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Lactation Curve in Kankrej Cattle

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ABSTRACT

Data on 3307 monthly milk yield records from 425 lactations of Kankrej cows, maintained at Livestock Research Station, Sardar Krushinagar over the period from 1979 to 1987 revealed the significant differences among the months (stage) of a lactation and the years of calving. The first two months in most of the lactations belonged to an ascending phase, as average daily milk tended to increase during this phase. After second month, there was gradual decline upto the end of lactation. Herd production during later years was found to be better mostly due to selective breeding and improved management over the years. The exponential, parabolic and gamma functions using least square means for daily milk yield were fitted to know the shape of lactation curve. The co-effecients of determinants projected the parabolic as the best fit to the lactation curve, followed by the exponential. Thus, lactation curve in Kankrej cattle would be explained to the maximum extent (99.19 to 100%) by parabolic function with minimum error.

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INTRODUCTION

Lactation curve is the graphical representation of the daily or weekly milk production and can be used to estimate the milk yield at any time or in the extension of incomplete lactations. Various workers (Jain *et al.*, 1980; Rao and Sundaresan, 1982., Goel and Tomar, 1982., Pande, 1983 and Gahlot *et al*, 1988) described the shape of lactation curve in different Indian breeds of dairy cattle. However, such attempts are very much lacking in Kankrej cows.

MATERIALS AND METHODS

Data pertaining to 3307 monthly milk yield records from 425 lactations, completed during the period from 1979 to 1987 at Livestock Research Station, Sardar Krushinagar were collected. The lactations were spread over first to fourth parity. Monthly milk yields from first month of calving upto the end of ninth month of lactation were utilized. Average daily milk yields during each month of calving was calculated for all the nine months of lactation. Lactation records less than four months, incomplete due to abortions, culling, sickness and death were excluded. The following three mathematical models were fitted to find out the best fit curve.

(i) Exponential function (Broady *et al.*, 1923)

$$Y_t = Ae^{-ct}$$

(ii) Parabolic function (Sikka, 1950)

$$Y_t = Ae^{bt + ct^2}$$

(iii) Gamma type (Wood, 1967)

$$Y_t = Ae^{be\text{ -}ct}$$

Where Y_t is defined as the average daily milk yield at the time 't'. A is the initial milk yield after calving, 'b' is the linear constant measuring the average slope of the curve and 'c' describes the rate of change for the decline phase. All the functions were transformed to it's long base. The efficiencies of the above functions were compared by coefficient of determination (R^2), residual sum of squares (R.S.S.). Least squares estimates of daily milk yield averages for various months were used,

while fitting the functions. Least squares model included the fixed effects due to year of calving and month after calving and random error besides general mean.

RESULTS AND DISCUSSION

On an average Kankrej cow yielded 4.35 kg of milk daily during first nine months of their lactation (Table 1). Average daily milk yield tended to increase gradually from first to third lactation whereafter it declined (Table 1). Thus, the third lactation appears to be the mature lactation with maximum milk yield. Present findings were in close accordance with earlier report on the same herd (Gujar *et al.*, 1989). On the contrary, Chaudhary (1989) found sixth lactation as mature lactation in Kankrej cattle. Least square analysis of variance (Table 2) revealed the significant variation associated with year of calving and stage of lactation (months). Average daily milk yield tended to increase slowly upto second month. Thereafter, it showed a gradual decline upto the end of lactation (Table 1). Thus, the peak yield in Kankrej would be during the second month of lactation. This resembled the findings of earlier workers in Kankrej (Bhambure, 1986). Gir (Jain *et al.* 1980) and Rathi cattle (Gahlot *et al.* 1988).

Trend of average daily milk yield (wet average for a year) over the years would reflect the phenotypic trend. The production of Kankrej herd appeared to be improved after 1983, the maximum being mostly during 1986, except that for fourth lactation it was during 1985. The improvement in wet average over the years could be due to selective breeding and improved management. Abrupt

TABLE 1

Least squares means of daily milk yield (kg) in different months of lactation and years of calving in Kankrej cattle.

