregnancy rate, repeated measures analysis, tropics (*Source: CAB*).

RESUMEN

Objetivo. Comparar la fertilidad de vacas cruzadas Suizo Pardo x Cebú y Simmental x Cebú criadas en un ambiente tropical. **Materiales y métodos**. Se evaluaron características reproductivas de 185 vacas cruzadas Suizo Pardo x Cebú y Simmental x Cebú con diversos porcentajes de raza europea. El pastoreo de las vacas fue rotacional. El ordeño fue dos veces al día con la ayuda (amamantamiento) del becerro, el cual se mantuvo atado cerca de la vaca mientras ella se ordeñaba. Las características se evaluaron ajustando un modelo de mediciones repetidas (excepto para edad a primer parto). Periodo interparto, edad a primer parto, días abiertos, periodo parto-primer servicio y peso al parto fueron analizados con PROC MIXED de SAS. Tasa de gestación a primer servicio y servicios por concepción,

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se analizaron con PROC GENMOD del mismo programa. **Resultados.** Las vacas Simmental x Cebú se sirvieron después del parto 39 días antes ($p<0.05$) y tuvieron 47 días abiertos menos ($p<0.05$) que las Suizo Pardo x Cebú. El periodo interparto de las vacas Simmental x Cebú fue 45 días más corto ($p<0.05$) que el de las Suizo Pardo x Cebú. Las vacas Simmental x Cebú pesaron 34 kg más al parto ($p<0.05$) que las Suizo Pardo x Cebú. **Conclusiones.** Las vacas Simmental x Cebú tuvieron mejor fertilidad que las Suizo Pardo x Cebú.

Palabras clave: Análisis de mediciones repetidas, cruzamiento, edad a primer parto, periodo interparto, tasa de gestación, trópico (*Fuente: CAB*).

INTRODUCTION

In numerous tropical-climate countries, crossbreeding Zebu with *Bos taurus* breeds (Holstein, Jersey, Brown Swiss) has been a common practice in double-purpose herds to improve milk composition and yield traits, health, survival and fertility. Among these traits, fertility has been observed to have the greatest impact on herd efficiency.

Crossbreeding allows the introduction of favorable genes, and takes advantage of breed complementarity and heterosis. Breed complementarity allows breeders to capitalize on the strengths of different breeds because no single breed excels at all of the traits that affect profitability. In Mexico, the double-purpose production system is mainly formed by crosses between Zebu and Brown Swiss, Holstein Friesian and Simmental (1,2,3).

Several studies performed in different regions of the world have evaluated the reproductive performance of Holstein Friesian x Zebu (4,5,6,7,8,9) or Jersey x Zebu cows (10,11), or have compared the reproductive performance of pure indigenous cows and Holstein Friesian x Zebu crossbred cows (12,13), of Holstein Friesian x Zebu and Jersey x Zebu cows (12,14,15), of Zebu cows and 3/8 Simmental x 5/8 Zebu cows (16), of Brown Swiss x Zebu and Holstein Friesian x Zebu cows (17), and of Holstein Friesian x Zebu and Simmental x Zebu cows (18,19). However, scientific papers related to the reproductive assessment of Brown Swiss x Zebu and Simmental x Zebu cows under the same tropical or subtropical conditions are very scarce; apparently, only one paper regarding the comparison of these last two genotypes has been published (1). A previous Mexican study showed that Simmental x Zebu and Brown Swiss x Zebu cows yielded similar levels of milk (3).

Based on these antecedents, the aim of present study was to compare the fertility of Brown Swiss x Zebu and Simmental x Zebu cows reared in a tropical environment.

MATERIALS AND METHODS

Site of the study. The study was implemented in a dual-purpose cattle herd at Playa Vicente research station belonging to the National Institute for Forestry, Agriculture and Livestock Research (INIFAP), and located at 95 m above the sea level, at 17° 19’ north latitude and 95° 41’ west longitude, in Veracruz, Mexico. The region has humid tropical climate, and average annual temperature and precipitation of 26.8°C and 2,200 mm, respectively (20).

