IJABR, VOL.8 (1) 2018: 38-43 ISSN 2250 – 3579

INTERNATIONAL JOURNAL OF ADVANCED BIOLOGICAL RESEARCH

www.scienceandnature.org

GENETIC STUDIES ON TEST DAY MILK YIELD RECORDS AND FIRST LACTATION MILK YIELD IN CROSSBRED CATTLE

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ABSTRACT
Data on 264 crossbred cattle calving during 1996 to 2014 were analysed to assess effect of sire group, period of calving, season of calving and age at first calving on test day milk records up to 10 records (TD_1 to TD_{10}) and first lactation milk yield (FLMY). The overall least squares means for different TD and FLMY were 5.08 ±0.16, 9.11 ±0.14, 9.39 ±0.14, 9.27 ±0.15, 8.75 ±0.14, 8.08 ±0.13, 7.37 ±0.19, 7.07 ±0.20, 6.40 ±0.20, 5.35 ±0.40 in kg/day and 2331.18 ±52.16 kg, respectively. Effect of sire group was significant only on TD_8 and TD_9. Period of calving significantly affected TD_6 and TD_7 only, while season of calving showed significant effect on TD_1, TD_2, and TD_5 to TD_7. AFC significantly affected TD_2, TD_7 to TD9 and FLMY. The heritability estimates for test day milk records ranged from 0.04 (TD_{10}) to 0.26 (TD_2). The genetic and phenotypic correlation among test day milk records ranged from 0.12 to 0.82 and 0.11 to 0.75, respectively and the highest correlations were found between adjacent test day milk records and the correlations decreased as interval between test days increased in the present study. The genetic and phenotypic correlation between test day milk records and FLMY ranged from 0.27 to 0.64 and 0.27 to 0.55, respectively. The high correlation among proximate test day milk records suggested that for prediction of FLMY on the basis of test day milk records, number of test day could be reduced, with a small loss of accuracy of prediction.

KEYWORDS: Test day, First lactation milk yield, Heritability, correlation.

INTRODUCTION

India is one of the leading countries in cattle population (190.90 million) which is 14.7% of world's cattle population. Total crossbred cattle population of India was 39732 thousand (Basic Animal Husbandry Statistics (BAHS), 2013-14) of which 33760 thousands are females. Total milk production of India in 2012-13 was 132.4 million tones whereas, exotic/crossbred cows contributed 24.5% and that of indigenous/nondescript were 20.7%. This revealed the importance of crossbred cows as compared to indigenous cows for milk production. Milk yield is the single most important economic trait determining economic returns from dairy animals. Because of variability of lactation days of dairy animals, the use of test-day models is of more interest in genetic evaluation. In a country like India, where large number of cattle are sparse over a number of small sized herds, especially, those maintained by the small and marginal farmers, it is not feasible both economically and physically to have day to day records of milk yield. Recording at intervals rather than daily may be an alternative proposition. In developing countries, breeding programmes are characterized by insufficient field recording system and poor data collection, storage and processing procedures (Kahi *et al*., 2004). Use of test day milk records can be helpful in early sire evaluation, reducing generation interval and increasing rate of genetic progress. The earlier studies conducted in cattle and buffaloes (Appannayar *et al*., 1995, Dass and Sadana, 2003, Saini *et al.*, 2005, Kokate, 2009 in crossbred cattle and Geetha *et al.* (2007) and Katneni (2007) in Murrah buffaloes have revealed fairly large predictability by the use of test-day milk yields because of high association between test-day milk yields and first lactation milk yield. Therefore, the present study was carried out to find out genetic and non-genetic factor affecting on different test day milk records and FLMY and their inheritance pattern.