Classification	*Parity*				
	I	*II*	*III*	*IV*	*Pooled*
1	*2*	*3*	*4*	*5*	*6*
(a) Month of lactation					
1.	3.98±0.16 ^{bcd} (142)	4.72±0.16^{a} (153)	5.41±0.25^{a} (80)	5.60±0.27^{ab} (50)	4.74±0.10 ^{bc} (425)
2.	4.53±0.16^{a} (142)	4.90±0.16^{a} (153)	5.90±0.22^{a} (80)	6.21±0.23^{a} (50)	5.12±0.11^{a} (425)
3.	4.55±0.14^{a} (142)	4.71±0.15^{a} (153)	5.64±0.20^{a} (80)	5.92±0.21^{ab} (50)	4.95±0.10^{ab} (425)
4.	4.32±0.13^{ab} (142)	4.25±0.15^{b} (153)	5.24±0.27^{ab} (80)	5.22±0.20^{ab} (50)	4.50±0.10^{cd} (425)
5.	4.15±0.14^{abc} (137)	4.05±0.15^{bc} (149)	4.65±0.22^{bc} (76)	4.75±0.20^{bc} (49)	4.25±0.10^{de} (411)
6.	4.03±0.14 ^{bc} (114)	3.69±0.15^{cd} (136)	4.27±0.22^{cd} (66)	4.16 ± 0.22^{cd} (47)	3.95±0.10 ^{ef} (363)
7.	3.80±0.12^{cd} (106)	3.45±0.15 ^{de} (124)	4.10 ± 0.21 ^{cde} (55)	4.03 ± 0.27^{de} (38)	3.74±0.10 ^{fg} (323)
8.	3.76 ± 0.13^{cd} (98)	3.43±0.11^{de} (98)	3.58±0.19 ^{de} (52)	3.68±0.31 ^{de} (30)	3.61 ±0.11^{gh} (278)
9.	3.49 ± 0.13 ^{d} (86)	3.06 ±0.14^{e} (86)	3.32+0.26^{e} (36)	3.29 ± 0.34^{e} (24)	3.35 ± 0.12^{h} (232)

1	2	3	4	5	6
(b) Year of calving					
1979	3.10 ± 0.10^{d} (358)	3.94 ± 0.12^{b} (199)	-	-	3.44 ± 0.07^{c} (557)
1980	4.45 ± 0.14^{b} (101)	4.06 ± 0.12^{b} (222)	4.16 ± 0.16^{bc} (137)	-	4.18 ± 0.08^{c} (460)
1981	3.25 ± 0.14^{cd} (97)	3.60 ± 0.15^{c} (118)	4.71 ± 0.19^{b} (93)	4.61 ± 0.13^{b} (121)	4.06 ± 0.08^{c} (429)
1982	3.02 ± 0.06^{d} (210)	3.28 ± 0.14^{cd} (143)	3.75 ± 0.17^{c} (112)	3.49 ± 0.16^{d} (81)	3.32 ± 0.08^{c} (546)
1983	3.73 ± 0.15^{c} (93)	3.01 ± 0.21^{d} (52)	4.47 ± 0.25^{bc} (51)	3.94 ± 0.20^{c} (48)	3.79 ± 0.10^{d} (244)
1984	4.81 ± 0.16^{ab} (76)	5.02 ± 0.15^{a} (44)	4.37 ± 0.26^{bc} (40)	4.33 ± 0.20^{bc} (46)	4.66 ± 0.10^{b} (206)
1985	4.80 ± 0.14^{ab} (36)	5.01 ± 0.13^{a} (167)	5.68 ± 0.21^{ab} (36)	5.69 ± 0.19^{a} (48)	5.25 ± 0.08^{b} (287)
1986	5.40 ± 0.18^{a} (60)	5.32 ± 0.12^{a} (192)	6.09 ± 0.23^{a} (60)	3.21 ± 0.18^{f} (44)	5.25 ± 0.09^{b} (356)
1987	3.73 ± 0.16^{c} (78)	4.35 ± 0.10^{b} (68)	4.30 ± 0.20^{bc} (76)	-	4.25 ± 0.10^{c} (222)
Overall	4.12 ± 0.05 (1109)	4.13 ± 0.05 (1205)	4.82 ± 0.08 (605)	4.71 ± 0.09 (388)	4.35 ± 0.03 (3307)

Means carrying same superscripts within a classification did not differ significantly (P≤0.05) from one another.

TABLE 2

Least squares analysis of variance of average daily milk yield in Kankrej cattle.

