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Estimation of genetic parameters of first lactation 305-day and monthly test-day milk yields in Karan Fries cattle

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ABSTRACT

The present investigation was carried out using first lactation 16,184 monthly test-day milk yields (MTDMYs) records of 1,583 Karan Fries cattle that calved from 1983 to 2012 sired by 130 bulls maintained at ICAR-National Dairy Research Institute, Karnal. Mixed model analysis was carried out by least-squares maximum likelihood programme to study the effects of genetic and non-genetic factors on first lactation 305-day milk yield (FL305DMY) and MTDMYs record of Karan Fries cattle. The highest and lowest MTDMYs were observed in TD-2 (12.95 kg) and TD-10 (9.72 kg), respectively. The average FL305DMY was 3123 kg. The effect of season of calving was found to be highly significant on all the MTDMYs while non-significant effect was observed on FL305DMY. Period of calving had non-significant effect on most of the MTDMYs and on FL305DMY, whereas; the effect of age at first calving was highly significant on majority of the MTDMYs and on FL305DMY. The heritability estimates for FL305DMY was 0.35±0.07 and for MTDMYs it ranged from 0.11 (TD-11) to 0.34 (TD-6). The genetic and phenotypic correlations among MTDMYs and with FL305DMY were found to be highly significant. The estimates of phenotypic and genetic correlations among all the MTDMYs ranged from 0.15 (TD-1 and TD-11) to 0.83 (TD-8 and TD-9) and 0.29 (TD-1 and TD-10) to 0.99 (TD-2 and TD-3), respectively. High phenotypic and genetic correlations of TD-3 (0.69 and 0.91) and TD–4 (0.65 and 0.99) with FL305DMY indicated that these key test-day yields could be used for the early and accurate selection of animals resulting in faster genetic gain.

Key words: Cattle, First lactation 305-day milk yield, Genetic parameters, Karan Fries, Monthly test-day milk yield

Over the years, the genetic evaluation of dairy cattle has been performed on the basis of first lactation 305-day milk yield (FL305DMY) which leads to increased generation interval, decreased genetic gain per unit of time, fewer number of daughters per sire due to smaller herd size and is a costly and time consuming proposition under field conditions. Now-a-days in many countries of world, genetic evaluation of dairy animals for milk production is based on test-day milk yield (TDMY) records instead of using 305-day lactation yield (Jamrozik and Schaeffer 1997, Schaeffer *et al.* 2000, Togashi and Lin 2004). A test-day (TD) record is the milk yield (morning and evening) of cattle at the time of testing on a particular day. Test-day milk yield model is a statistical procedure which considers all genetic and environmental effect directly on a test-day basis (Swalve 1995). The data for TDMY of dairy cows provide an example of repeated measures or longitudinal data, the essential feature of which is the presence of correlations between test-days on the same animal. The investigations conducted on TD records at various intervals, viz. weekly, fortnightly, monthly and bimonthly (Singh and Rana 2008, Chakraborty *et al.* 2010, Tailor and Singh 2011, Kokate *et al*. 2013, Debbarma *et al.* 2014) also revealed the importance of TDMY for early selection of dairy animals because of high genetic association among different test-day records and with 305-day milk production record. As per the Livestock Census (2012), India has 190.09 million cattle, out of which 39.73 million are crossbred. Though the population of crossbred cattle is very small in comparison to indigenous cattle, the contribution of crossbred cattle to total cow milk produced in India is 54% (31.07 million tonnes) which is more than the milk produced from indigenous cattle viz. 26.69 million tonnes (46%) as per BAHS (2013). This revealed the importance of crossbred cattle as compared to indigenous cattle for milk production. Karan Fries is a crossbred cattle developed at ICAR-National Dairy Research Institute, Karnal in India using Tharparkar as a Zebu (*Bos indicus*) and Holstein Friesian as exotic (*Bos taurus*) cattle in the year 1980. The level of inheritance of Friesian cattle in Karan Fries is 50–75% (Gurnani *et al.* 1986). Information on estimates of genetic parameters of FL305DMY and monthly test-day milk yields (MTDMYs) of Karan Fries cattle is scanty and therefore, the present investigation was aimed to estimate the genetic parameters of FL305DMY and MTDMYs of Karan Fries cattle, intending to provide useful data to the dairy cattle genetic improvement programs.

