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Wilmink lactation curve model for prediction of monthly test day milk yields and first lactation milk yield in crossbred cattle of Kerala

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Abstract
The milk yield information of progenies of test bulls were collected from the history sheets and milk record registers of ICAR-Field Progeny Testing Scheme, Kerala. A total of 10 monthly test-day milk yield records (20thday, 50th day,…, 290th day) were taken at an interval of 30 days. Total of 8020 first lactation MTDMYs records of crossbred cattle of Kerala was used to estimate lactation curve parameters for the Wilmink function lactation curve model. Average first lactation MTDMYs predicted with maximum accuracy (R^2= 86.45%), AIC (-58059.79), BIC (-9656.57) and (RMSE = 0.009949 kg). was obtained with Wilmink function. Average first lactation milk yield and predicted FLMY was 2507.87 kg and 2529.43 kg, respectively. This property can be useful in case of incomplete records because in field level more chances for missing data due to certain expected conditions. Modelling of lactation curve is an important tool in designing appropriate breeding and management strategies to achieve genetic improvement.

Keywords: Wilmink lactation curve model, crossbred cattle

Introduction
From the time immemorial, milk and animal rearing were closely knitted to the agrarian based Indian economy. Milk and its products are the major sources of animal protein for the rural masses. The continued emphasis and development of dairy sector of the country made it highest producer of milk in the world. Though buffaloes are the major milk producers of India, cattle are also an important contributor. Milk production of Kerala is estimated to be 2520.04 thousand tones of which 2358.00 thousand tones are from crossbreds and 23.46 thousand tones are from indigenous cattle [1]. Lactation curve is the graphical representation of milk yield against time. Lactation curve has three different phases, namely, ascending phase, persistent phase and declining phase. The ascending phase is the period of sudden rise in the milk yield. The persistent phase indicates the inherent capacity of the animal for sustaining the level of milk production which is the longest phase of the lactation. The last phase is declining phase, indicating drying off the stage of the animal, which is comparatively short. Hence, the shape of lactation curve (LC) gives indications about the various changes in different stage of lactation. The main aim of modelling of the LC is to predict the first lactation milk yield with a minimum error for evaluation of animals for breeding. At any stage of lactation, it is possible to predict milk yield. This property can be used in case of incomplete records as there are more chances for missing data in small holder systems. Modelling of lactation curve is an important tool in designing appropriate breeding and management strategies to achieve genetic improvement.

Materials and Methods
The milk yield and pedigree information of progenies of test bulls were collected from the history sheets and milk record registers of ICAR-Field Progeny Testing Scheme, Kerala. The data from records on monthly test day milk yields and first lactation milk yield of 936 crossbred cattle sired by 188 bulls spread over a period of 16 years (2002-2017) were collected. The records of the cross bred cattle of known pedigree and with normal lactation were included in the present study. The normal lactation of not less than 100 days lactation length and not less than 500 kg lactation milk yield were only considered in the present investigation. The calving should be under normal physiological conditions.

Crossbred cattle having history of abortion, still birth, infertility and other reproductive problems were not included in the present study. Milk yield traits were normalized, so as to make sure that range of normal distribution of values of all traits remain within mean ± 3 standard deviation. In different field centers of ICAR-Field Progeny Testing Scheme, Kerala test day milk yields of animals were recorded at 30 days interval after 20 days of calving. Average lactation length in cross bred cattle was 305 days. A total of 10 monthly test-day milk yield records (20thday, 50th day, 290th day) were taken at an interval of 30 days. Total of 8020 first lactation MTDMYs records of crossbred cattle of Kerala was used to estimate lactation curve parameters for the Wilmink function lactation curve model.

Table 1: Lactation curve model

S. No	lactation curve	Model
1	Wilmink function[2]	$Y_t = a + be^{-k\,t} + ct$

In this model, Yt = Average daily milk yield in the tth test day, a = Approximate initial milk yield just after calving, b = Inclining slope parameter up to peak yield, c = Declining slope parameter, t = monthly test days in milk at tth test day and k = 0.05.

The most suitable model for first parities was identified on the basis of Co-efficient of determination (R^2) value, Root Mean Square Error (RMSE) values, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

Results and Discussion

Table 2: Estimates of lactation curve parameters of different models in crossbred cattle.

Sr. No	Functions	Lactation curve parameters		
		a	b	C
1	Wilmink function	12.41631	-5.21446	-0.02536

Table 3: Goodness of fit criteria for different lactation curve functions.

