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Influence of milk production records on the estimation of typical and extended curve lactation parameters in local goats under grazing management

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ABSTRACT

The effect of measure number of milk production (MP) on the estimation of parameters in typical and extended lactations curve parameters of local goats was evaluated. This study was conducted with 14 producers in 5 communities of the Comarca Lagunera, State of Coahuila, México. MP was measured monthly by hand-milking during 4 years. Data analyzed included 12,097 observations belonging to 2,229 lactations from 1,125 local goats. The Wood model was utilized to characterize the lactation curve and its parameters (a, b, and c). Two groups were formed, G1 (typical lactation with 3–7 milk measures), and G2 (extended lactations with 8–10 milk measures). The criterion utilized to determine the adequate number of MP measures during lactation was the standard error of the estimate. The best fit in the estimation of the curve parameters was obtained in G2. Factors affecting the curve parameters were also evaluated utilizing the MIXED procedure of SAS. Community, year, and parity number influenced all the parameters in both groups. Flock within community influenced b and c in G1. Season of parity influenced c in G2. It is concluded that a higher measure number of MP in an extended lactation helps in better estimation of lactation curve parameters.

Keywords: Arid zones, Goat milk, Precision, Wood model

Lactation is a biological process that can be described by means of a mathematical function (Quintero *et al*. 2007), and graphically represents the milk production profile of a female from parity to drying off, or end of milk production (Marete *et al*. 2014). The knowledge of lactation curves in dairy cattle is a useful tool in breeding programs, since it allows, a better selection of milk-producing females (Ángel-Marín *et al*. 2009). To ensure that the follow up on a lactation curve is appropriate, it is necessary to collect milk production records throughout lactation (Chang *et al*. 2001). However, under conditions of goat production in extensive systems, as in the north of Mexico, producers are unaware of criteria indicating when to start measuring milk production, how long they should measure it, how long intervals have to be among records (milk measurements), etc., aspects that will allow us to know the milk production curve and, consequently, to have elements to estimate the genetic quality of the goats. Owing to the lack of production data of goats from northern México, parameters such as lactation curve have not been widely studied, hence it is important to generate this information, since the large majority of producers in this region do not know this information and, consequently, decisions at flock level are made empirically. Additionally, some farmers told that the goats in this region have lactations that go beyond the normal period, known as 'extended lactations' (EL), mainly because the producers in this region are more interested in MP than production of kids, as well as feeding limitations which in turn put at risk the maintenance of pregnancy. However, the information describing the extended lactations in local goats of the Lagunera region is limited and the current information indicate only averages of milk production per goat per day (Maldonado-Jáquez *et al*. 2018). The practice of allowing EL in goats has become popular in recent years and its implications have been analyzed at flock level (Butler *et al*. 2010). It had been reported that an EL results in an increase in MP in goats (Douhard *et al*. 2013). Thus, the possibility of modifying the lactation curve means the possibility to prolong lactation and, therefore, increase the lactation persistence, defined as the slope of the decrease in MP starting from the peak of lactation (Sorensen *et al*. 2008). The aim of this study was to evaluate the effect the record number of milk production has on the parameters estimation that characterize the typical and extended lactation curve of local goats in the Comarca Lagunera, México.

MATERIALS AND METHODS

The study was conducted with 14 goat producers in 5

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communities, of which 4 were located in the Municipality of Viesca and one in the Municipality of Matamoros, in the State of Coahuila, México. This region is located between the coordinates 24° 22′ and 26° 23′ North latitude and 102° 22′ and 104° 47′ West longitude, at 1,100 masl. The climate is classified as Bwhw, which is characterized by being very dry or arid, semi-warm with cool winter, an average annual rainfall of 240 mm and an average annual temperature of 25°C, ranging from –1°C in winter to 44°C in summer (García 1998).

This study used a database that initially included 3,397 lactations with 13,899 monthly records of milk production (MP), from 1,749 local goats from 1 to 4 (or more) parities. Individual records and/or lactations with less than 3 records were discarded, which accounted for 13% of the total initial database. Eventually, the edited database included 2,229 lactations with 12,097 observations of 1,125 goats. Goats' management is typical for the extensive system, day grazing and night confinement, without supplementation. Feeding was carried out with native plant species of the region, grasses such as (*Sporobolus* spp. and *Muhlenbergia* spp.), shrubs (*Acacia* spp. and *Prosopis* spp.); occasionally the flocks had access to agricultural wastes of melon (*Cucumis melo*), watermelon (*Citrillus lanatus*), forage oats (*Avena sativa*) and sorghum (*Sorghum halepense*). The care and management of animals was in accordance with the guidelines of the Mexican Council on Animal Care (NOM-062-ZOO-1999).