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MATERIALS AND METHODS

Data structure: The relevant data on FL305DMY and MTDMYs were collected from the history-cum-pedigree sheets and daily milk yield record registers of Karan Fries cattle maintained at Dairy Cattle Breeding Division of ICAR-National Dairy Research Institute, Karnal. Cows were milked by machine milking, thrice a day and all animals are stall-fed and nutritional requirements are met through a balanced ration of green and dry fodder along with suitable roughages and concentrate. Total 16,184 MTDMYs records were analyzed from 1583 Karan Fries cattle sired by 130 bulls during 1983 to 2012. TDMY records were taken at monthly intervals starting from day 6th of lactation (TD-1) to 305th day (TD-11). Bulls with 5 or more progenies were considered for the present study. Lactation yields shorter than 100 days and less than 800 kg were excluded from the study. Culling in the middle of lactation, still birth, abortion, dystocia or any other pathological problems which affected the lactation yield were considered as abnormalities and were not taken for the present investigation. The data were classified into different seasons and periods. Each year was classified into 4 calving seasons - winter (December to March), summer (April to June), Rainy (July to September) and autumn (October to November). The data spread over 30 years duration (1983–2012) were classified into total 5 periods of calving of 6 year each. Age at first calving (AFC) was classified into 11 groups at an interval of 60 days (< 800, 801–860, 861–920, ..., >1341).

Statistical analysis: Mixed model analysis of data was carried out by least-squares maximum likelihood programme (Harvey 1990) to study the effects of genetic and non-genetic factors on FL305DMY and MTDMYs record of Karan Fries cattle. The following model was used:

For 305 Days Milk Yield: $Y_{ijklm} = \mu + S_i + P_j + A_k + B_l + e_{ijklm}$

For Test Day Milk Yields: $TDY_{ijklm} = \mu + S_i + P_j + A_k + B_l + e_{ijklm}$

where, Y_{ijklm}, FL305DMY of the mth individual of lth sire in kth age group of jth period and ith season; TDY_{ijklm}, test-day milk yield of the mth individual of lth sire in kth age group of jth period and ith season; μ, population mean; S_i, fixed effect of ith season (i=1 to 4); P_j, fixed effect of jth period (j=1 to 5); A_k, fixed effect of kth age group (k=1 to 11); B_l, random effect of lth sire, NID (0, σ^2_s); e_{ijklm}, random error, NID (0,σ^2e). For significant effects, the differences between pairs of levels of effects were tested by Duncan's multiple range test as modified by Kramer (1957). The model–II of LSML software using mixed model procedure readily provided the estimates of heritability and genetic and phenotypic correlations along with the standard errors among different MTDMY and with FL305DMY from the analysis of variance and covariance among sire groups. The statistical significance of correlations was tested by 't' test as given by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Highest and lowest MTDMYs were observed on TD-2

Table 1. Mixed models ANOVA showing mean sum of squares for factors affecting monthly test-day milk yields and first lactation 305-day or less milk yield

Source of variation	Degree of freedom	TD–1	TD–2	TD-3	TD-4	TD-5	TD-6	TD-7	TD-8	TD-9	TD–10	TD–11	305-DMY
Sire	130	16.48	16.93	18.39	18.50	19.00	19.88	20.62	21.53	24.75	31.33	34.06	1257401
Season	3	63.41**	494.59**	475.68**	582.60**	397.90**	342.95**	279.90**	339.35**	426.27**	549.62**	440.47**	1202861^{NS}
Period	4	25.57^{NS}	21.73^{NS}	25.53*	27.33^{NS}	28.37*	22.03*	23.83^{NS}	35.51*	33.08^{NS}	18.39^{NS}	27.15^{NS}	1351509^{NS}
AFC	10	50.39**	60.53**	44.68**	24.44*	27.04**	16.13^{NS}	25.40*	31.45**	18.77^{NS}	15.54^{NS}	21.96^{NS}	1513490*
Error	1435	11.52	10.46	10.18	12.14	11.17	9.53	11.08	13.04	14.78	19.07	25.39	601221

*P < 0.05; **P< 0.01; NS (Non-significant).

(12.95 kg) and TD-10 (9.72 kg), respectively. In general, MTDMYs increased till TD-2 and thereafter a gradual decline was noticed up to TD-10 and then again increased at TD-11. The coefficient of variation of MTDMYs ranged from 27.79% (TD-2) to 55.32% (TD-11) and exhibited a consistently increasing trend with advancement in the stage of lactation. Kokate *et al.* (2013) also reported consistently increasing trend of coefficient of variation with advancement in lactation with a wider range of 27.17–92.72%. The average FL305DMY was 3,123 kg with coefficient of variation 27.49%. This estimated value was near to the earlier estimates reported by Singh (2006), Kokate *et al.* (2013) and Divya *et al.* (2014) being 3,197 kg, 3,068 kg and 3,110 kg, respectively, in Karan Fries cattle. However, the estimate was higher than the average 305-day milk yield reported by Saha *et al.* (2010) being 2,470 kg in Karan Fries cattle.

