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Original

Milk production of Holstein x Gyr cows in a dual-purpose system in the tropics

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ABSTRACT

Objective. To determine the effect of breed group (BG), parity number (PN) and season of calving on lactation length (LL), milk production per lactation (MPL) and per day (MPD) of dual-purpose (DP) cows. **Material and methods.** Data from 160 Holstein x Gyr cows (0 to 75% Holstein) managed in a DP production system in the humid tropics of Chiapas, Mexico were used. Information for LL was analyzed using survival analysis, and that for MPL and MPD by general linear models. The model included the effects of BG (0-25%, 50% and 62.5-75% Holstein), PN and season of calving. **Results.** The means for LL, MPL, MPD were 219.3 ± 39.6 days; 2125.1 ± 568.7 kg; 9.66 ± 1.96 kg, respectively. BG and PN affected all variables. The hazard ratio (HR) of 1.815 indicates that 0-25% Holstein cows had higher risk of being dry-off earlier than F1 cows, which had similar LL than 62.5 to 75% Holstein group. The HR was higher for cows calving in the windy-rainy season (HR=1) than those calving in the dry and rainy seasons (HR=0.448 and 0.446, respectively). The risk that a primiparous cow was dry-off was higher (HR=2.198). The LL of cows with 2 and ≥3 parities was similar. **Conclusions.** BG, PN and season of calving affected LL and milk yield of dual-purpose cows.

Keywords: Calving number; daily milk production; humid tropic; season; survival analysis (*Source CAB*).

RESUMEN

Objetivo. Determinar el efecto del grupo racial (GR), número de parto (NP) y época de parto sobre la duración de la lactancia (DL), la producción de leche por lactancia (PLL) y por día (PLD) de vacas de doble propósito (DP). **Material y métodos.** Se usaron los datos de 160 vacas Holstein x Gyr (0 a 75% Holstein) manejadas en un sistema de producción DP en el trópico húmedo de Chiapas, México. La información de DL se analizó mediante análisis de supervivencia, y la de PLL y PLD usando modelos lineales generales. El modelo incluyó los efectos de GR (0-25%, 50% y 62.5-75% Holstein), NP y época de parto. **Resultados.** Las medias para LL, MPL, MPD fueron 219.3 ± 39.6 días; 2125.1 ± 568.7 kg; 9.66 ± 1.96 kg, respectivamente. El GR y NP afectaron todas las variables. La razón de riesgo (HR) de 1.815 indica que las vacas 0-25% Holstein tuvieron mayor riesgo de terminar la

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lactancia antes que las vacas F1, con una DL similar al GR 62.5 a 75% Holstein. La HR fue mayor para las vacas que parieron en la época de nortes (HR = 1) que aquellas que parieron en las épocas seca y lluviosa (HR = 0.448 y 0.446, respectivamente). El riesgo de que una vaca primípara se seque fue mayor (HR = 2.198). El LL de vacas con 2 y ≥3 partos fue similar. **Conclusiones.** GR, NP y la época de parto afectaron la DL y PLL de vacas doble propósito.

Palabras clave: Análisis de sobrevivencia; época; número de parto; producción de leche; trópico húmedo (*Fuente CAB*).

INTRODUCTION

In Mexico, livestock is an important activity in the agriculture sector, with more than 50% of the national territory dedicated to this activity. The tropical regions in Mexico occupy 25% of the national territory and have great potential development for the production of bovine meat and milk, due to its abundant natural resources. The Mexican tropics contributes 39.6% of the country meat and 21.4% of the country milk production (1,2). In addition, approximately 60% of the 2.3 million cows in Mexico are involved in milk production, being managed in dual-purpose systems using zebu cows crossed to Holstein or Brown Swiss bulls (2). The dual-purpose system is characterized by being extensive, where the animals are fed with native or introduced pastures and occasionally supplemented with agro-industrial by-products (3,4,5).

The productive performance of cattle in the dual-purpose system is poor, with calving intervals of 15 months, calving rates of 40 to 60%, daily milk production between 3.5 to 8 kg, lactations of 800 to 1600 kg of milk and calves weight of 160 kg at weaning (1,4). Some studies (6,7,8,9,10) report the effect of different environmental and breed related factors on milk production in dual-purpose systems under sub-humid tropical conditions, but few of them under humid tropical conditions. Subhumid and humid tropical conditions are different, not only in management practices but also in the amount of rainfall, season differences, and quantity and quality of pasture by month of the year. In addition, the levels of stress and the amount of parasites are different. In general terms, crossbred cows seems to perform better than pure *Bos taurus* or *Bos indicus* cows under tropical climate and extensive management system, due to heat stress and the presence of diseases.