In order to characterize the lactation curve, the incomplete gamma function was used (Wood 1967), a model that has already been used to adjust the lactation curve of local goats (Gaddour *et al*. 2009). Moreover, it estimates MP with a good level of approximation (Portolano *et al*. 1996). The model is:

$$y_n = an^b e^{-cn}$$

where Y_n, MP on the n-th day of lactation; e, base of the natural logarithm; a, b and c, constants, where a represents the scaling factor, or MP at the beginning of lactation, while b and c represent the limit decline of the curve before and after the lactation peak. By logarithmic transformation the Wood equation was linearized to the form:

$$l\ y_n = la + b\ ln - cn$$

and after this transformation, the parameters a, b, and c were estimated through multiple regression. For the estimation of the curve parameters, two groups were formed; group 1 (G1=typical lactation), considering a six-month lactation for crossbred goats from northern Mexico (Mellado *et al*. 1991) included lactations since 3 until 7 measures (n=1,888 lactations), while group 2 (G2=extended lactation) included lactations since 8 until 10 measures (n=339 lactations). Parturition from 70% of goats used in this study was in autumn (November to February) and remaining 30% in summer (June and July). The criterion used to determine the appropriate number of MP records during lactation was the magnitude of the standard error of the estimator, hierarchizing the equations by frequency of recording (Ramírez-Valverde *et al*. 2004).

Finally, factors affecting the parameters of the lactation curve in G1 and G2 were analyzed using the MIXED procedure of the statistical package SAS v 9.0. (SAS 2002) under the following model. In addition, the lactation curves of both groups were estimated.

$$Y_{ijklmn} = \mu + ID_i + C_j + R_{k(j)} + A_l + EP_m + NP_n + E_{ijklmn}$$

where Y_{ijklmn}, parameter of the curve (a, b, c); μ, constant that characterizes the population; ID_i, random effect of the i^{th} animal (i=1,2,3,., 1125); C_j, fixed effect of the j^{th} community (j=1, 2, 3, 4, 5); $R_{k(j)}$, fixed effect of the k^{th} flock nested in the j^{th} community (k=1, 2, 3, ..., 14); A_l, fixed effect of the l^{th} year of production (l=1, 2, 3, 4); EP_m, fixed effect of the m^{th} season of parity (m=1, 2); NP_n, fixed effect of the n^{th} parity number (n=1, 2, 3, 4+); E_{ijklmn}, random error. It was assumed that for the statistical analysis all random components were normally distributed with zero mean and common variance.

RESULTS AND DISCUSSION

The best fit in the estimation of the lactation curve parameters was obtained by increasing the number of MP records (Table 1). In addition, it was observed that in G1 the standard error was greater than the value of the parameter b. In G2, by increasing the number of records of MP, the estimator value increased, whereas the value of the standard error decreased. Silvestre *et al*. (2006) found that differences between models to estimate lactation curves in dairy cows were higher when the number of records was lower. Gálmez *et al*. (1987) indicated that, due to the fact that MP is a highly variable characteristic, the use of a greater number of records is justified. However, Yépez *et al*. (2010) evaluated the effect of the monthly and biweekly records in the MP and estimation of the lactation curve and did not find significant differences between both methods, so these authors concluded that the monthly measure can replace the biweekly measure. In practical terms, this recommendation means to reduce the number of records, which translates into significant labour savings and stress in animals.

Table 2 shows the factors that influenced the parameters of the lactation curve. Community was significant in both groups (P<0.05). Flock within community was not significant in G1 (P>0.05) for parameter a, but it was

Table 1. Least-squares means and standard errors of the extended lactation curve parameters, according to measure number of milk production in local goats of the Comarca Lagunera, México

Group	Parameter	Estimate	Standard error
G1	a	6.8005	0.0118
	b	0.0293	0.0314
	c	–0.0426	0.0115
G2	a	7.0597	0.0193
	b	0.1567	0.0402
	c	–0.0828	0.0105

Table 2. Non-genetic factors that influence the extended lactation curve parameters, according to measure number of milk production in local goats of the Comarca Lagunera, México

Group	Source of variation	P value of parameter		
		A	B	C
G1	Community	0.0019	0.0018	0.0019
	Flock (Community)	0.0887	0.0254	0.0269
	Year	<0.0001	<0.0001	<0.0001
	Kidding season	0.1307	0.2311	0.3694
	Parity number	<0.0001	<0.0001	<0.0001
G2	Community	<0.0001	<0.0001	<0.0001
	Flock (Community)	<0.0001	<0.0001	<0.0001
	Year	<0.0001	<0.0001	<0.0001
	Kidding season	0.1089	0.0466	0.0275
	Parity number	<0.0001	<0.0001	<0.0001

significant (P<0.05) in G2. Other studies (Macciota *et al*. 2005) pointed out that in goat's environmental factors like month and year of kidding, parity number, lactation stage and altitude within flock affect all parameters of the curve. Waheed and Sajjan-Khan (2013) found that flock had a significant effect on all parameters of the curve and the total MP on Latxa sheep and Beetal goats. Akpa *et al*. (2001) indicated that the effect of the flock on the lactation curve estimators of Red Sokoto goats may have practical implications for trying to find the optimal feeding management in order to maximize the MP level.