Animals. The number of cows evaluated, and the number of sires and dams used to produce them are presented in table 1.

Table 1. Number of cows, sires and dams, by genetic group.

Genetic group	Cows	Sires	Dams
Zebu	-	-	65
Simmental	-	21	-
Brown Swiss	-	24	-
½ Simmental x ½ Zebu	36	2	21
½ Brown Swiss x ½ Zebu	47	1	28
¾ Simmental x ¼ Zebu	35	2	4
¾ Brown Swiss x ¼ Zebu	45	6	7
⅝ Simmental x ⅜ Zebu	7	-	-
⅝ Brown Swiss x ⅜ Zebu	15	4	4
Total	185	60	129

Reproductive traits of 185 Simmental x Zebu and Brown Swiss x Zebu crossbred cows with diverse percentages of European breed (50.0, 62.5 or 75.0%) were studied. Evaluated cows were born from 1981 to 2003 and were produced with 60 pure and hybrid sires with diverse percentages of the Brown Swiss or Simmental breed, and 129 pure and hybrid dams with diverse percentages of the Zebu breed. The Zebu breed of the pure dams was Indubrazil. The 129 dams were mated to the 60 sires through AI (mainly) and natural service. Cows of both genetic groups were managed together in the same way, and grazed in the same pastures.

Table 2 presents the way crosses were carried out to produce the 185 cows evaluated. The F1 cows were produced with Simmental or Brown Swiss bulls. The 75% European-25% Zebu cows were produced with pure European and 75% European-25% Zebu bulls; the 62.5% European-37.5% Zebu cows were produced with F1 and 75% European-25% Zebu bulls. In addition, the 62.5% Brown Swiss-37.5% *Bos indicus* cows were produced with 62.5% European-37.5% Zebu bulls.

Fedding. Cows were maintained in a rotational grazing system on Guinea (*Panicum maximum*) and African Star (*Cynodon plectostachyus*) grasses. In addition, cows consumed 2 kg/animal/day of a commercial supplement with 70% TDN and 16% CP, 30 days before calving and at each milking until drying off. During the dry season, cows were supplemented with 15-20 kg/animal/day of chopped Japanese cane (*Saccharum sinense*) or corn (*Zea mayz*) silage.

Artificial insemination. Cows were first bred when they reached about 350 kg of body weight. Heat detection was performed 1 h in the morning (from 06:00 a.m. to 07:00 a.m.) and 1 h in the afternoon (from 05:00 p.m. to 06:00 p.m.), with the help of a heat-detector bull. Heat detection efficiency was 60%. 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. Cows were confirmed pregnant by rectal palpation after 45 days of last service. Cows were mainly culled for reasons of poor fertility.

Milking. The milking was mechanical, twice daily, after a brief suckling by the calf to stimulate milk ejection. Calves were kept tied, on one side of their dams, while they were milked. The milk yield of each individual cow was recorded at each milking. During the first three months of lactation, only three quarters of the udder were milked, leaving one quarter for calf's milk consumption, plus the residual milk of the three milked quarters.

From day 91 of lactation to weaning of the calf, the four quarters of the udder were milked, leaving just the residual milk for feeding of the calf. After milking, calves were allowed to suckle for about one hour. Later, the calves were separated from their dams. After weaning, calves were just used to stimulate milk ejection of their dams until drying off, which was performed when cows were seven month pregnant or when they produced less than 3 kg of milk per day.

Response variables. Records for age at first calving, interval from calving to first service, days open, calving interval, services per conception, pregnancy rate and weight at calving were analyzed. Days open was defined as the interval (days) from calving to conception; this trait reflects both pregnancy rate and the female's capability to cycle and express estrus. Pregnancy rate at first service was defined as a binary variable; therefore, if a female became pregnant after first service, a value of 1 was assigned; otherwise, a value of 0 was assigned.

