

Milk production, age at first calving, and calving-to-conception interval in Holstein, Brown Swiss, and Holstein x Brown Swiss cows

Producción de leche, edad al primer parto e intervalo parto-concepción en vacas Holstein, Pardo Suizo y Holstein x Pardo Suizo

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ABSTRACT

The objective of this study was to evaluate milk production, age at first calving, and calving to conception interval in Holstein, Brown Swiss, and Holstein x Brown Swiss crossbred cows within a pasture-based dairy system in Argentina. The increasing global demand for more resilient and locally adapted dairy systems has led to a renewed interest in crossbreeding to enhance both reproductive and productive efficiency through heterosis. We analyzed data collected over 10 years (2014-2023) from 647 first-lactation cows, including Holstein, Brown Swiss, and Holstein x Brown Swiss crossbred cows. Data were examined using a mixed-effects linear model with breed, season, and their interactions as fixed effect and year as random effect. The results showed no significant differences in milk production between breeds or seasons. However, a significant interaction between breed and season was observed for the calving-to-conception interval, with a shorter interval for crossbred cows during spring-summer (102 days), compared to Holstein cows (156 days). This finding highlights a potential advantage of crossbreeding in reducing open days during the warmest months, thereby enhancing reproductive efficiency in pasture-based systems. This study suggests that crossbreeding can be a viable strategy for improving reproductive performance of dairy systems while maintaining similar milk yield compared to the other breeds, particularly in grazing systems.

Keywords

dairy cows • crossbreeding • Argentina • fertility • pasture-based systems • Holstein • Brown Swiss

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RESUMEN

El objetivo de este estudio fue evaluar la producción de leche, la edad al primer parto y el intervalo parto-concepción en vacas Holstein, Pardo Suizo y cruzas Holstein x Pardo Suizo en un sistema lechero pastoril en Argentina. La creciente demanda mundial de sistemas lecheros más resilientes y adaptados a las condiciones locales ha generado un renovado interés por los cruzamientos para mejorar la eficiencia reproductiva y productiva mediante la heterosis. Se utilizaron datos recopilados durante 10 años (2014-2023) de 647 vacas de primera lactancia, incluyendo vacas Holstein, Pardo Suizo y cruza de Holstein x Pardo Suizo. Los datos se analizaron utilizando un modelo lineal de efectos mixtos con la raza, la estación y sus interacciones como efecto fijo y el año como efecto aleatorio. Los resultados no mostraron diferencias significativas en la producción de leche entre razas o estaciones. Sin embargo, se encontró una interacción significativa entre raza y estación para el intervalo parto-concepción, teniendo las vacas cruza un intervalo parto-concepción más corto durante la primavera-verano (102 días) en comparación con las vacas Holstein (156 días), destacando una ventaja potencial del cruzamiento en la reducción de los días abiertos durante los meses más cálidos, mejorando así la eficiencia reproductiva en los sistemas pastoriles. Este estudio sugiere que el cruzamiento puede ser una estrategia viable para mejorar el rendimiento reproductivo de los sistemas lecheros, manteniendo al mismo tiempo una producción de leche similar a la de las demás razas, sobre todo en los sistemas pastoriles.

Palabras clave

vacas lecheras • cruzamientos • Argentina • fertilidad • sistemas pastoriles • Holstein • Pardo Suizo

INTRODUCTION

Holstein cows are the predominant dairy cattle breed around the world (6) and also in Argentina, where they account for 91.6% of the dairy cow population, followed by Jersey (4.7%) and other breeds, including Brown Swiss (9, 10, 15, 20). Despite the predominance of Holstein, Brown Swiss cows offer comparative advantages in milk composition, reproduction, and longevity, which are beneficial in challenging environments for dairy production (2, 8). These characteristics could potentially improve efficiency in dairy systems in regions with variable climatic conditions and variable forage availability, such as in pasture-based systems.

As global demand shifts toward more resilient and locally adapted dairy systems (18), farmers in Argentina have shown renewed interest in crossbreeding. This practice aims to improve the productive, reproductive, and economic efficiency of herds in pasture-based systems (18, 23). Heterosis in crossbred cattle can increase milk production up to 6.5% and enhance fertility and disease resistance by 10% (5, 12, 13).

Crossbreeding strategies worldwide integrate diverse production environments with different genetic groups, leading to greater diversification and optimization of productive systems (3, 21). Crossbreeding Holstein and Brown Swiss cows can combine desirable traits from both breeds. This study aimed to compare milk yield (MY305), calving-to-conception interval (CCI), and age at first calving (AFC) in Holstein (H), Brown Swiss (BS), and their crossbreed (H x BS) in a pasture-based dairy farm in Entre Ríos, Argentina.