The objective of this study was to determine the effect of breed group, season of calving and parity number on lactation length and milk production of dual-purpose cows managed under humid-tropical conditions. This in order to generate useful information for dairymen to make better management decision.

MATERIAL AND METHODS

Area and period of study. An observational retrospective study was carried out using data from November 2017 to February 2019 in a livestock production unit located on the Juárez-Reforma highway kilometer 10, Ría, Aldama, municipality of Juárez, Chiapas, Mexico. The coordinates are 17°33’19.8” and 17°50’44.88” north and 93°23’25.8” and 93°00’42.84” west latitude, and at an altitude of 140 m above sea level. The climate is hot-humid with average temperature and rainfall of 26°C and 3000 mm, respectively (11). The predominant soil type is luvisol with pH values between 5.5 and 7.0.

Animals and management. The animals were mainly Holstein x Gyr crossbred cows managed under rotational grazing of *Pennisetum purpureum, Panicum maximun, Brachiaria decumbens* and *Brachiaria brizantha*, plus 1 kg of a commercial feed with 18% crude protein (during milking), mineral salt three times a week and water *ad libitum*. The farm was certifícated in good management practices for milk production by SAGARPA-SENASICA. The cows were milked with a mechanical milking machine (DeLaval®), once a day (04:00 to 07:00 hours) every 14 days, after udder disinfection and with calf support. Cows stay with the calves during the first two weeks of life, and subsequently, they were under restricted suckling until weaning (240 days of age). The first 60 days of age, the calves were left with a quarter udder plus residual milk and then, only residual milk until weaning. The calves had free access to African star grass (*Cynodon nlemfuensis*) during the day and 0.5 kg of concentrated feed per animal per day. The reproductive management was by direct mounting. Vaccination was annually against hemorrhagic septicemia, blackleg, and malignant edema.

The information of 160 cows with complete records on lactation length (one lactation per cow) and 142 cows with records on milk production per lactation registered on November of 2017 until February of 2019 was used. Nineteen data from the same number of cows were delete, because milk yield was registered 28 days after calving. Milk yield was weighed every 14 days and that day, the California mastitis test was carried out.

The variables of interest were lactation length (LL, days), milk production per lactation (MPL, kg) and per day (MLD, kg). The LL comprised from the date of calving to the end of lactation, and milk production per day was calculated as MPL/LL. Data were explore and analyzed using the SAS package (12). According to the Kolmogorov-Smirnov test from the UNIVARIATE procedure, LL data (range 105 to 284 days) do not follow a normal distribution ($p<0.01$); therefore, the data were analyzed using time-event (days in lactation-dry-off, respectively) procedures, LIFETEST and PHREG. The fixed model that described the LL variable included the effects of breed group (0-25, 50, 62.5-75% Holstein; reference group 50% Holstein blood), season of calving (dry, rainy and windy-rainy seasons) and parity number (1, 2 ≥ 3 parity cows). The dry season included the months of March, April and May; the rainy season the months of June to October; and the windy-rainy season the months from November to February.

The data for MPL and MPD had normal distribution ($p>0.05$). Therefore, the data were analyzed using GLM procedures applying a fixed effects model similar to that for LL. Simple correlations coefficients were calculated among LL, MPL and MPD using the CORR procedure.

RESULTS

The overall means and standard deviations obtained for LL, MPL and MPD were 219.3±39.6 days, 2125.1±568.7 kg and 9.66±1.96 kg, respectively.

The survival curves by breed group, season of calving and parity number of the cows are shown in figures 1a, 1b and 1c, respectively. The Cox regression coefficients and Hazard ratios (HR) for LL are shown in table 1. The Wilcoxon test provided by the LIFETEST procedure and Wald Chi-square test given by the PHREG procedures showed significant differences of breed group (0.0134 and 0.0107), season (0.0001 and 0.001) and parity number on LL (0.0208 and 0.0024). The HR of 1.815 indicates that cows with 0-25% Holstein blood have higher risk of being dry-off earlier than cows with 50% or 62.5-75% Holstein (HR=1 and HR=1.151, respectively. This indicates a longer LL for F1 (50%) and 62.5-75% Holstein cows. Similarly, cows calving in the windy season had shorter LL than those calving in the dry and rainy seasons (HR=0.448 and 0.446, respectively). In addition, the possibility of a cow being dry-off early and in consequence having a short lactation was higher in the primiparous (HR=2.198) than in multiparous cows (Table 1; HR=0.659 for parity 2 cows and 1 for cows with 3 or more parities). LL of cows with 2, and 3 or more calvings were similar. This is also appreciated in Figure 1.

