PREDICTION OF FIRST LACTATION MILK IN SAHIWAL CATTLE USING STATISTICAL MODELS

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ABSTRACT

A study was carried out on 25499 weekly test day milk yields records of first lactation pertaining to 593 Sahiwal cows spread over 49 years located at National Dairy Research Institute, Karnal. The relative efficiency of three lactation curve models via: exponential decline function, parabolic exponential function and inverse polynomial function were compared. Inverse polynomial function described the highest coefficient of determination (99.8%) and with least value (0.055 kg) of root mean square error (RMSE); whereas, the least coefficient of determination (67.7%) was observed in exponential decline function having maximum (0.102 kg) RMSE. On an average, the peak yield from all lactation curves functions was found to be 7.9 kg in 8th week of lactation. The predicted first lactation 305 day milk yields by exponential decline function, parabolic exponential function and inverse polynomial function were 1983.8 ± 32.7, 1986.6 ± 35.4 and 1976.0 ± 24.9 kg, respectively.

Key Words: Lactation curve, Sahiwal cattle, Weekly test day milk yield

INTRODUCTION

Lactation curve can be defined as the graphical representation of milk yield against time (Brody et al., 1923). There are lots of advantages of evaluation of lactation curve such as prediction of total milk yield, designing suitable breeding and management strategies for dairy cattle as well as for genetic evaluation of dairy cows (Macciota et al., 2005). Various lactation curve models have been tried by different workers to fit the lactation curve in indigenous as well as in exotic cattle (Gahlot et al., 1988; Guo and Swallve 1995; Cilek and Keskin 2008; Rashia, 2010). However, very scanty work has been reported on the Sahiwal cattle which are considered to be one of the best breed of dairy cattle in India. Therefore, the objective of the present investigation was to predict first lactation 305 day milk yield and also to predict weekly test day (TD) milk yields using three lactation curve models in Sahiwal cows.

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MATERIALS AND METHODS

The data of 25499 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. The climate of the farm is subtropical. The minimum temperature falls to 2ºC in winter months, whereas the maximum temperature goes up to 45ºC in summer. The annual rainfall is about 760 to 960 mm out of which most of the rainfall is received during July and August. The relative humidity ranges from 41 to 85%. The data were used to estimate lactation curve parameters of the three lactation curve models via: exponential decline function (EDF), parabolic exponential function (PEF) and inverse polynomial function (IPF) for developing the best model. In the formulae given below, Y_t = average daily yield in the t^{th} week of lactation; a = initial milk yield just after calving; b= inclining slope parameter up to the peak yield; c = descending slope parameter and t = length of time since calving.

1. Exponential decline function: (Brody *et al*., 1923)

$$Y_t = a\ e^{-ct}$$

In it logarithm form, this reduces to:

$$Ln\ Y_t = ln\ a - ct$$

2. Parabolic exponential model: (Sikka, 1950)

$$Y_t = a \exp (bt - ct^2)$$

In its logarithm form, this reduces to:

$$Ln\ Y_t = ln\ a + bt + ct^2$$

3. Inverse polynomial model: (Nelder, 1966)

$$Y_t = t\ (a + bt + ct^2)^{-1}$$

The above function after simplification becomes:

$$t / Y_t = a + bt + ct^2$$

The first lactation 305-day milk yield was obtained by addition of the weekly test days (per day average X 7) estimates up to 43 weeks. After log transformation of the functions, the test day milk yield was set as dependent variable and days in milk was set as an independent variable. The functions were analyzed with by multiple regression analysis by the proc Reg of SAS (SAS Institute, 2010) to obtain the model parameters (a, b and c).

RESULTS AND DISCUSSION

The average weekly test day milk yield increased from 4.94 kg in week 1 to a peak yield of 8.31 kg in week 7, and subsequently declined to 4.59 kg in week 43. Lactation curve parameters (a, b and c) were estimated by multiple regression analysis (Table 1).

Three lactation curve function were developed after fitting the values of the lactation curve parameters for predicting first lactation 305 day and weekly test day milk yields. The peak weekly test day milk yield was 8.38 kg in the 8^{th} week of lactation by inverse polynomial function; 8.33 kg in 1^{st} week of lactation for the exponential decline function and finally by parabolic exponential function, it was 7.54 kg in 9^{th} week of lactation (Table 2).

The inverse polynomial function had the highest coefficient of determination (R^2-value) and the lowest root mean square error. Thus, the best model for predicting weekly test day and first lactation 305 day milk yield was inverse polynomial function. Singh *et al.* (2002) and Faro *et al.* (2001) reported 98 and 97.6 %

coefficient of determination values for inverse polynomial function in Sahiwal and Caracu cows, respectively. Contrary to the present investigation, lower value (90.3 %) was reported by Pundir and Kaushik (1993) in Gir cows.

Prediction of first lactation 305-day or less milk yield

The first lactation 305-day milk yield was predicted with high degree of error. However, comparatively, inverse polynomial function explained less error. The three different lactation curve functions viz. exponential decline function, parabolic exponential function and inverse polynomial function predicted first lactation 305-day milk yield as 1983.8 ± 32.7, 1986.6 ± 35.4 and 1976.0 ± 24.9 kg, respectively (Table 3).