MATERIALS & METHODS

The study was conducted on data pertaining 264 crossbred cattle maintained at Department of Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal sciences, Hisar over a period of 19 years from 1996 to 2014 were collected and analysed. The lactation records with less than 100 days lactation length were excluded from the study. Cows having incomplete and abnormal records due to abortion, still birth and sickness etc. were excluded. The sire groups were made on the basis of year in which their first daughter calved. Different sire groups were used in different periods. Sires having less than 3 observations were excluded from the study. Whole duration of 19 years from 1996-2014 was divided into 5 periods each comprising of 3 years duration except period 1 because of less number of observation in early year. Each year was further divided into four seasons *i.e.* summer (April to June) rainy (July to September) autumn (October to November) and winter season (December to March) on the basis of fluctuations in the atmospheric temperature and relative humidity. Since the numbers of observations in each subclass were unequal, the least squares method was used to estimate the effect of non-genetic factors. The model was used with assumptions that different components being fitted into the model were linear, independent and additive. The effect of genetic factor *i.e*. sire group and non-genetic factors *viz*. period of calving, seasons of calving and age at first calving on TD and FLMY was studied by least squares analysis technique (Harvey, 1990) using the following mixed model; $Y_{ijklm} = \mu + G_i + T_{ij} + P_k + S_l + b\,(A_{ijklm} - \bar{A}) + e_{ijklm}$, Where, Y_{ijklm}, Observation of m^{th} progeny of j^{th} sire belonging to i^{th} sire group, k^{th} period and l^{th} season of calving; μ, Overall population mean; G_i, fixed effect of i^{th} sire group (i=1 to7); T_{ij}, random effect of j^{th} sire within i^{th} sire group assumed to be NID (0, σ^2_s); P_k, fixed effect of k^{th} period of calving (k = 1, to 5); S_l, fixed effect on l^{th} season of calving (l = 1, 2, 3, 4); A_{ijklm}, age at first calving pertaining to $Y_{ijklm}{}^{th}$ observation; $\bar{A}$, mean age at first calving; b, linear regression coefficient of a trait on age at first calving and e_{ijklm}, random residual error associated with observation of m^{th} progeny of j^{th} sire belonging to i^{th} sire group, k^{th} period and l^{th} season of calving assumed to be NID (0, σ^2_e). Least squares means were compared using Duncan's multiple range test (DMRT) as modified by Kramer (1957). Paternal half-sib correlation method was used to estimate the heritability of different traits (Becker, 1975) in crossbred cattle. Genetic and phenotypic correlations among different traits were calculated from sire components of variances and co-variances obtained from above model.

RESULTS & DISCUSSION

Least Squares Analysis

The analysis of variance and least squares means along with standard errors of test day milk records and FLMY are given in Table 1 and 2, respectively. The overall least squares means for different test days milk records were 5.08 ±0.16, 9.11 ±0.14, 9.39 ±0.14, 9.27 ±0.15, 8.75 ±0.14, 8.08 ±0.13, 7.37 ±0.19, 7.07 ±0.20, 6.40 ±0.20 and 5.35 ±0.40 kg for TD_1, TD_2, TD_3, TD_4, TD_5, TD_6, TD_7, TD_8, TD_9, and TD_{10}, respectively. Perusal of the Table 2 showed that the highest monthly test day milk records was observed in TD_3 (9.39 ±0.14 Kg) followed by TD_4 (9.27 ±0.15 kg) and the lowest in TD_1 (5.08 ±0.16 Kg). The result of present investigation pertinent to least squares mean of various individual test-day milk records are in close confirmation with those reported by Pander *et al*. (1992), Swalve (1994) in Holstein Friesian and Dev and Gurani (1994) in crossbred cattle, Hernandez *et al*. (2013) in Mambi de cuba cattle and Kokate *et al*. (2013) Karan Fries cattle.

TABLE 1: Analysis of variance for various test day milk records and first lactation milk yield

Source of variations	d.f	Mean squares										
		TD1	TD2	TD3	TD4	TD5	TD6	TD7	TD8	TD9	TD10	FLMY
Sire group	6	2.53	5.50	1.93	4.52	4.93	3.58	5.02	7.58*	5.45*	2.95	419109.32
Sire within sire group	47	4.23	3.27	3.35	3.50	3.37	2.62	4.06	2.94	2.46	3.49	456734.26
Period	4	3.07	1.07	4.75	3.15	3.01	8.77*	7.17*	5.40	0.69	3.37	203518.62
Season	3	10.03*	8.93*	5.85	4.65	15.81**	20.18**	15.28*	8.20	3.95	3.70	639869.22
Regression on AFC (L)	1	0.11	10.21*	6.16	6.32	12.03	4.86	26.78*	29.71*	9.96*	0.17	2413246.49**
Error	202	3.31	2.50	2.77	2.86	3.40	3.06	4.94 (154)	4.39 (143)	1.74 (120)	3.44 (112)	380654.17