Year was significant (P<0.05) in both groups in all parameters of the lactation curve. This coincides with the results of Shaat (2014) in Zaraibi goats concerning parameter a. Parity season had significant effect on parameters b and c (P<0.05) from group G2. Akpa *et al*. (2001) reported that the parity season affects all parameters of the lactation curve, whereas Ruvuna *et al*. (1995) found in crosses of Galla and African Dwarf goats with Toggenburg and Anglo Nubia that the parity season had a significant effect (P<0.05) on all curve parameters, except for parameter a. Also, Sánchez de la Rosa *et al.* (2006) reported that parity season mainly affected (P<0.05) the shape of the lactation curve of local goats.

The parity number had influence (P<0.05) on all curve parameters. Akpa *et al*. (2001) reported that the parity number only affected the a parameter in Red Sokoto goats from Nigeria, and Marete *et al*. (2014) found that the parity number had a significant effect on the parameters a and b, but not on parameter c in Kenya dairy Alpine goats. Other studies (Waheed and Sajjan-Khan, 2013) with Beetal goats in Pakistan indicated that the parity number did not affect any of the parameters of the curve. From the comparison of the results of this study with the different studies in the literature, a great variability as to the effect of the various factors of environmental (non-genetic) origin can be observed in the estimators of the lactation curve, in which mainly climate, feed, and general management can be mentioned.

The lactation curves of G1 (Fig. 1) and G2 (Fig. 2) were

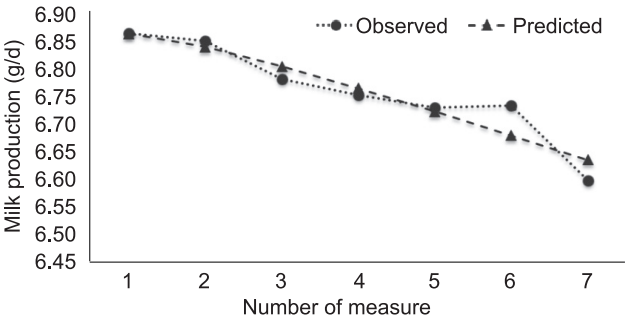

Fig.1. Lactation curve of group G1 (Typical lactation) of local goats of the Comarca Lagunera, México. Milk production values are shown as logarithm of y.

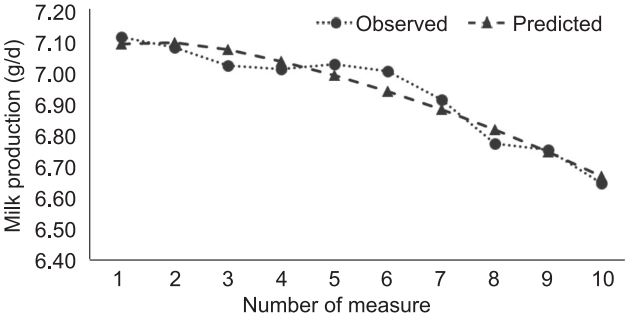

Fig.2. Lactation curve of group G2 (extended lactation) of local goats of the Comarca Lagunera, México. Milk production values are shown as logarithm of y.

estimated based on the parameters shown in Table 1. The lactation curves observed in the two groups followed the same pattern, where the peak of production occur at the beginning of lactation and then decreased gradually. Because in G2 the value of the standard errors was lower than in G1, the lactation curve thus estimated (G2) shows a tendency to represent the typical lactation curve of dairy goats; that is, it started with a slight and gradual increase until reaching a maximum (peak), and then gradually decreased until the complete drying. A similar pattern as for the shape of the lactation curves was found by Marete *et al*. (2014) in local goats from Kenya.

Parameters of the lactation curve are best estimated with a higher number of records of milk production during extended lactations of local goats. Community, year, and parity number affected (P<0.001) all the estimated parameters of the Wood model, in both G1 and G2.

Results of this study suggest recommending producers the need to use a larger number of records of milk production during lactation, in order to achieve an efficient estimation of the lactation curve, and thus have an important criterion for selection of their goats. It is essential that producers in this region begin keeping records such as date of parity, date of drying, additionally information like, size and weight of the litter, sex of the kids, and weight of the goat at parity. This will allow producers to make an efficient selection of their goats during their productive life and thereby help La Comarca Lagunera region continue to lead the way in goat milk production in México.

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