Table 2. Matings carried out to produce the *Bos taurus* x *Bos indicus* cows[a]

Sire	Dam					
	Z	**1S1Z**	**1B1Z**	**3S1Z**	**3B1Z**	**5B3Z**
S	50%S-50%Z	75%S-25%Z				
B	50%B-50%Z		75%B-25%Z			
1S1Z				62.5%S-37.5%Z		
1B1Z					62.5%B-37.5%Z	
3S1Z		62.5%S-37.5%Z		75%S-25%Z		
3B1Z			62.5%B-37.5%Z		75%B-25%Z	
5B3Z						62.5%B-37.5%Z

[a]Z= Zebu, S= Simmental, B= Brown Swiss, 1S1Z= ½ Simmental x ½ Zebu, 1B1Z= ½ Brown Swiss x ½ Zebu, 3S1Z= ¾ Simmental x ¼ Zebu, 3B1Z= ¾ Brown Swiss x ¼ Zebu, 5B3Z= ⅝ Brown Swiss x ⅜ Zebu

Statistical analyses. Age at first calving was analyzed with the MIXED procedure of SAS (21) with a simple model that included cow nested within genetic group of the cow, and sire of the cow nested within genetic group of the sire as random effects, and season of calving, genetic group of the cow, and year of calving as fixed effects.

Remaining traits were analyzed with a repeated measures model that included cow nested within genetic group of the cow, and sire of the cow nested within genetic group of the sire as random effects (except for pregnancy rate and services per conception), and year of calving, lactation number, genetic group of the cow, and season of calving as fixed effects. In addition, for pregnancy rate at first service, the 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 open, weight at calving, interval from calving to first service, and calving interval were analyzed with PROC MIXED of SAS (21); pregnancy rate and services per conception were analyzed with PROC GENMOD of the same software. For services per conception, a Poisson distribution was specified in the model statement; in the statistical analysis of pregnancy rate, a binomial distribution was specified and a logit link function was used.

The statistical model to analyze weight at calving, days open, interval from calving to first service, and calving interval was preliminarily fitted testing different covariance structures (ante-dependence, first-order autoregressive, heterogeneous autoregressive, compound symmetry, heterogeneous compound symmetry, simple, Toeplitz, heterogeneous Toeplitz, and unstructured) in order to provide the best fit to the data.

The covariance structures tested to analyze pregnancy rate and services per conception were first-order autoregressive, compound symmetry, independent, Toeplitz, and unstructured. The selection of the appropriate covariance structure for days open, interval from calving to first service, weight at calving and calving interval was based on Akaike's, second order, and Schwarz's Bayesian information criteria fit statistics. For pregnancy rate and services per conception, the appropriate covariance structure was selected based on the quasi-likelihood information criterion fit statistic.

RESULTS

Table 3 summarizes characteristics of the data for all response variables. Raw means for calving interval, services per conception, age at first calving, interval from calving to first service, days open, pregnancy rate at first service and weight at calving were: 447.5 d, 2.1 services, 36.1 months, 119.5 d, 162.1 d, 43.9%, and 482.4 kg, respectively.

Table 3. Descriptive statistics.

Variable[a]	n	Mean	Std Dev	CV (%)	Minimum	Maximum
AFC (months)	176	36.1	7.2	19.9	23.4	56.0
ICS (days)	641	119.5	78.7	65.9	7	906
SPC	595	2.1	1.3	61.9	1	8
DO (days)	596	162.1	104.9	64.7	7	926
PR (%)	595	43.9	49.7	113.2	0	100
CI (days)	596	447.5	100.1	22.4	298	975
CW (kg)	655	482.4	74.0	15.3	285	770

[a]AFC= age at first calving; ICS= interval from calving to first service; SPC= services per conception; DO= days open; PR= pregnancy rate at first service; CI= calving interval; CW= cow weight at calving.