Figures in parenthesis are degree of freedom for respective error; *P<0.05; **P<0.01

The analysis of variance revealed that the influence of sire group was significant on TD_8 and TD_9. Whereas, Rose (2008), and Kokate *et al.* (2013) reported significant effect on all test day milk records in Karan Fries cattle. The least squares means for all test day milk records except TD_7 to TD_{10} was highest in sire group 3 and was lowest for all test day milk records in sire group 1. These result indicated that selection programme adopted is appropriate and is in good direction. Critical examination of the results indicated that the fourth (2009-11) and fifth (2012-14) period calvers excelled in performance for all test day milk records except TD_8. However, no definite trend could be obtained for these test day milk records. Differences in these traits might be attributed to variation in nutrition, managemental practices, feeding regimes and sire groups. The result revealed that season of calving had statistically significant effect on TD_1, TD_2, TD_5, TD_6 and TD_7. Perusal of Table 2 revealed that TD_1 was obtained highest in summer season calvers (April- June) and thereafter for TD_2 and TD_3 the animals calved in winter season (Dec-March) produced highest average individual test day milk records. Autumn season calvers produced highest milk yield for TD_4 to TD_{10}. The findings of Bhadouria *et al*. (1986), Rose (2008) and Kokate *et al*. (2013) supported the results of significant effect of season of calving for TD_1, TD_2 and TD_5 to TD_7 in crossbred cattle. The study of results indicated that most of the test day milk yields were maximum in autumn season which may be because of availability of green fodder in the form of berseem and others. The linear regression of AFC on test day milk records had statistically significant effect on TD_2 and TD_7 to TD_9. Significant effect of the age at first calving on test day milk records is on the same line as reported by Zaman *et al.* (1990) for TD_2, TD_7 to TD_9. Appannayar *et al.* (1995) and Kokate *et al.* (2013) in crossbred cattle.

TABLE 2: Least Squares Mean with standard errors for various test day milk records and first lactation milk yield