Effect of non-genetic factors: The effect of season of calving on all MTDMYs was highly significant ($P<0.01$) (Table 1). Machado *et al.* (1999), Rose (2008) and Kokate *et al.* (2013) also observed significant effect of seasons on all MTDMYs in crossbred cattle. The least squares mean alongwith their standard errors for seasons affecting MTDMYs are presented in Table 2. The MTDMYs were highest in summer followed by winter for TD-1. However, for TD-2 and TD-3, the highest milk yield was observed in winter followed by autumn season. TD-4, TD-5 and TD-6 observed the highest milk yield in autumn, on TD-7, the highest milk yield was observed in rainy followed by autumn season and for TD-8, the highest milk yield was observed in rainy followed by summer. In case of TD-9, TD-10 and TD-11, the highest milk yield was observed in summer season. This revealed that no definite trend for effect of season of calving was observed for MTDMYs. The effect of season of calving on FL305DMY was non-significant (Table 1). Rashia (2006) and Divya (2012) in Karan Fries cattle also observed non-significant effect of season of calving on FL305DMY. On the contrary, Saha *et al.* (2010) found significant effect of season of calving on FL305DMY. The least squares mean alongwith their standard errors for seasons affecting FL305DMY are presented in Table 2. The FL305DMY was observed to be highest (3,270 kg) for autumn followed by rainy (3,139 kg), winter (3,138 kg) and summer (3,095 kg) season. Rashia (2006) also reported highest FL305DMY in autumn (3,059 kg) and lowest in summer season (2,901 kg).

The effect of period of calving on all MTDMYs and on FL305DMY was non-significant except on TD-3, TD-5, TD-6 and TD-8 (Table 1). Singh and Gurnani (2004) also reported that the 305-days or less milk yield was non-significantly influenced by the period of calving in Karan Fries cattle at NDRI. On the contrary, Saha *et al.* (2010) and Kokate *et al.* (2013) reported highly significant effect of period of calving on 305-day or less milk yield. The least squares means alongwith their standard errors for the effect of period of calving on MTDMYs and on FL305DMY are

Table 2. Least squares means along with their standard errors for non-genetic factors affecting monthly test-day milk yields and first lactation 305-day or less milk yield

	TD–1	TD–2	TD-3	TD-4	TD-5	TD-6	TD-7	TD-8	TD-9	TD–10	TD–11	305-DMY
Overall (1583)	9.64	12.77	12.52	12.01	11.59	10.97	10.40	9.61	8.87	7.61	5.6	3160
	±0.15	±0.15	±0.16	±0.15	±0.16	±0.17	±0.17	±0.17	±0.18	±0.21	±0.21	±43
Seasons												
Winter (704)	9.99^{a}	14.20^{a}	13.71^{a}	12.90^{b}	11.61^{b}	10.35^{c}	9.45^{c}	8.37^{c}	7.84^{c}	6.87^{c}	5.62^{b}	3138
	±0.17	±0.17	±0.18	±0.188	±0.19	±0.19	±0.19	±0.20	±0.21	±0.24	±0.25	±48
Summer (444)	10.08^{a}	12.61^{b}	11.92^{b}	10.78^{c}	10.19^{c}	9.69^{d}	9.78^{c}	9.95^{ab}	10.03^{a}	9.23^{a}	7.25^{a}	3095
	±0.20	±0.20	±0.20	±0.21	±0.21	±0.21	±0.21	±0.22	±0.24	±0.27	±0.29	±53
Rainy (252)	9.51^{ab}	11.41^{c}	11.19^{c}	10.84^{c}	11.25^{b}	11.65^{b}	11.53^{a}	10.45^{a}	9.35^{b}	7.97^{b}	5.36^{b}	3139
	±0.25	±0.24	±0.25	±0.26	±0.25	±0.25	±0.26	±0.27	±0.29	±0.33	±0.36	±63
Autumn (183)	8.95^{b}	12.84^{b}	13.26^{a}	13.48^{a}	13.29^{a}	12.20^{a}	10.83^{b}	9.68^{b}	8.26^{c}	6.39^{c}	4.17^{c}	3270
	±0.28	±0.27	±0.27	±0.29	±0.28	±0.27	±0.29	±0.30	±0.33	±0.37	±0.41	±70
Periods												
Period (1983–88)	10.15	12.73	12.35^{a}	12.68	11.91^{a}	10.71^{b}	10.30	9.75^{a}	9.11	7.88	6.60	3233
	±0.51	±0.49	±0.48	±0.52	±0.51	±0.47	±0.51	±0.55	±0.58	±0.66	±0.75	±120
Period (1989–94)	10.63	12.86	12.96^{a}	12.30	12.11^{a}	10.68^{b}	10.50	9.79^{a}	9.08	7.82	6.25	3244
	±0.41	±0.40	±0.40	±0.43	±0.41	±0.39	±0.42	±0.45	±0.47	±0.54	±0.61	±99
Period (1995–00)	9.45	11.73	11.54^{b}	10.89	10.59^{b}	9.98^{b}	9.32	8.19^{b}	7.49	6.60	4.62	2891
	±0.44	±0.43	±0.42	±0.46	±0.44	±0.42	±0.44	±0.48	±0.51	±0.58	±0.66	±105
Period (2001–06)	9.76	13.14	12.63^{a}	12.25	11.97^{a}	11.49^{a}	10.76	9.76^{a}	9.03	7.37	4.99	3173
	±0.42	±0.41	±0.41	±0.44	±0.42	±0.40	±0.42	±0.46	±0.49	±0.55	±0.63	±101
Period (2007–12)	8.16	13.37	13.12^{a}	11.87	11.37^{ab}	12.00^{a}	11.11	10.59^{a}	9.64	8.40	5.54	3262
	±0.72	±0.69	±0.68	±0.74	±0.71	±0.66	±0.71	±0.77	±0.82	±0.93	±0.99	±167