Table 1. Coefficients of the Cox proportional hazard model and hazard ratio by breed group, season of calving and parity number for lactation length of Holstein x Gyr dual-purpose cows under the humid tropical conditions of Mexico.

Items	Coefficient ± SE	P value	Hazard ratio
Breed group			
0-25	0.596±0.198	0.0026	1.815
50	0	-----	1
62.5-75	0.141±0.222	0.5275	1.151
Season			
Dry	-0.802±0.252	0.0015	0.448
Rainy	-0.807±0.194	<0.0001	0.446
Windy-rainy		-----	1
Parity			
1	0.788±0.255	0.0020	2.198
2	-0.417±0.270	0.1222	0.659
≥3	0	----	1

SE = standard error

With respect to MPL and MPD, breed group and parity number had significant effect on those traits. However, season of calving only have effect on MPL. MPL and MPD were lower in the 0-25% Holstein cows 1785.0 kg and 8.59 kg, respectively) and for primiparous cows 1595.2 kg and 8.13 kg, respectively. The worst MPL was observed in the windy season (Table 2).

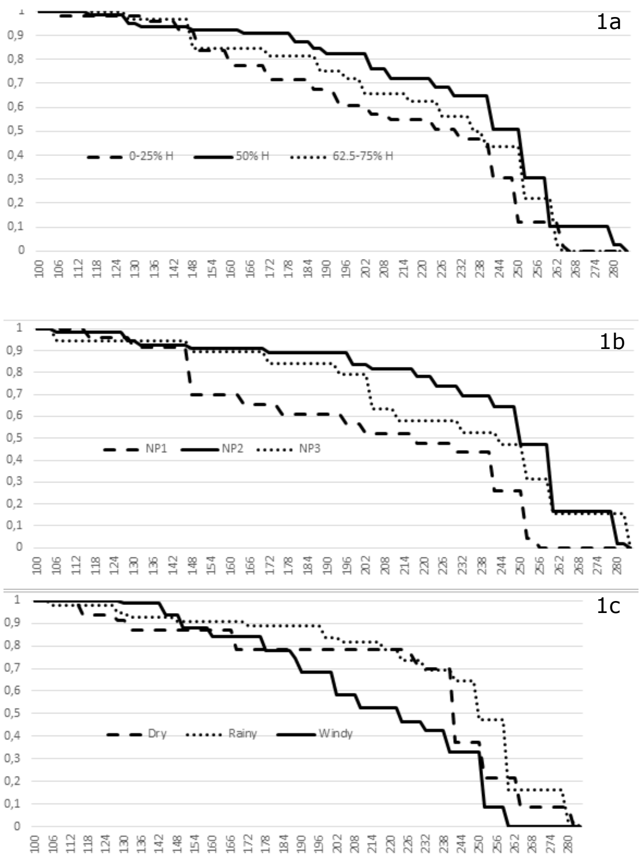

Figure 1. Probability by breed group, parity number (NP) and season of calving that a dual-purpose cow get dry-off under the humid tropical conditions of Mexico

Table 2. Least squares means and standard errors by breed group, number of parities and season of calving for milk production per lactation (MPL) and day (MPD) of dual-purpose cattle under the humid tropical conditions of Mexico.

Items	n	MPL (kg)	MPD (kg)
Breed group			
0-25	49	1785.0±98.5^{a}	8.59±0.37^{a}
50	79	2116.3±82.1^{b}	9.55±0.30^{b}
62.5-75	32	2313.2±112.4^{b}	10.46±0.41^{c}
Season			
Dry	23	2089.1±130.0^{ab}	9.15±0.49^{a}
Rainy	55	2176.6±88.2^{b}	9.76±0.32^{a}
Windy-rainy	82	1948.7±77.8^{a}	9.69±0.29^{a}
Parity number			
1	23	1595.2±122.0^{a}	8.13±0.41^{a}
2	19	2374.4±141.5^{b}	10.51±0.49^{b}
≥3	118	2244.6±64.3^{b}	9.96±0.22^{b}

a,b,c columnas con diferente literal difieren estadísticamente (p<0.05).

