

Modelling Lactation Curve in Dairy Sheep Rose under Extensive Production System

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Abstract

The objective of this study was to compare the goodness-of-fit of four mathematical functions (Wilmink, 1987; Ali and Schaeffer, 1987; Guo and Swalve, 1995; and a cubic regression model) for modeling lactation curve on dairy ewes. Data comprising 53,428 test-day records of daily milk yield (DMY) of 11,251 ewes raised under extensive production system, collected during six consecutive years (2000 to 2005) by the milking recording program of the Churra da Terra Quente (CTQ) dairy sheep breed, were used. Test-day records registered before 30 and after 150 days in milk (DIM) were discharged. All models presented similar fitting quality, with coefficient of determination between 71.0 and 71.3%, and underestimate the DMY for high production levels; this trend was more pronounced for Wilmink model. All models presented similar data fitting-quality, and Wilmink model presented higher difficulties in modeling the beginning and the end of lactation curve, however, being a model with less parameters can present advantages in dairy ewes productions systems where small number of test days controls per ewe can occur.

Key words: Dairy, Lactation, Models, Test-day, Ewes

Introduction

In Portugal, dairy sheep populations are explored mainly under extensive production systems, based in natural pastures and crop residues. Milk is used to produce industrial processed or traditional handmade cheeses. However, lamb meat is very appreciated in Portugal, that is why the dairy ewes production systems includes on month of suckling after which lambs are slaughtered, and lamb meat has Origin Denomination Protection, that's the case of CTQ dairy ewes breed. Selection of animals with optimal production level in different production systems may ensure farmers to produce dairy products more efficiently, and being the first tool to improve cheese production, and consequently the income to the producers. On the other hand, the genetic improvement of small ruminants can contribute to breed conservation, and to maintain a genetic pool of diversity as pointed out by Macciotta et al. (1999). Fitting an appropriate mathematical model to lactation curves is required in order to study the environmental and biological variables that affect milk production, and can also be used to predict future milk yield for lactation currently in progress (Pollot and Gootwine, 2000). The objective of this study was to compare the goodness-of-fitting of Wilmink (1987), Ali and Schaeffer (1987), Guo and Swalve (1995), and a cubic regression functions for modeling lactation curve on dairy sheep rose under an extensive production system.

Material and methods

Data comprising test-day records of DMY from 11,251 ewes, collected during six consecutive years (2000 to 2005) by the milking recording program of the CTQ ewes, were used. All flocks were on the alternate a.m.-p.m. testing plan, and all ewes were milked twice a day, after one month of suckling, following the ICAR

(1992) rules with the A_4 standard method. A maximum of four test-day records were carried out after weaning of lambs (approx. 30 days after lambing). Data were edited and test-day records were removed from analysis: (1) if errors were detected in lambing and birth dates; (2) if the first test-day record was obtained before 30 days post-partum; (3) if the first test-day record was obtained after 75 days post-partum; (4) if records occurring after 150 days post-partum; and (5) if ewes presented less than 3 test-days records. After the first test-day record, subsequent records were included if obtained at approximately monthly intervals thereafter. After editing, a total of 53,428 test-day records were in the final data set. Ewes lactation curve was modelled using four mathematical functions proposed by Wilmink (1987), Ali and Schaeffer (1987), Guo and Swalve (1995) and with a cubic regression model.