presented in Table 2. The effect of period of calving on MTDMYs and on FL305DMY showed no definite trend across the periods.

The effect of AFC was found to be highly significant (P<0.01) on TD-1 to TD-3, TD-5 and TD-8, significant effect (P<0.05) was observed on TD-4 and on remaining MTDMYs, effect of AFC was found to be non-significant (Table 1). The least squares means alongwith their standard errors for the effect of AFC on MTDMYs and FL305DMY are presented in Table 2. Rose (2008) reported that the AFC had non-significant effect on MTDMYs in Karan Fries cattle. Kokate *et al.* (2013) however, reported the effect of AFC to be non-significant on all MTDMYs except TD-2 and TD-3 in Karan Fries cattle. The effect of AFC on FL305DMY was found to be significant (P<0.05) (Table 1). Varade and Ali (2002) in Jersey crossbred cattle and Kokate *et al.* (2013) in Karan Fries cows also reported significant effect of AFC on FL305DMY. The highest FL305DMY (3,307 kg) was observed in the 6th AFC group (1,041–1,100 days) and lowest in 1st AFC group (2,942 kg). Increasing trend was noticed from 1st to 3rd AFC group and thereafter no definite trend was observed.

Genetic and phenotypic parameters: The heritability estimate of MTDMYs ranged from 0.11 to 0.34 (Table 3) and found to be the lowest (0.11±0.05) for TD-11 and highest (0.34±0.07) for TD-6. Similar estimates were reported by Kokate *et al.* (2013) in Karan Fries cattle. On the contrary, Debbarma *et al.* (2014) reported the estimates of heritability of MTDMYs ranging from 0.05±0.07 (TD-1) to 0.36±0.14 (TD-9) in Sahiwal cattle at NDRI farm. The heritability of FL305DMY was 0.35±0.07 (Table 3), Saha *et al.* (2010) and Singh and Gurnani (2004) also reported the heritability estimate as 0.30 and 0.39 respectively in Karan Fries cattle. However, a lower estimate of heritability (0.23±0.14) in Karan Fries cattle was reported at NDRI, Karnal (Divya *et al.* 2014).

The genetic and phenotypic correlations among MTDMYs and with FL305DMY were highly significant (P<0.01; Table 3). The estimates of phenotypic correlations among all MTDMYs ranged from 0.15 (TD-1 and TD-11) to 0.83 (TD-8 and TD-9) and genetic correlations varied from 0.29 (TD-1 and TD-10) to 0.99 (TD-2 and TD-3). The magnitude of phenotypic and genetic correlations among MTDMYs decreased with increasing time interval between test-day milk yields. The phenotypic and genetic correlations among MTDMYs decreased with increasing time interval between test-days in Sahiwal and Karan Fries cattle (Debbarma *et al.* 2014, Kokate *et al.* 2013). The estimates of phenotypic and genetic correlations of MTDMYs with FL305DMY ranged from 0.41 to 0.82 (TD-

Table 3. Heritability, genetic and phenotypic correlations among monthly test-day milk yields and with first lactation 305-day or less milk yield