A positive simple correlation was found between LL and MPL (r=0.725**) and MPL and MPD (r=0.754**). The relationship between LL and MPD was non-significant (r=0.103).

DISCUSSION

It was decided to use time-event procedures (survival analysis) to determine the effect of breed group, parity number and season on LL of cow data, because they showed no normal distribution according to the Komolgorov Smirnov test (p<0.001). The use of GLM procedure, which is the commonly used in the literature, may give different magnitude of the significance of the factor studied (information not shown). All references here cited, except that of the present study, used GLM procedures.

The overall mean for LL here obtained (219.3 days) is similar to the 214 days reported by Magaña-Monforte et al (13), and less than the 255 and 225 days reported by Hernández-Reyes et al (6) and Parra- Bracamonte et al (7), respectively. However, it is greater than the 203 days reported by Magaña et al (14). All of those works were carried out under subhumid tropical conditions (average temperature and rainfall around 26°C and 1,000 mm). Arce-Recinos et al (15) obtained a LL of 237 days under humid tropical conditions of Tabasco, Mexico (average temperature and rainfall of 27.8°C and 3682 mm, respectively). In Brazil, working with Holstein x Gyr cows, managed with two daily milkings, reached a LL of 283.8 days (16). Likewise, the LL mean here obtained is lower than the means of 326.7 and 305 days in pure Holstein cows reported by Carbajal-Hernández et al (17) under humid and subhumid tropical conditions of Mexico. Differences in LL could be attributed to breed groups and management practices used in each farm and region.

The overall mean for MPL estimated for the farm here studied (2125.1 kg) is higher than the values of 1468 to 1862 kg reported by other authors under subhumid tropical (6,7,13,14) and humid tropical conditions of Mexico (1148 kg; Arce-Recinos et al (15). Similarly, the MPD here found (9.66 kg) is greater than the means of 6.71, 5.81 and 4.84 kg reported by Magaña-Monforte (13), Parra-Bracamonte et al (7) and Arce-Recinos et al (15). There are some main differences between the subhumid tropics and humid tropics of Mexico. In addition to management differences, the humid tropical regions commonly has, more rain per year (about 3000 mm) compared to the subhumid tropics (1000 mm). Disease presence and parasites may be are also important factors. In the subhumid tropics, the worst season is usually the dry season, due to the scarcity of pastures; while in the humid tropics of México the worst season is the windy season, due to the mud and cool rainy-winds present during November to February.

Breed group. The breed groups here evaluated had effect ($p<0.05$) on LL. The 0-25% Holstein cows had shorter LL as compared to the F1 and 62.5-75% Holstein cows, not being significance difference between the last two breed groups. Similar results were obtained for dual-purpose crossbred cows kept under humid tropical (15) and subhumid tropical conditions (9,10,18). Arce-Recinos et al (15) observed that the group with 62.5 to 75% Holstein genes had longer LL (260.3 days) compared to cows with 0-25 and 37.5-50% Holstein blood. The difference between results could be explained, in part, because Arce-Recinos et al (15) grouped F1 and 37.5% Holstein cows. Parra-Bracamonte et al (7) found also that low graded BCS cows had shorter LL than medium and high graded cows; the LL of last two breed groups being similar.

The lowest MPL and MPD here observed, agree with Parra-Bracamonte (7) results, who found that low graded *B. taurus* cows had lower MPL than high graded *B. taurus* cows, not having differences ($p>0.05$) with the middle-graded cows. However, they reported that medium-grade cows had the highest MPD mean. The best performance of medium-grade cows in dual-purpose systems has been notified in different countries (19,20). MPL superiority of the medium-grade cows here compared to the high-grade cows was not dependent on LL because they had similar LL. This study suggest the use of 50 to 75% Holstein cows in dual-purpose production systems. However, how to keep crossbred populations without losing productivity is a problem. Some authors have suggested several breeding alternatives (19,20).