	Parity				
Source of variance	*I*	*II*	*III*	*IV*	*Pooled*
1	2	3	4	5	6
Years	88.93** (8)	73.24** (8)	52.90** (8)	51.44** (5)	230.46** (8)
Months	10.26** (8)	50.94** (8)	52.97** (8)	48.61** (8)	133.04** (8)
Errors	1.95 (1092)	2.67 (1188)	3.11 (589)	1.88 (374)	2.57 (3290)

Figures in parentheses are degrees of freedom.

** Significant (P ≤ 0.01)

TABLE 3

Estimates of parameters for fitting lactation curves in Kankrej cows.

Types of curve	Estimates of Parameters A	B	C	Coefficient of determination (R^2)	Residual S.S.
1	2	3	4	5	6
		First lactation			
Exponential	4.62	-0.025	-	98.51	0.26
Parabolic	4.10	0.041	-0.007	99.19	0.14
Gamma	1.33	0.217	-0.003	77.71	3.94
		Second lactation			
Exponential	5.37	-0.059	-	99.14	0.03
Parabolic	5.08	-0.031	-0.003	100.00	0.00
Gamma	1.33	0.233	-0.016	72.04	4.86
		Third lactation			
Exponential	6.55	-0.071	-	100.00	0.00
Parabolic	5.73	0.002	-0.007	100.00	0.00
Gamma	1.39	0.259	-0.020	52.86	10.02
		Fourth lactation			
Exponential	6.89	-0.078	-	99.34	0.14
Parabolic	6.19	-0.020	-0.006	99.38	0.13
Gamma	1.40	0.265	-0.022	73.86	5.89
		Pooled over lactation			
Exponential	5.42	-0.052	-	100.00	0.00
Parabolic	5.07	-0.013	-0.004	99.45	0.10
Gamma	1.34	0.237	-0.013	82.14	3.34

TABLE 4

Average absolute deviation of predicted from the observed daily average milk yield in different lactations of Kankrej.

Curve	I	II	III	IV	Pooled
Parabolic	0.17 ± 0.05	0.12 ± 0.03	0.22 ± 0.08	0.14 ± 0.05	----
Exponential	0.65 ± 0.15	1.33 ± 0.30	1.12 ± 0.29	0.94 ± 0.31	1.15 ± 0.27
Gamma	1.28 ± 0.32	1.36 ± 0.39	1.74 ± 0.49	1.80 ± 0.42	1.47 ± 0.36

decline in the milk yield during 1987 was mostly due to non culing of poor yielders during 1986 and partly due to less availability of green fodder.

Fitting of lactation curve

Least square means for daily averages during various months of a lactation were used to fit exponential, parabolic and gamma functions in Kankrej. Estimates of parameters to fit these function with their efficiencies are given in Table 3.

It's perusal revealed that maximum variability in a lactation for daily milk yield could be explained by fitting a parabolic function (R^2 = 99.19 to 100 per cent). Fitting of exponential curve also determined around 98.57 to 100 per cent of variability in the curves for first to fourth lactation (Table 3). On the contrary gamma function could only explain 52.86 to 77.71 per cent variability in a lactation curve. Accordingly, the residual sum of squares were also negligible for parabolic and exponential curves. Thus, the best fit for all lactation curves was found to be parabolic function. There was no much difference in the efficiencies of parabolic and exponential curves. Hence, either of the one could be used to explain the lactation curve in Kankrej cattle. These results are contrary to the findings of Yadav *et al.* (1977) and Singh and Bhat, (1978) in Hariana Catle and of Gahlot *et al.* 1988 in Rathi cattle. They found the maximum efficiency for gamma and inverse polynomial curves and the least for exponential and parabolic functions. The differences in results could be attributed to the breed differences.

The average daily milk yields during various months of a lactation were predicted by fitting parabolic, exponential and gamma curves. The average absolute deviations from the observed milk yield (Table 4) were minimum for parabolic folowed for exponential curves. Similarly, Gahlot *et al.*, (1988) observed less absolute deviations for parabolic than for gamma functions in Rathi cattle. However they found maximum error for exponential curve. Exponential function had shwon the tendency to under estimate the milk yield during latter phase of lactation, especially beyond fourth month. Thus, the prediction of daily milk yield during various months by fitting a parabolic curve would be less erroneous.

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