Information criterion fit statistics for Akaike's, second order, Schwarz's Bayesian, and quasi-likelihood information criteria are presented in table 4.

Table 4. Akaike's (AIC), second order (AICC), Schwarz's Bayesian (BIC) and quasi-likelihood (QIC) information criteria fit statistics.

Trait/Covariance structure	Fit statistic[a]			
	AIC	AICC	BIC	QIC
Services per conception[b]				
First-order autoregressive	-	-	-	**879.33**
Compound symmetry	-	-	-	881.01
Independent	-	-	-	880.28
Toeplitz	-	-	-	881.54
Pregnancy rate at first service[b]				
First-order autoregressive	-	-	-	825.51
Compound symmetry	-	-	-	**825.37**
Independent	-	-	-	825.46
Toeplitz	-	-	-	825.52
Interval from calving to first service[c]				
Simple	**6584.2**	**6584.2**	**6593.9**	-
First-order autoregressive	6585.5	6585.6	6598.6	-
Days open[c]				
Simple	**6375.6**	**6375.7**	**6385.4**	-
First-order autoregressive	6377.6	6377.7	6390.6	-
Calving interval[c]				
Simple	**6305.4**	**6305.5**	**6315.2**	-
First-order autoregressive	6304.0	6304.1	6317.0	-
Compound symmetry	6317.4	6317.5	6327.2	-
Weight at calving[c]				
Simple	6288.2	6288.3	6298.0	-
First-order autoregressive	**6284.1**	**6284.1**	**6297.1**	-

[a]Smaller values indicate better fit; [b]Unstructured covariance was not estimable; [c]Ante-dependence, unstructured, heterogeneous autoregressive, compound symmetry, heterogeneous compound symmetry, Toeplitz, and heterogeneous Toeplitz covariance structures were not estimable.

Appropriate covariance structures used in the definitive model were: first-order autoregressive for weight at calving and services per conception; compound symmetry for pregnancy rate; and simple for calving interval, interval from calving to first service, and days open.

Probability levels of genetic and environmental effects are shown in table 5. Cow nested within genetic group of the cow was a significant source of variation for weight at calving ($p<0.0001$), days open ($p<0.0075$), age at first calving ($p<0.0001$), interval from calving to first service ($p<0.0244$) and calving interval ($p<0.0072$). Sire of the cow nested within genetic group of the sire was significant for weight at calving ($p<0.0206$), days open ($p<0.0107$), interval from calving to first service ($p<0.0278$) and calving interval ($p<0.0125$). Genetic group accounted for variation in days open ($p<0.0023$), calving interval ($p<0.0018$), interval from calving to first service ($p<0.0002$), and weight at calving ($p<0.0008$). Lactation number was a significant source of variation for days open ($p<0.0001$), weight at calving ($p<0.0001$), calving interval ($p<0.0001$), interval from calving to first service ($p<0.0001$) and pregnancy rate ($p<0.0130$).

Adjusted means for response variables analyzed are shown in table 6. Simmental x Zebu cows started to re-bred 39 days earlier after calving ($p<0.05$), had 47 fewer days open ($p<0.05$) and 45 fewer days from calving to calving ($p<0.05$), and were 34 kg heavier ($P<0.05$) at calving than Brown Swiss x Zebu cows.

Table 5. Levels of statistical significance of fixed and random effects for response variables.