The mean MPL here found (2125.1 kg) is higher than the MPL obtained (1148.2 kg) by Arce-Recinos et al (15) in cows supplemented with molasses-urea and one milking per day. It is also higher than the MPL reported (1862 kg) in Yucatán, Mexico by Hernández-Reyes et al (6) in *B. taurus* x *B. indicus* crossbred cows milked once a day and given 3 kg of commercial feed (18% CP). In Veracruz, Mexico, in crossbred animals, milked twice a day, grazing in improved pastures and supplemented with 1 kg of commercial feed (18% CP, 1.65 Mcal EM) for every 3 kg of milk produced, a high milk production of 4961 kg was reported (10). In Brazil, with Holstein-Gyr crossbred animals, milked twice a day, with a diet based on improved pastures, plus corn silage and concentrated feed, Faco et al (18) reported 2865.2 kg of milk per lactation. The introduction of *B. taurus* genes through crossbreeding increases the production of milk. However, a great variation was observed between and within breed groups; mainly affected by milking system, health status, type of feeding, and quantity and quality of pasture.

Parity number. The parity number affected the LL of the Holstein x Gyr cows here evaluated. Primiparous cows had shorter LL. This result disagrees with those of Magaña-Monforte et al (13), who found no differences between cow parity numbers; however, they observed short LL mean (204 days) for primiparous cows than for older cows (range from 214 to 242 days). Other authors (6) found no effect of parity number, but primiparous cows always showed short LL. The expected short LL of primiparous cows is because they are still growing and the immature reproductive tract limits milk production.

Parity number had significant effect on MPL and MPD (Table 2). Poor MPL and MPD means were observed for the primiparous cows than for older cows, which agree with results by other authors (6,7) in the Mexican subhumid tropics. The poor performance shown by primiparous cows is because they are more susceptible to the effects of the stress of first calving and first lactation (21). In addition, they use part of the energy consumed for growing and reproductive development until they get mature (third or fourth calving). At the end of reproductive development, the milk production of the first parity cows stabilizes, reaching its maximum production, to later decrease as the cows get older (>6 parities). The dissimilarity in milk-yield traits are partly attributed to shorter LL for first parity cows.

Season of calving. In this study, the calving season had effect on the LL and MPL of the crossbred cows here evaluated. The cows calving in the windy season had shorter LL and produced less MPL than those calving in the dry and rainy seasons (Tables 1 and 2). Difference in LL between seasons have also been reported by Magaña-Monforte et al (13) who obtained shorter means for the rainy season (210 days) than for the dry season (228 days). However, in the same sub-humid region Hernández-Reyes et al (6), and Arce-Recinos et al (15) in the humid tropics find no effect of season on LL. This is probably associated to the fact that cows calving in the dry and rainy seasons cows have plenty availability of good pasture, not being the case in windy season when paddocks areas are flooded.

Season effect on MPL is relevant in the humid-tropics, because the direct effects of it on the amount and quality of forage, and temperature and humidity that affect the animals. Feeding could help but reduction of stress caused by high humidity and constant rain and wind should be considered. In this study, cows calving in the windy-rainy season produced 7.2 and 11.7% less MPL than cows calving in the dry and windy-rainy seasons, respectively (Table 2). However, other investigations (6) found no significant differences between seasons in Yucatan, Mexico. Seasonal differences in milk yield are expected to be influenced by feeding management practices in the regions or herds, as well by the type of tropical climate (subhumid or humid) and forage availability (21).

Here, the calving season had also effect on MPL, but not in MPD as have been reported (15). Under the subhumid tropical conditions of Mexico some authors (6,7,13) found differences between season of calving for MPL ($p<0.05$), but the results, in the same region, also differ about which season is better. Magaña-Monforte (13) reported more MPL in the rainy season, contrary to what was observed by others (6,7), who found a better productive performance for cows calving in the dry season.

The season effect is expected to vary if a feed supplement is provided, the period of time given, and the quality of the supplement. In the subhumid tropics, the low milk production in the dry season could be associated with nutritional stress (lack of pasture of good quality). In addition, contrary to what have been found in the sub-humid tropics; in this study, the greatest stress is expected to occur in the windy-rainy season, since here the mud and drizzles and low temperatures play an important role. This directly affect the milk productive performance of dual-purpose cows under humid tropical conditions.

In conclusion breed group, season and parity had effect on LL and MPL of dual-purpose cows under the humid tropical conditions of Mexico. There were positive simple correlation of LL with MPL and of MPL and MPD. Better management of the herd must have a strong impact on milk production of cows kept under humid-tropical conditions.

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Conflicts of interest

The authors do not have any conflict of interest in the publication of this article.

Authors’ contribution

Peralta-Torres JA and Izquierdo-Camacho Y, carried out the design and execution of the experiment; Severino-Lendechy VH participated in the field data collection. Segura-Correa JC participated in the statistical analysis of the data. All authors reviewed and wrote this article.

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