Effect		Least Squares Mean ± S.E.										
		TD_1	TD_2	TD_3	TD_4	TD_5	TD_6	TD_7	TD_8	TD_9	TD10	FLMY
OVER ALL MEAN		5.08±0.16 (264)	9.11±0.14 (264)	9.39±0.14 (264)	9.27±0.15 (264)	8.75±0.14 (264)	8.08±0.13 (264)	7.37±0.19 (216)	7.07±0.20 (205)	6.40±0.20 (182)	5.35±0.40 (174)	2331.18±52.1 6 (264)
Sire group	SG 1 (2000-01)	4.21±0.77 (12)	7.39±0.68 (12)	8.67±0.69 (12)	8.59±0.70 (12)	7.54±0.70 (12)	6.77±0.66 (12)	5.67±0.89 (12)	5.54^{b}±0.93 (11)	4.71^{c}±0.91 (11)	5.21±0.79 (10)	1966.42±254. 18 (12)
	SG 2 (2002-03)	5.20±0.33 (60)	9.39±0.30 (60)	9.43±0.30 (60)	8.85±0.31 (60)	8.66±0.30 (60)	8.25±0.28 (60)	7.23±0.38 (54)	5.68^{b}±0.39 (53)	5.72^{b}±0.40 (46)	4.87±0.49 (45)	2368.54±112. 43 (60)
	SG 3 (2004-05)	5.41±0.34 (68)	9.98±0.31 (68)	9.82±0.49 (68)	9.95±0.52 (68)	9.62±0.50 (68)	8.81±0.48 (68)	7.27±0.39 (54)	6.78^{ab}±0.41 (51)	5.78^{b}±0.42 (43)	0.89±0.50 (39)	2285.29±110. 55 (68)
	SG 4 (2006-07)	5.29±0.57 (18)	9.56±0.50 (18)	9.60±0.51 (18)	9.11±0.31 (18)	9.50±0.51 (18)	7.98±0.28 (18)	7.68±0.72 (14)	8.37^{a}±0.77 (13)	7.21^{a}±0.76 (12)	4.95±0.65 (12)	2430.49±187. 13 (18)
	SG 5 (2008-09)	4.83±0.42 (40)	9.02±0.37 (40)	9.32±0.37 (40)	8.97±0.38 (40)	8.75±0.35 (40)	7.96±0.34 (40)	7.86±0.52 (28)	7.13^{ab}±0.55 (25)	7.13^{ab}±0.56 (22)	5.93±0.55 (21)	2363.24±136. 28 (40)
	SG 6 (2010-11)	5.32±0.46 (41)	9.21±0.41 (41)	9.24±0.40 (41)	9.64±0.42 (41)	8.81±0.39 (41)	8.25±0.37 (41)	7.47±0.54 (32)	7.02^{ab}±0.56 (31)	6.64^{ab}±0.58 (27)	5.75±0.52 (26)	2306.56±149. 15 (41)
	SG 7 (2012-14)	5.28±0.55 (25)	9.22±0.49 (25)	9.63±0.30 (25)	9.75±0.50 (25)	8.32±0.30 (25)	8.55±0.47 (25)	8.40±0.67 (22)	8.11^{a}±0.71 (21)	7.62^{a}±0.67 (21)	5.86±0.61 (21)	2597.68±182. 33 (25)
Period of calving	1996-2002	4.52±0.40 (22)	8.77±0.31 (22)	9.12±0.59 (22)	8.54±0.60 (22)	8.13±0.36 (22)	7.12^{b}±0.34 (22)	7.46^{ab}±0.7 2 (21)	8.01±0.97 (20)	7.11±1.02 (18)	4.53±0.68 (17)	2222.51±219. 27 (22)
	2003-2005	4.60±0.37 (85)	9.16±0.56 (85)	8.61±0.33 (85)	8.77±0.34 (85)	8.65±0.65 (85)	.72^{b}±0.62 (85)	6.62^{b}±0.5 4 (67)	6.52±0.59 (63)	5.88±0.59 (55)	5.58±0.53 (52)	2196.78±123. 35 (85)
	2006-2008	5.32±0.65 (59)	9.00±0.35 (59)	9.19±0.36 (59)	9.41±0.37 (59)	8.64±0.40 (59)	8.21^{a}±0.38 (59)	7.90^{a}±0.58 (46)	7.04±0.62 (44)	6.49±0.64 (37)	5.29±0.60 (35)	2274.51±135. 15 (59)
	2009-2011	5.34±0.45 (46)	9.17±0.39 (46)	9.98±0.41 (46)	9.78±0.42 (46)	9.26±0.45 (46)	9.05^{a}±0.42 (46)	8.02^{a}±0.91 (35)	7.37±0.78 (32)	6.82±0.76 (27)	5.46±0.62 (26)	2506.65±151. 58 (46)
	2012-2014	5.61±0.51 (52)	9.45±0.44 (52)	10.03±0.46 (52)	9.82±0.47 (52)	9.08±0.51 (52)	8.30^{a}±0.48 (52)	6.84^{b}±0.8 1 (47)	6.43±0.89 (46)	5.72±0.86 (45)	5.91±0.59 (44)	2455.43±170. 95 (52)
Season of calving	Summer (April-June)	5.51^{a}±0.26 (73)	9.43^{a}±0.23 (73)	9.52±0.24 (73)	9.29±0.24 (73)	8.52^{ab}±0.26 (73)	7.67^{b}±0.24 (73)	6.66^{b}±0.4 4 (59)	6.97±0.37 (56)	6.26±0.39 (46)	5.00±0.39 (44)	2350.86±88.5 9 (73)
	Rainy (July-Sept)	4.99^{ab}±0.30 (50)	8.51^{b}±0.27 (50)	8.87±0.28 (50)	8.79±0.28 (50)	8.02^{b}±0.30 (50)	7.40^{b}±0.28 (50)	6.98^{b}±0.3 5 (38)	6.53±0.49 (33)	5.49±0.49 (30)	5.56±0.32 (27)	2149.20±102. 44 (50)
	Autumn (Oct-Nov.)	4.44^{ab}±0.30 (52)	9.00^{ab}±0.2 6 (52)	9.42±0.27 (52)	9.62±0.27 (52)	9.34^{a}±0.29 (52)	8.94^{a}±0.27 (52)	8.46^{a}±0.43 (42)	7.97±0.44 (42)	7.11±0.44 (39)	5.77±0.34 (38)	2445.57±99.5 5 (52)
	Winter (Dec- Mar)	5.34^{a}±0.25 (89)	9.49^{a}±0.22 (89)	9.73±0.23 (89)	9.37±0.23 (89)	9.14^{ab}±0.24 (89)	8.31^{b}±0.23 (89)	7.37^{b}±0.3 3 (77)	6.82±0.35 (74)	6.74±0.35 (67)	5.14±0.31 (65)	2380.08±83.7 8 (89)