The model can be represented as:

$$y_{ijklmn} = \mu + Y_i + M_j + YM_{ij} + P_k + B_l + fym_m + \sum_{q=1}^4 b_{iq}x_q + e_{ijklmn}$$

where: y_{ijklmn} = DMY; μ = constant; Y_i = fixed effect of the year of lambing i , with 6 levels (2000 to 2005); M_j = fixed effect of month of lambing j , with 8 levels (April grouped with March; and July grouped with August since the number of records on April and July were small; YM_{ij} = interaction between fixed effect of the year of lambing i and fixed effect of month of lambing j ; P_k = fixed effect of the parity k , with 9 levels (1st to 9th); B_l = fixed effect of birth type l , with two levels (single or multiple); fym_m = random effect of flock-year-month of test day record interaction; b_{iq} = regression coefficients for mathematical functions in study; x_q = different transformations for DIM; e_{ijklmn} = random residual effect, assumed normally distributed with zero mean and variance. Models comparison was based on the root mean square error (RMSE), and adjusted coefficient of determination. Model residuals were plotted against DIM to evaluate the quality of fitting. A lag graph (Draper and Smith, 1981) was plotted in order to evaluate the autocorrelation of residuals, and relates the i^{th} with the $(i-1)^{th}$ residual, allowing the identification of correlation between successive residuals.

Results and Discussion

The estimated parameters and statistics to evaluate models fitting quality are shown in Table 1. The DMY decreased 58.5% between 30th and 120th day of lactation (data not shown), this decrease in DMY is similar to values presented by Gonzalo et al. (1994). The pattern of DMY across DIM is shown in Figure 1, and unusual lactation curve, with some unusual variations along DIM, can be observed. This high and random variation in DMY can result from the variations in pasture quality and other temporary environmental effects as suggested by Carta et al. (1995).

Table 1. Models parameters, average response, standard error (SE), adjusted coefficient of determination (AdjR²) and root mean square error (RMSE): Wilmink (W), Ali and Schaeer (AS); Guo and Swalve (GS), and cubic regression (CR)

	W	AS	GS	CR
Models parameters				
b_0	968.5 ± 36.65	9708.0 ± 1535.29	1137.42 ± 73.40	554.81 ± 40.59
b_1	-5.2 ± 0.076	-13708.9 ± 2059.54	-2152.2 ± 411.29	11.6 ± 0.78
b_2	-226.8 ± 30.57	4381.1 ± 538.92	-0.0256 ± 0.01465	-0.222 ± 0.010
b_3		-5549.7 ± 1081.22	0.00025 ± 0.00006	0.0009 ± 0.00004
		969.6 ± 232.14	-1107.1 ± 167.11	
Models fitting quality statistics				
Mean	502.3	502.3	502.3	502.3
SE	0.784	0.786	0.786	0.786
AdjR ²	0.710	0.713	0.713	0.713
RMSE	118.9	118.3	118.4	118.4

A similar fitting quality can be observed among the four models studied (Table 1), with similar adjusted R-square (71.0 to 71.3%) and RMSE (118.9 to 118.4 ml). Model residual does not present a random distribution along DIM, showing the difficulty of data to be modelled by the mathematical functions analysed. In extensive production systems the random environmental effects, like feed availability or climate events, could affect DMY during a period of 60 days after its occurrence (Pulina et al., 2005). All models presented

residuals normally distributed around average zero, showed a similar pattern across DIM (Figure 2), and residuals were correlated (figure 3). The Wilmlink function did not fit well at the beginning and end of lactation, being a function with less parameters which makes more difficulty to shape the lactation curve. Valverde et al. (2004) found that differences in equations fitting depends on sampling frequency (number of test days) and on cow's genotype (production level). The shape of lactation curve showed to be atypical. First, a clear peak cannot be found; second, the lactation curve presents and irregular variation along DIM (Figure 1). This irregularity in the lactation curve can be associated to the extensive production system, and corroborates the results reported by Cappio-Borlino et al. (1997), in Valle del Belice sheep breed raised in harsh environmental conditions.