Effect	Response variable[a]						
	AFC	ICS	SPC	DO	PR	CI	CW
Cow[b]	<0.0001	0.0244	---	0.0075	---	0.0072	<0.0001
Sire[c]	0.0623	0.0278	---	0.0107	---	0.0125	0.0206
Genetic group	0.1315	0.0002	0.8939	0.0023	0.3617	0.0018	0.0008
Year (Y)	<0.0001	<.0001	0.0042	<0.0001	0.0358	<0.0001	<0.0001
Season (S)	0.1155	0.6925	0.3036	0.7028	0.8084	0.9605	0.2618
Lactation[d]	---	<.0001	0.5058	<0.0001	0.0130	<0.0001	<0.0001
Y x S	---	0.0392	---	0.0002	---	0.0001	0.0010
Stage[e]	---	---	---	---	0.4262	---	---

[a]AFC= age at first calving; ICS= interval from calving to first service; SPC= services per conception; DO= days open; PR= pregnancy rate at first service; CI= calving interval; CW= cow weight at calving; [b]Cow nested within genetic group of the cow; [c]Sire of the cow nested within genetic group of the sire; [d]Lactation= lactation number; [e]Stage= stage of lactation.

Table 6. Least squares means and standard errors for age at first calving (AFC), interval from calving to first service (ICS), services per conception (SPC), days open (DO), pregnancy rate at first service (PR), calving interval (CI) and weight at calving (CW), by genetic group, calving season, lactation number and stage of lactation.

	Response variable						
	AFC	ICS	SPC	DO	PR	CI	CW
Genetic group[d]							
B x Z	36.5±.62[a]	143±6.2[a]	2.1±.08[a]	192±9.6[a]	41±3[a]	476±9.1[a]	451±6.3[a]
S x Z	38.0±.82[a]	104±7.0[b]	2.1±.09[a]	145±10.8[b]	45±4[a]	431±10.3[b]	485±7.2[b]
Calving season							
Cold	38.1±.79[a]	120±6.3[a]	2.1±.10[a]	167±9.5[a]	43±5[a]	453±8.9[a]	470±5.5[a]
Dry	37.5±.75[a]	126±6.7[a]	2.1±.12[a]	173±9.8[a]	41±4[a]	455±9.3[a]	464±5.6[a]
Rainy	36.3±.72[a]	124±5.7[a]	2.0±.09[a]	165±8.4[a]	45±4[a]	452±7.9[a]	470±5.2[a]
Lactation number							
1		144±6.3[a]	2.2±.10[a]	200±9.2[a]	34±4[a]	487±8.7[a]	428±5.3[a]
2		125±6.9[b]	2.0±.12[a]	161±9.9[b]	52±5[b]	445±9.4[b]	469±5.5[b]
≥3		102±5.8[c]	2.0±.08[a]	144±8.7[b]	44±4[ab]	428±8.3[b]	506±5.5[c]
Stage of lactation[e]							
1					37±6[a]		
2					45±4[a]		
3					43±4[a]		
4					48±5[a]		

[a,b,c] Means with different superscript within the same column in each factor are different ($p<0.05$).
[d]B x Z= Brown Swiss x Zebu; S x Z= Simmental x Zebu.
[e]1= from 1 to 50 d; 2= from 51 to 100 d; 3= from 101 to 150 d; 4= ≥151 d postpartum.

Third-lactation cows had fewer ($p<0.05$) days to first service after calving than first- and second-lactation cows. Second-lactation cows had fewer ($p<0.05$) days to first service after calving than first-lactation cows. Second- and third-lactation cows had fewer ($p<0.05$) days open and shorter ($p<0.05$) calving intervals than first-lactation cows. Second-lactation cows had higher ($p<0.05$) pregnancy rate at first service than first-lactation cows; the pregnancy rate of third-lactation cows was intermediate. Third-lactation cows were heavier ($p<0.05$) at calving than first- and second-lactation cows. Second-lactation cows were heavier ($p<0.05$) at calving than first-lactation cows.

DISCUSSION

Scientific papers comparing the reproductive capability of Simmental x Zebu and Brown Swiss x Zebu cows are very scarce in the literature, therefore, in most cases, Simmental x Zebu cows were compared with Holstein Friesian x Zebu cows; however, scientific papers comparing reproductive performance of these last two genotypes are also rare.