MATERIALS AND METHODS

This study analyzed 10 years of records from a dairy farm at the "Las Delicias" Agricultural School, located in western Entre Ríos province (31°54'569" S, 60°25'253" W).

Database

The database included records from herd tests conducted over a 10-year period from January 2014 to December 2023. The records covered 647 first-lactation cows, including 565 H, 53 BS, and 29 H x BS. Monthly herd tests were conducted each year. Individual milk yield was recorded for each cow.

Dairy herd and analyzed variables

In 2014, the farm had 165 milking cows and 23 dry cows. By 2023, the herd consisted of 153 milking cows and 38 dry cows, all managed on the same milking platform within a 190-hectare area. The average annual milk production per cow in 2023 was 17 liters/cow/day (3.9 fat% and 3.7% crude protein). The average diet consisted of approximately 50% grazed pasture, primarily alfalfa and seasonal grasses, while the remaining portion was supplemented with maize silage and concentrate (13% or 16% CP, depending on nutritional requirements) during milking.

Variables analyzed

Year of calving: Year of first calving.

Season of calving: Season in which the first calving occurred.

Age at first calving (AFC): Cow's age at first calving, expressed in days.

Milk yield adjusted to 305 days (MY305): Milk produced in a 305-day period.

Calving-to-conception interval (CCI): Days between calving and conception.

Statistical analysis

Data were analyzed using a mixed-effects linear model, with breed and season as fixed and year as random effect. The model assumptions were verified by analyzing the residuals and adjusting the variance structures by season, breed, or interaction when necessary. The significance of the fixed effects was assessed using Type III ANOVA tables with a significance level of 5%. Significant effects were further analyzed using Tukey's post-hoc test for pairwise comparisons. All statistical analyses were conducted in the R statistical package (27) using the "nlme" (25) and "emmeans" (16) packages for modeling and post-hoc comparisons, respectively.

RESULTS

Table 1 presents the p-values obtained from the Type III ANOVA for the variables analyzed. No significant effects for breed, season, or their interaction were detected on AFC and MY305, indicating that these factors do not influence these variables. However, for CCI a significant interaction between breed and season was found, suggesting that the effect of breed on this variable depends on the time of year.

Table 1. P-values for the fixed effects in the models adjusted for the studied variables, obtained from the marginal ANOVA (Type III) tables.

Tabla 1. Resumen de los valores-p de los efectos fijos en los modelos ajustados por las variables estudiadas, obtenidos a partir de las tablas de ANOVA marginal (Tipo III).

	AFC ¹	CCI ²	MY305 ³
Breed	0.0699	0.8131	0.9331
Season	0.2497	0.1919	0.3843
Breed x Season	0.2143	0.0053	0.3735

¹ Age at first calving. ²

Calving-to-conception interval. ³ Milk yield adjusted to 305 days.

¹ Edad al primer parto.

² Intervalo parto-concepción. ³ Producción de leche ajustada a 305 días.

Table 2 (page XXX) shows the estimated means for each variable by breed and season, along with their standard errors and 95% confidence intervals. For CCI, the results show that H x BS cows have an average of 161 days in Autumn-Winter and 102 days in Spring-Summer. In contrast, H cows had fewer days of CCI in Autumn-Winter (131 days) than in Spring-Summer (156 days). Regarding MY305, higher values were observed across all

breeds for lactations from cows that calved in Autumn-Winter compared to Spring-Summer, although the differences were not statistically significant. For CCI no significant effect of season or breed was found.

Table 2. Estimated means, standard errors, and 95% confidence intervals for Age at first calving (AFC), calving-to-conception interval (CCI), and milk yield adjusted at 305 days in milk (MY305) for different breeds across Autumn-Winter and Spring-Summer.

Tabla 2. Medias estimadas, errores estándar e intervalos de confianza del 95% para la edad al primer parto (AFC), el intervalo parto-concepción (CCI) y la producción de leche ajustada a 305 días (MY305) para diferentes razas en otoño-invierno y primavera-verano.