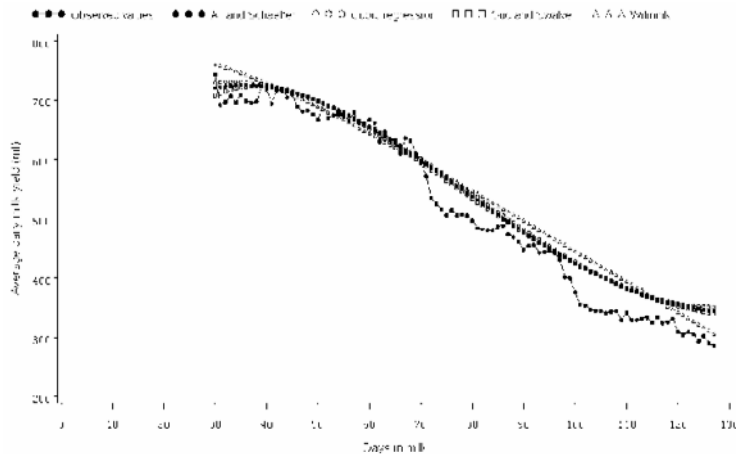


Figure 1. Observed and predicted means across DIM

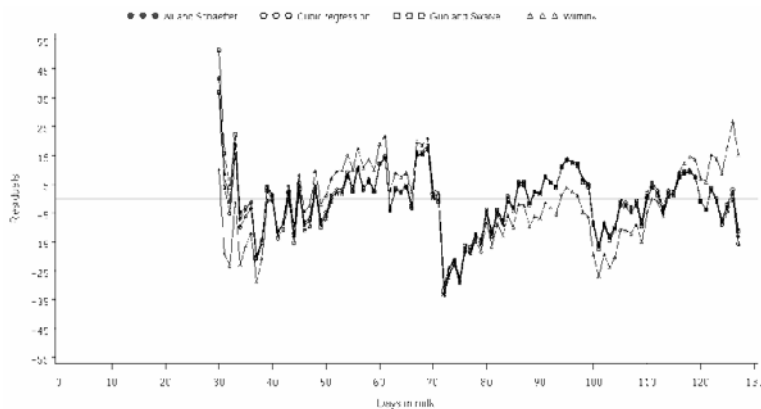


Figure 2. Models mean residuals across DIM

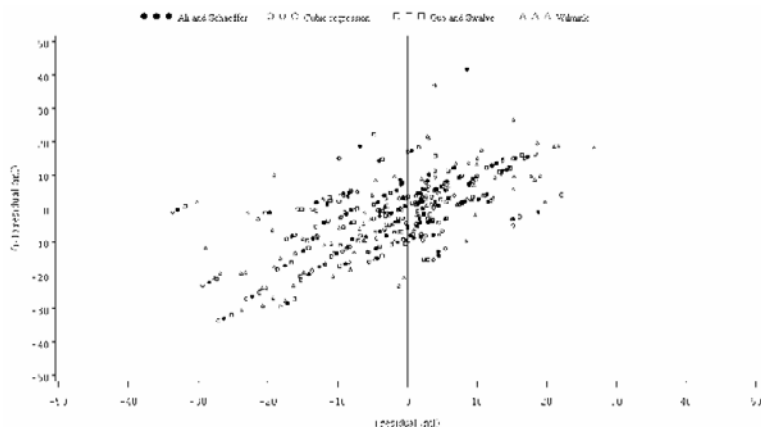


Figure 3. Lag graph of models average residuals

All models overestimate the DMY, especially in early (high production levels) and late lactation, this trend was more pronounced for Wilmlink model. Pollot and Gootwine (2000) found that functions fit better the lactations with low yields, than those with medium and high milk production, attributing this pattern to functions inability to model lactations with higher DMY peak or to the higher variability of DMY in high yielding animals.

Conclusions

All functions studied in this work showed difficulties in modelling the lactation curves of dairy ewes. These results can be explained by the atypical lactation curves presented by the CTQ breed raised under the extensive production system. All models presented similar data fitting-quality, and Wilmlink model presented higher difficulties in modelling the beginning and the end of lactation curve, however, being a model with less parameters can present advantages in dairy ewes productions systems where small number of test days controls per ewe can occur.

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