Sr. No	Functions	R^2 (%)	RMSE (Kg)	AIC	BIC
4	Wilmink function	86.45	0.009949	-58059.79	-9656.57

(AIC - Akaike information criterion, R^2 -Co-efficient of determination, BIC - Bayesian information criterion and RMSE - Root mean square error)

Table 4: Predicted MTDMYs and per cent deviation from observed value of different lactation curve functions in crossbred cattle.

5	O.V	WIF		MTD		O.V	
		P.V	% D		O.V	P.V	% D
1 (20th)	10.08	9.99	0.89	6 (170th)	8.39	8.14	2.98
2 (50th)	10.52	10.72	1.90	7 (200th)	7.73	7.44	3.75
3 (80th)	10.15	10.29	1.38	8 (230th)	6.96	6.76	2.87
4 (110th)	9.69	9.61	0.83	9 (260th)	6.09	6.10	0.16
5 (140th)	9.02	8.86	1.66	10 (290th)	5.30	5.49	3.77

(WIF - Wilmink function, MTD – Monthly test day, O.V – Observed value, P.V - Predicted Value and D – deviation)

Table 5: Actual and predicted average first lactation milk yield of different functions with average and per cent deviation.

Sr. No	Lactation curve models	Actual (kg)	Predicted (kg)	Average deviation	Percent deviation
1	Wilmink function	2507.87	2529.43	334.76	13.35

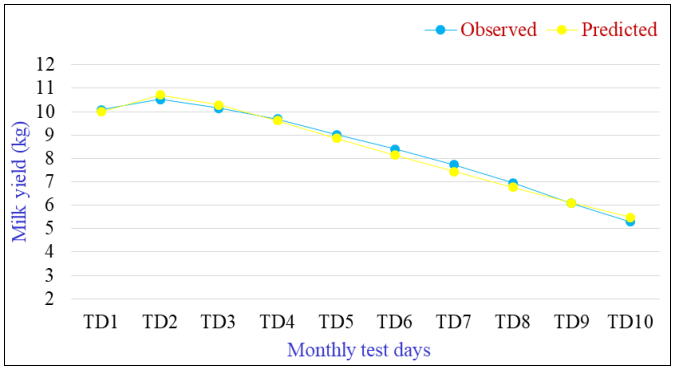

Fig 1: Observed and predicted MTDMYs for Wilmink function in crossbred cattle.

Average MTDMY start from 10.08 kg in first test day and its reached peak yield 10.52 kg at second test day then its start declining and reached minimum of 5.30 kg by last test day. In Holstein Friesian cattle and Karan Fries cattle also reported that highest MTDMY was observed in TD-2 and lowest in last test day [3, 4]. Average first lactation MTDMYs predicted with maximum accuracy (R^2= 86.45%) was obtained with Wilmink function. In HF, Italian water buffaloes, Murrah buffaloes, Simmental cattle, Holstein cows and Murrah buffaloes reported that among various lactation curve models Wilmink function had more than 90% of R^2 [5, 6, 7, 8, 9, 10]. Wilmink function (RMSE = 0.009949 kg). In Karan Fries cattle, Sahiwal cattle and Murrah buffaloes also reported minimum root mean square error 0.0236 kg, 0.08 kg and 0.02 kg, respectively [11, 12, 13].

Based on AIC (-58059.79) the best fitting model to predict first lactation MTDMYs in crossbred cattle of Kerala was Wilmink function. In Iranian primiparous Holsteins and Sahiwal cattle adjudged AIC as goodness of fit criteria for selection of best fit lactation curve, respectively [14, 15]. Thus, the best fitting model to predict first lactation MTDMYs in crossbred cattle of Kerala was Wilmink function when BIC values (-9656.57) are considered. In crossbred cattle, Chiapas sheep and Sahiwal cattle found AIC and BIC as better goodness of fit criteria for selection of best fit lactation curve [15, 16].

Average first lactation milk yield and predicted FLMY was 2507.87 kg and 2529.43 kg respectively. In Sahiwal cattle reported similar range of error in prediction of FLMY in five different lactation curve functions [12].

Concussion

The main aim of modelling of the lactation curve is to predict lactation milk yield with minimum error for evaluation of animals breeding. At any stage of lactation prediction can be done. This property can be useful in case of incomplete records because in field level more chances for missing data due to certain expected conditions. Modelling of lactation curve is an important tool in designing appropriate breeding and management strategies to achieve genetic improvement.

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