Figures in parenthesis are number of observations

Mean with different superscripts differ significantly among themselves

TABLE 3: Estimates of heritability (diagonal), genetic (above diagonal) and phenotypic correlation (below diagonal) amongtest day milk records and first lactation milk yield (FLMY)in crossbred cattle

	TD_1	TD_2	TD_3	TD_4	TD_5	TD_6	TD_7	TD_8	TD_9	TD_{10}	FLMY
TD_1	**0.13±0.21**	0.64±0.13	0.40±0.18	0.40±0.17	0.35±0.20	0.18±0.22	0.16±0.22	0.19±0.22	0.20±0.20	0.23±0.21	0.32±0.18
TD_2	0.41**±0.056	**0.26±0.22**	**0.82±0.15**	0.43±0.20	0.43±0.19	0.24±0.21	0.26±0.23	0.22±0.23	0.29±0.20	0.34±0.21	0.57±0.17
TD_3	0.25**±0.060	0.65**±0.047	**0.18±0.20**	0.65±0.21	0.45±0.20	0.45±0.19	0.26±0.23	0.33±0.22	0.49±0.22	0.53±0.24	0.59±0.18
TD_4	0.28**±0.059	0.40**±0.057	**0.75**±0.041**	**0.19±0.21**	0.67±0.17	0.40±0.22	0.16±0.27	0.50±0.23	0.41±0.21	0.27±0.25	**0.64±0.15**
TD_5	0.20**±0.061	0.37**±0.057	0.47**±0.055	0.53**±0.052	**0.16±0.24**	0.70±0.14	0.62±0.17	0.74±0.15	0.16±0.23	0.25±0.24	0.47±0.18
TD_6	0.26**±0.059	0.25**±0.060	0.40**±0.057	0.35**±0.066	0.61**±0.049	**0.12±0.23**	0.74±0.12	0.64±0.16	0.38±0.23	0.41±0.25	0.32±0.20
TD_7	0.17**±0.067	0.18**±0.067	0.35**±0.064	0.30**±0.065	0.53**±0.058	0.69**±0.051	**0.10±0.21**	0.71±0.13	0.23±0.22	**0.12±0.09**	**0.27±0.21**
TD_8	0.35**±0.066	0.18**±0.067	0.34**±0.066	0.27**±0.068	0.48**±0.062	0.56**±0.058	0.47**±0.062	**0.18±0.24**	0.55±.20	0.43±0.21	0.46±0.15
TD_9	0.29**±0.071	0.15**±0.074	0.22**±0.073	0.27**±0.072	0.29**±0.071	0.23**±0.072	0.44**±0.067	0.55**±0.059	**0.12±0.24**	0.56±0.11	0.50±0.14
TD_{10}	**0.11±0.075**	0.16**±0.075	0.17**±0.075	0.27**±0.073	0.21**±0.075	0.21**±0.075	0.30**±0.073	0.39**±0.069	0.49**±0.065	**0.04±0.21**	0.45±0.13
FLMY	0.41**±0.056	0.50**±0.054	0.53**±0.052	**0.55**±0.049**	0.48**±0.054	0.40**±0.057	0.42**±0.056	0.49**±0.054	0.45**±0.055	**0.27**±0.059**	**0.17±0.19**

* Significant at (P<0.05) ** Significant at (P<0.01)