	305-DMY	TD–1	TD–2	TD-3	TD-4	TD-5	TD-6	TD-7	TD-8	TD-9	TD–10	TD–11
305-DMY	**0.35**	0.67	0.81	0.91	0.99	0.87	0.99	0.96	0.96	0.94	0.91	0.94
	±0.07	±0.15	±0.08	±0.05	±0.07	±0.06	±0.02	±0.03	±0.03	±0.04	±0.06	±0.12
TD–1	0.41	**0.14**	0.83	0.91	0.94	0.91	0.75	0.51	0.39	0.48	0.29	0.45
	±0.02	**±0.05**	±0.14	±0.14	±0.19	±0.18	±0.17	±0.20	±0.23	±0.22	±0.24	±0.30
TD–2	0.64	0.50	**0.20**	0.99	0.99	0.87	0.80	0.67	0.63	0.63	0.44	0.72
	±0.01	±0.02	**±0.06**	±0.05	±0.10	±0.11	±0.10	±0.14	±0.16	±0.16	±0.20	±0.24
TD-3	0.69	0.42	0.72	**0.26**	0.99	0.92	0.93	0.80	0.72	0.66	0.62	0.71
	±0.01	±0.02	±0.01	**±0.07**	±0.07	±0.08	±0.07	±0.10	±0.13	±0.62	±0.16	±0.22
TD-4	0.65	0.33	0.57	0.68	**0.17**	0.89	0.97	0.90	0.94	0.88	0.86	0.86
	±0.01	±0.02	±0.02	±0.01	**±0.06**	±0.10	±0.09	±0.11	±0.13	±0.14	±0.16	±0.25
TD-5	0.68	0.27	0.50	0.57	0.58	**0.23**	0.84	0.71	0.77	0.69	0.70	0.71
	±0.01	±0.02	±0.20	±0.01	±0.01	**±0.06**	±0.07	±0.11	±0.12	±0.14	±0.15	±0.22
TD-6	0.80	0.29	0.49	0.58	0.56	0.66	**0.34**	0.97	0.94	0.90	0.88	0.85
	±0.01	±0.02	±0.02	±0.01	±0.02	±0.02	**±0.07**	±0.03	±0.06	±0.07	±0.09	±0.17
TD-7	0.82	0.27	0.43	0.49	0.50	0.57	0.79	**0.27**	0.99	0.99	0.89	0.88
	±0.01	±0.02	±0.02	±0.01	±0.02	±0.03	±0.02	**±0.07**	±0.03	±0.05	±0.08	±0.16
TD-8	0.82	0.24	0.39	0.45	0.46	0.52	0.68	0.79	**0.21**	0.99	0.99	0.99
	±0.01	±0.02	±0.02	±0.01	±0.02	±0.03	±0.02	±0.01	**±0.06**	±0.03	±0.06	±0.15
TD-9	0.80	0.24	0.36	0.40	0.40	0.45	0.62	0.73	0.83	**0.22**	0.87	0.88
	±0.01	±0.02	±0.02	±0.01	±0.02	±0.03	±0.02	±0.01	±0.02	**±0.06**	±0.06	±0.13
TD–10	0.72	0.19	0.27	0.31	0.32	0.37	0.51	0.60	0.69	0.76	**0.21**	0.94
	±0.01	±0.02	±0.02	±0.02	±0.02	±0.02	±0.03	±0.02	±0.02	±0.02	**±0.06**	±0.09
TD–11	0.59	0.15	0.22	0.24	0.23	0.28	0.40	0.45	0.50	0.58	0.73	**0.11**
	±0.02	±0.02	±0.02	±0.01	±0.02	±0.01	±0.03	±0.02	±0.03	±0.01	±0.01	**±0.05**

Figures along the diagonal in bold scripts are the heritability estimates. The values above and below the diagonal are genetic and phenotypic correlations, respectively, which are highly significant (P<0.01).

1 and FL305DMY) and 0.67 to 0.99 (TD-7 and FL305DMY), respectively, and the estimates were generally higher in the middle segment of lactation.

This investigation revealed that the effect of season of calving was found to be highly significant (P≤0.01) on all the MTDMYs while non-significant effect was observed on FL305DMY. Period of calving had non-significant effect on most of the MTDMYs and on FL305DMY, whereas, the effect of age at first calving was highly significant on majority of the MTDMYs and significant effect was observed on FL305DMY. The heritability estimates of MTDMYs were found to be the lowest (0.11±0.05) for TD-11 and the highest (0.34±0.07) for TD-6. The high genetic and phenotypic correlations of MTDMYs with FL305DMY observed in the mid segment of lactation suggested that these key test-day yields could be used for the early and accurate selection of animals resulting in high genetic and economic gain.

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