Variable	Breed ¹	Autumn-Winter	Spring-Summer	Autumn-Winter Confidence Interval	Spring-Summer Confidence Interval
AFC (days)	H x BS	941 (37)	896 (68)	(858, 1024)	(742, 1050)
	H	928 (23)	957 (26)	(877, 979)	(897, 1016)
	BS	957 (35)	1053 (42)	(878, 1035)	(958, 1148)
CCI (days)	H x BS	161 (26)	102 (28)	(102, 220)	(37, 166)
	H	131 (11)	156 (13)	(107, 155)	(127, 185)
	BS	179 (25)	131 (17)	(123, 235)	(92, 170)
MY305 (lt/cow/year)	H x BS	6484 (275)	5703 (543)	(5862, 7106)	(4474, 6933)
	H	6308 (145)	6226 (174)	(5980, 6637)	(5833, 6619)
	BS	6490 (246)	6078 (303)	(5935, 7046)	(5394, 6763)

¹ HxBS: Holstein x Brown Swiss;
H: Holstein; BS: Brown Swiss.

¹ HxBS: Holstein x Pardo Suizo; H: Holstein; BS: Pardo Suizo.

DISCUSSION

This study evaluated the effect of dairy breed on AFC, MY305 and CCI in primiparous cows within a pasture-based system, emphasizing the need to select genotypes adapted to local agroecological conditions for improved efficiency (1).

Milk yield. Our results contrast with studies conducted in intensive systems where H, BS y H x BS produced higher milk yield. Dechow *et al.* (2007) reported that H x BS cows performed similarly to pure H cows in confined systems, exceeding 11,000 liters per lactation. However, in pasture-based systems, forage availability and seasonal variations limit potential milk production (17, 24). In our study, despite the higher productive potential, H cows did not outperform crossbred, likely due to these constraints. A previous study (31) conducted in the same production system (Agricultural School "Las Delicias") but during an earlier period (2007-2013), reported adjusted 305-day milk yield of 7162±856 liters (23.5 liters per cow per day) for H cows, 6168±1046 liters (20.2 liters per cow per day) for BS cows, and 6743±1048 liters (22.1 liters per cow per day) for H x BS cows, with significant differences among breeds. The findings of the previous study suggest that environmental conditions, particularly management and feeding practices, may have contributed to higher milk yields, especially among Holstein cows, which produced significantly more milk.

Age at first calving (AFC). Previous research highlights the benefits of hybrid vigor in improving the reproductive efficiency of crossbred dairy cows. García-Peniche *et al.* (2006) found that crossbred cows (H, BS and Jersey) tend to reach reproductive maturity earlier, offering farmers a significant economic advantage by reducing rearing costs and accelerating the return on investment. However, our study found no significant effect of breed on AFC.

Management and agroecological impacts become evident when comparing our results with previous studies (19). Hutchison *et al.* (2017), found that H cows in intensive systems reach first calving at an average of 24-25 months. In contrast, in our study, H and BS cows took longer to reach reproductive maturity, suggesting that pasture-based conditions impose additional constraints on the growth and development of heifers. This difference highlights the importance of adapting both nutritional and genetic management to local conditions to optimize reproductive efficiency (22).

Calving-to-conception interval (CCI) H x BS crossbred cows in our study had shorter CCI during the Spring-Summer than pure H cows, consistent with previous finding on their superior reproductive performance in warm months (7, 28, 29). In Argentina's main dairy region cows are exposed to heat stress for at least 100 days per year, primarily in spring and summer (15). Thus, a shorter CCI is advantageous in grazing systems, enhancing reproductive efficiency and reducing unproductive periods. Similar trends have been reported by Blöttner *et al.* (2011a) and Prendiville *et al.* (2010), confirming higher pregnancy rates in crossbred cows.

The improvement in reproductive efficiency observed in H x BS crossbred cows could be attributed not only to hybrid vigor but also to the reduction of negative effects associated with inbreeding depression, which commonly affects pure H cows in intensive systems (5). This enhanced reproductive efficiency may be explained by the greater adaptability of crossbred cows to environmental fluctuations, such as forage quality and seasonal variations in temperature (30).

CONCLUSIONS

While no significant differences were observed in age at first calving (AFC) and 305-day milk yield (MY305) among breeds, the significant interaction between breed and season in calving-to-conception interval (CCI) suggests that both environmental conditions and genetic factors influence reproductive efficiency, particularly in H x BS cows during the warmest period of the year. Future studies could focus on further exploring the environmental and genetic factors that drive the observed interactions between breed and season, particularly in relation to optimizing reproductive efficiency in pasture-based systems.

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AUTHOR CONTRIBUTIONS

JB: Conceptualization, Writing - review & editing; PRM: Supervision, Methodology, Writing -;
VC: Data curation, Writing, review & editing; BL: Review & editing; AA: Statistical analysis.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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A DATA AVAILABILITY STATEMENT

The data that supports this study will be shared upon reasonable request to the corresponding author.