The overall least squares mean of 2331.18 ±52.16 kg for FLMY as reported in the present study is in close conformity to those reported by Saha *et al.* (2010) and SubhaLaxmi *et al.* (2010) in crossbred cattle. While, FLMY reported by Kharat *et al.* (2008), and Hasan and Khan (2013) were onlower side and the FLMY reported by Singh *et al.* (2008), Nehra (2011) and Goshu *et al.* (2014) were on higher side.
The analysis of variance revealed non-significant effect of sire group, period of calving and season of calving on FLMY in the present study. Similar results were also reported by Kharat *et al*. (2008), Saha *et al.* (2010), SubhaLaxmi *et al.* (2010), Nehra (2011), Divya (2012) and Hasan and khan (2013). The least squares mean indicated that later groups were superior over the previous sire groups which showed that selection programme adopted for selection of sires is in positive direction. Effect of age at first calving on FLMY was found to be significant. This is in conformity to the results of Mukharjee (2005) and Nehra (2011).

Estimation of heritability:

The heritability estimates for test day milk record presented in Table 3 ranged from 0.04 (TD_{10}) to 0.26 (TD_2). The heritability for various test day milk records were 0.13 ±0.21, 0.26 ±0.22, 0.18 ±0.20, 0.19 ±0.21, 0.16 ±0.24, 0.12 ±0.23, 0.10 ±0.21, 0.18 ±0.24, 0.12 ±0.24 and 0.04 ±0.21 for TD_1 to $TD_{10,}$ respectively. These estimates of heritability were in consonance with those reported by Lidauer *et al.* (2003) in Ayrshire cattle and Kokate *et al*. (2013) in Karan-Fries cattle. Whereas, higher estimates were reported by Druet *et al*. (2003) in French Holstein cows.
The heritability estimate of FLMY in the present study was low (0.17 ±0.19). Estimates of similar magnitude were also reported by Singh *et al.* (2008), Rashia (2010) and SubhaLaxmi *et al.* (2010) in crossbred cattle. However, moderate heritability estimates were reported by Kumar *et al.* (2008), Kharat *et al.* (2008) and Saha *et al.* (2010) and higher estimates were reported by Nehra (2011).

Estimation of genetic and phenotypic parameters:

The genetic and phenotypic correlations among test-day milk records and FLMY are presented in Table 3. The genetic correlation among test day milk yields ranged from 0.12 to 0.82. The lowest correlation was found between most distant (I^{st} to 10^{th}) test day milk records, being 0.12. Genetic correlation of all test day milk records with FLMY ranged from 0.27 to 0.64 which was highest for TD_4 (0.64). The lower genetic correlation of early and later test day milk records with FLMY might be partly due to calving and pregnancy stress, respectively. The phenotypic correlations between test day milk records ranged from 0.11 to 0.75. The phenotypic correlation among all test day milk records were significant ($P<0.01$) except TD_1 with TD_{10}. Phenotypic correlation between TD and FLMY ranged from 0.27 to 0.55 with the highest value for TD_2 to $TD_{4.}$ These results are in close conformation with Lidauer *et al.* (2003) and Kokate *et al*. (2013). Highest correlation between adjacent test day milk records were supported by Pander *et al.* (1992), Dev and Gurani (1994) and Kokate *et al*. (2013). The high positive genetic and phenotypic correlations of test day milk records TD_2 to TD_4 with FLMY suggested that we may predict the FLMY on the basis of early test day records ($TD_{2,}$ TD_3 and TD_4).

CONCLUSION

The result of present investigation indicated that the highest monthly test day milk records were observed in TD_3 followed by TD_4 and the lowest in TD_1 and the mean yield per test day exhibits the typical lactation curve for dairy cattle with a peak around 40-60 days for milk yield. The high correlation among proximate test day milk records suggested that for prediction of FLMY on the basis of test day milk records, number of test day could be reduced, with a small loss of accuracy of prediction. The estimates of heritability, genetic and phenotypic correlations for test day milk records and FLMY indicated that for early selection of sires for FLMY on the basis of test day milk records (TD_2, TD_3 and TD_4) , selection criterion should be family/ progeny testing.

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