COMPARATIVE STUDY OF FITTING VARIOUS LACTATION CURVE MODELS IN SAHIWAL COWS

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ABSTRACT

The present investigation was carried out on 25,499 weekly test day milk yield records of first lactation pertaining to 593 Sahiwal cows spread over 49 years located at National Dairy Research Institute, Karnal, India. The comparison of three lactation curve models viz, quadratic model, gamma type function and mixed log function was made in the present investigation. Mixed log function described the best fit with highest coefficient of determination (97.9%) with lowest value of root mean square error (0.025 kg) value. The peak yield of 8.08 kg in 8th week of lactation was observed by mixed log function. The closeness of the curves of mixed log function and gamma type function with the observed lactation curve was of the same order of magnitude. The least coefficient of determination (77.8%) was observed in quadratic model with maximum root mean square error (0.081 kg). The gamma type function when compared to mixed log function, explained low peak yield and it is recommended that this function can give best fit for the low yielding cows.

Key Words: Lactation curve, Sahiwal cattle, Weekly test days

INTRODUCTION

Milk production in dairy animals is a complex physiological process which follows a definite trend of milk secretion throughout the lactation. This is characterized by a peculiar pattern known as lactation curve. Lactation curve is the graphical representation of milk yield against time (Brody et al., 1923). Despite of the prediction of total milk yield of cows, there are lots of advantages of evaluation of lactation curve such as designing suitable breeding and management strategies for dairy cattle as well as for genetic evaluation of dairy cows. Various models have been tried by different workers to fit the lactation curve in indigenous, crossbred as well as in exotic cattle (Guo and Swallve, 1995; Cilek and Keskin, 2008; Rashia, 2010). However, very scanty work has been reported on the Sahiwal cattle which is considered to be one of the best milch breed of dairy cattle in India. Therefore, the present investigation has been undertaken with the objectives to fit and compare three lactation curve models in Sahiwal cows.

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Materials and methods

For the present study, the data of 25,499 weekly test day milk yields (WTDMYs) of first lactation pertaining to 593 Sahiwal cows spread over 49 years (1961-2009) was collected from National Dairy Research Institute, Karnal, India. The climate of the farm is subtropical in nature. The minimum temperature falls to 2º C in winter months, whereas the maximum temperature goes up to 45º C in summer. The annual rainfall is about 760 to 960 mm out of which most of the rainfall is received during the months of July and August. The relative humidity ranges from 41 to 85 per cent.

The data were used to fit three lactation curve models viz, quadratic model (QM), gamma type function (GF) and mixed log function (MLF) on weekly test day milk yields for evaluating best model amongst these three. A total of 43 individual weekly test day milk yields were taken from daily milk yield at an interval of 7 days from 6th day to 305-day of lactation.

Following three models were used in the present study:

1. Quadratic model: (Dave, 1971)
   \[ Y_t = a + bt - ct^2 \]

2. Gamma-type function: (Wood, 1967)
   \[ Y_t = a t^b e^{-ct} \]

3. Mixed log function (Guo and Swallve, 1995)
   \[ Y_t = a + bt^{1/2} + c \log t + e_t \]

In the models given above, \( Y_t \) = Average daily yield in the \( t \)th week of lactation; \( a \) = initial milk yield just after calving; \( b \) = ascending slope parameter up to the peak yield; \( c \) = descending slope parameter; \( t \) = length of time since calving and \( e_t \) = residual error.

The most suitable model was identified on the basis of the highest coefficient of determination (\( R^2 \)) value and lowest value of root mean square error (RMSE). Residuals were plotted graphically which gave an accuracy of the model to fit the lactation curve.

Results and Discussion

Quadratic model: Quadratic model gives least fit than any other lactation curve function studied. It explained the least coefficient of determination (77.8 %) value with highest RMSE (0.081 kg). Lactation curve obtained from quadratic model indicate that milk yield was linearly related with the advancement of the lactation in initial phase and peak phase of lactation. This function could not explain the peak yield of the lactation. Hence, it can neither describe the initial increase of milk yield or the peak production. It can only describe the decline phase of the lactation. Therefore, quadratic model has the merit to represent only the descending segment of the lactation curve in Sahiwal cattle (Fig.1). Similar finding was
reported for quadratic model by Singh and Bhat (1978) in Hariana cattle.

**Gamma type function**: Gamma type function gave high coefficient of determination (95.6%) with low RMSE (0.037 Kg). It could explain low peak yield (Fig. 2). Nearly same coefficient of determination value has been reported by Cilek and Keskin (2008) in Simmental cows of Kazova state farm in Turkey. However, lower R²-value has been reported by Kocak and Ekiz (2008) in Holstein cattle. In accordance with the present finding, Rashia (2010) reported 87.9% of coefficient of determination in Karan Fries cows and also observed low peak yield estimates of weekly test day milk yields. It is recommended that this function can give best fit for the low yielder cows.

**Mixed log function**: Mixed log function explained the highest coefficient of determination (97.9%) value and least value of RMSE (0.025kg). Nearly same coefficient of determination value of mixed log function has been reported by Olori et al. (1999) and Cilek and Keskin (2008) in Holstein Friesian and Simmental cows, respectively. However, lower value (59.1%) was reported by Kocak and Ekiz (2008) in Holstein Friesian cows. The mixed log function gave a very close fit with the observed lactation curve throughout the whole lactation except the peak yield which was slightly lower than the observed (fig. 3).

The peak yield of 8.8 kg in 8th week of lactation was observed by mixed log function. It gave very close fit of observed weekly test day milk yield in the descending phase of the lactation curve. The closeness of the curves of mixed log function and gamma type function with the observed lactation curve was of the same order of magnitude. This may be due to the fact that both of these functions accounted for rising and the declining segments of the lactation curve.

It is observed that from 19th to 20th weeks of lactation, almost all the lactation curve functions gave the same estimates of weekly test day milk yields. The residuals of first lactation weekly test day milk yield estimated by three different lactation curve functions are graphically presented in figure 4.

Mixed log function is the best function for fitting lactation curve amongst three models under study and explained highest coefficient of determination with lowest root mean square error in Sahiwal cattle.

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Fig. 1: Observed and predicted weekly test day milk yields for quadratic model

Fig. 2: Observed and predicted weekly test day milk yields for gamma type function
Fig. 3: Observed and predicted weekly test day milk yields for mixed log function

Fig. 4: Residuals of predicted first lactation weekly test day milk yields for different lactation curves

QM: Quadratic model; GF: Gamma-type function; MLF: Mixed log function

Study of Lactation curve models in Sahiwal cows

REFERENCES