Least squares means for age at first calving and calving interval reported for the Simmental x Zebu and Brown Swiss x Zebu genetic groups of the present study are similar to those reported for the Brown Swiss x Zebu genetic group under tropical conditions of Yucatán, Mexico (22), and for the Holstein Friesian x Zebu genetic group in smallholder dairy farms of Ethiopia (5).

In a study carried out in the humid tropics of Mexico, the Brown Swiss x Zebu and Simmental x Zebu genotypes had similar age at first calving and calving interval (1). These results partially agree with those of the present study, in which the Simmental x Zebu and Brown Swiss x Zebu genotypes had similar age at first calving ($p>0.05$), but the Simmental x Zebu genotype had shorter calving intervals ($p<0.05$) than the Brown Swiss x Zebu genotype.

Colombian researchers (19) observed that the interval from calving to first heat of Simmental x Zebu cows was 48.8 days shorter than that of Holstein x Zebu cows; however, these researchers also found that these genetic groups did not significantly differ in age at first heat. In a study carried out in Ethiopia (18), it was found that the calving interval of ¾ Simmental x ¼ Horro (Zebu) cows was 178 days shorter than that of ¾ Friesian x ¼ Horro (Zebu) cows. In contrast, in a study carried out in Brazil (23) Simmental x Zebu and Holstein Friesian x Zebu cows had similar calving intervals.

The lower fertility rate in the Brown Swiss x Zebu cows found in the present study could be due to a greater selection intensity for milk yield in the Brown Swiss breed than in the Simmental breed. It has been shown that milk yield has an unfavorable genetic correlation with fertility, which indicates that selection for more milk diminish fertility (24).

In several studies, the reproductive assessment of *Bos taurus* x *Bos indicus* crossbred cows has revealed that second- and third-lactation cows have shorter calving intervals than first-lactation cows (1,13,15,22), which is in agreement with present findings. This is explained, in part, by the fact that first-lactation cows have not completed their body development, so part of the food that they consume is used for growth, sacrificing milk production and fertility (22). On the contrary, in a study carried out in Tabasco, Mexico (9), with Holstein Friesian x Zebu cows, third-lactation cows had longer calving intervals than first-lactation cows (440 vs 414 days), finding that is in disagreement with present result; also in disagreement are the results obtained with Jersey x Red Sindhi cows in India, where first-, second- and third-lactation cows had similar calving intervals (11). The discrepancy with this last study could be due to the fact that replacement females had an excellent nutrition, which resulted in a good body development before the start of their reproductive life.

In the present investigation, pregnancy rate at first service was not affected by stage of lactation. On the contrary, in a diallel cross with Holstein Friesian and Brown Swiss (25), cows in Stage 4 of lactation (≥151 d postpartum) had higher pregnancy rate at first service than cows in Stages 1 (from 1 to 50 d postpartum) and 2 (from 51 to 100 d postpartum) of lactation (63% versus 44 and 50%, respectively), and cows in Stage 3 of lactation (from 101 to 150 d postpartum) were superior to cows in Stage 1 of lactation (56% versus 44%); however, the discrepancy between studies could be due to differences in genotypes evaluated and herd managing practices. In dairy herds, calves are separated from their dams 4-5 d after calving, but in dual-purpose herds calves are kept tied, on one side of their dams, while the cows are milked. In addition, during the first months of lactation, only three quarters of the udder are milked, leaving one quarter for calf's milk consumption, plus the residual milk of the three milked quarters. The presence of the calf and calf suckling alter the interaction among hypothalamus, pituitary gland and ovaries, inhibiting the release of GnRH, which results in insufficient LH pulses, avoiding ovulation (26).

In conclusion, Simmental x Zebu cows were heavier at calving and had shorter intervals from calving to first service, from calving to conception, and from calving to calving than Brown Swiss x Zebu cows. These results suggest that Simmental x Zebu cows are a better alternative for livestock production in the tropics than Brown Swiss x Zebu cows.

Conflict of interest

The authors declare no conflicts of interest.

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