CONCLUSION

The inverse polynomial function is the best function of the three models studied which had the highest coefficient of determination with the lowest root mean square error; while exponential decline function was the worst in Sahiwal cattle. On an average, the peak yield from all lactation curves functions was found to be highest at 8th week of lactation in Sahiwal cows. First lactation 305-day milk yield was predicted with higher error from all lactation curve functions except with Inverse polynomial function which give comparatively lesser error. Therefore, it is recommended to use inverse polynomial function for prediction of first lactation 305 days milk yield in Sahiwal cattle.

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Table 1

Different lactation curve functions with parameters for prediction of WTDMYs

Function	Function Equation	Parameters			R^2 (%)	RMSE (kg)
			a	b	c	
EDF	$Y_t = 8.425\ e^{-0.0063*t}$	8.425	-	0.0063	67.7	0.102
PEF	$Y_t = 7.245 \exp(0.0085*t - 0.00047*t^2)$	7.245	0.0085	0.00047	80.5	0.078
IPF	$Y_t = t\,(0.225+0.0656*t + 0.0032*t^2)^{-1}$	0.225	0.0656	0.0032	99.8	0.055

(EDF: exponential decline function; PEF: parabolic exponential function; IPF: inverse polynomial function; RMSE: root mean square error; a = initial milk yield just after calving; b = inclining slope parameter up to peak yield; c = descending slope parameter)

Table 2
Predicted WTDMY and error (kg) of different lactation curve functions

TD	Obs.	EDF		PEF		IPF	
	value	Predicted	Error	Predicted	Error	Predicted	Error
TD-1	4.94	8.33	3.39	7.30	2.36	3.40	-1.54
TD-2	6.67	8.23	1.57	7.36	0.69	5.41	-1.25
TD-3	7.52	8.14	0.61	7.40	-0.12	6.65	-0.87
TD-4	7.93	8.04	0.11	7.44	-0.49	7.42	-0.51
TD-5	8.12	7.95	-0.17	7.47	-0.65	7.89	-0.23
TD-6	8.23	7.86	-0.37	7.50	-0.73	8.17	-0.06
TD-7	8.32	7.77	-0.56	7.52	-0.80	8.32	0.00
TD-8	8.28	7.68	-0.61	7.53	-0.75	8.38	0.09
TD-9	8.27	7.59	-0.68	7.54	-0.73	8.37	0.10
TD-10	8.19	7.50	-0.69	7.53	-0.66	8.32	0.13
TD-11	8.09	7.41	-0.68	7.53	-0.56	8.25	0.16
TD-12	7.94	7.33	-0.62	7.51	-0.43	8.15	0.20
TD-13	7.82	7.24	-0.57	7.49	-0.33	8.03	0.22
TD-14	7.69	7.16	-0.53	7.46	-0.23	7.91	0.22
TD-15	7.59	7.08	-0.52	7.42	-0.17	7.78	0.19
TD-16	7.47	6.99	-0.47	7.38	-0.09	7.64	0.18
TD-17	7.34	6.91	-0.43	7.33	-0.01	7.51	0.17
TD-18	7.22	6.83	-0.39	7.28	0.06	7.37	0.15
TD-19	7.04	6.75	-0.29	7.22	0.18	7.24	0.20
TD-20	6.90	6.68	-0.22	7.15	0.25	7.10	0.21
TD-21	6.83	6.60	-0.23	7.08	0.25	6.97	0.15
TD-22	6.73	6.52	-0.20	7.00	0.27	6.84	0.12
TD-23	6.62	6.45	-0.17	6.91	0.29	6.72	0.10
TD-24	6.51	6.37	-0.13	6.83	0.32	6.59	0.09
TD-25	6.38	6.30	-0.08	6.73	0.35	6.47	0.09
TD-26	6.29	6.23	-0.06	6.63	0.34	6.36	0.07
TD-27	6.20	6.15	-0.05	6.53	0.32	6.24	0.04
TD-28	6.16	6.08	-0.08	6.42	0.26	6.13	-0.03
TD-29	6.01	6.01	0.00	6.31	0.29	6.02	0.01
TD-30	6.01	5.94	-0.07	6.19	0.18	5.92	-0.09
TD-31	5.94	5.87	-0.07	6.07	0.13	5.82	-0.13
TD-32	5.87	5.81	-0.06	5.95	0.08	5.72	-0.15
TD-33	5.78	5.74	-0.04	5.83	0.05	5.62	-0.15
TD-34	5.66	5.67	0.02	5.70	0.04	5.53	-0.12
TD-35	5.56	5.61	0.05	5.57	0.01	5.44	-0.12
TD-36	5.50	5.54	0.04	5.44	-0.06	5.35	-0.15
TD-37	5.42	5.48	0.06	5.30	-0.12	5.27	-0.15
TD-38	5.28	5.41	0.14	5.17	-0.11	5.18	-0.09
TD-39	5.16	5.35	0.20	5.03	-0.13	5.10	-0.05
TD-40	5.01	5.29	0.28	4.89	-0.12	5.03	0.01
TD-41	4.89	5.23	0.34	4.76	-0.13	4.95	0.06
TD-42	4.77	5.17	0.40	4.62	-0.15	4.88	0.10
TD-43	4.59	5.11	0.52	4.48	-0.11	4.80	0.21

EDF: exponential decline function; PEF: parabolic exponential function; TD-: test day

Table 3 - Actual and predicted first lactation 305-day milk yield

Lactation curve models	Actual (kg)	Predicted (kg)	Error (kg)
Exponential decline function	1951.14	1983.85	32.71
Parabolic exponential function	1951.14	1986.6	35.46
Inverse polynomial function	1951.14	1976.04	24.9

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