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Genetic and non-genetic factors affecting monthly test day milk yields and first lactation milk yield in crossbred cattle of Kerala

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Abstract
In this present study data of 936 crossbred cattle sired by 188 bulls spread over a period of 16 years (2002-2017) in seven different field centers of ICAR-Field Progeny Testing Scheme, Kerala were used. Least squares means for ten monthly test days starting from 20th day of calving at 30 days interval and first lactation milk yield (FLMY) were 10.35±0.15, 10.71±0.14, 10.25±0.14, 9.73±0.13, 9.11±0.13, 8.44±0.13, 7.80±0.12, 7.03±0.0.11, 6.16±0.12, 5.41±0.13 and 2510.71±30.49 kg, respectively. Period of calving and batches of sires had significant effect on some of the MTDMYs and FLMY. Season of calving had significant effect only on first MTDMY. Genetic group, sources of sires and age at first calving had non-significant effect on MTDMY and FLMY. Heritability estimates ranged from 0.004±0.107 in 9th MTDMY to 0.531±0.136 in 4th MTDMY. The correlations of other MTDMY were not estimable. Higher estimates of genetic and phenotypic correlations of MTDMYs with FLMY revealed that MTDMY and FLMY can be used as selection criteria for cow or sire evaluation in crossbred cattle of Kerala.

Keywords: Monthly test day milk yield, first lactation milk yield and crossbred cattle

Introduction
India is mainly an agricultural country and the livestock production play a major role in the rural economy. The livestock sector gives employment to millions of rural poor, as well as is the major source of income for them throughout the year. India with fast growing milk and its byproduct production sector is now first in world in milk production. Total milk production in India during 2017-18 from all livestock population is 176.5 million tones out of which 26% is from crossbred cattle [1]. The population of crossbred cattle in the country is increasing and their contribution to total milk production is substantial. Kerala is having more than 95% of its cattle population as crossbreds. Monthly test day milk yields (MTDMY) are the method to evaluate the lactation yield of cows in places where daily milk recording is not possible. The influence of non-genetic factors on these can affect the prediction values derived from MTDMY. The first Lactation Milk Yield (FLMY) is considered as the best indicator of performance of lactating animals.

Materials and Methods
The milk yield and pedigree information of 936 crossbred cattle sired by 188 bulls spread over a period of 16 years (2002-2017) were collected from the history sheets and milk record registers of ICAR- Field Progeny Testing Scheme, Kerala. The normal lactation was considered as that of lactation length of not less than 100 days and production of not less than 500 kg. Crossbred cattle having history of abortion, still birth, infertility and other reproductive problems were not included in the present study. Monthly test day milk yields starting from 20th day of calving at 30 day intervals and 305 day first lactation yield were collected. On standardization and normalisation, (with mean ± 3Standard Deviation) 835 lactation records were obtained. Season of calving was grouped in to three namely rainy season (June to September), post monsoon (October to January) and summer (February to May) as per the classification of Joseph (2011). Period of calving was divided into eight groups of two years each from 2002 to 2016. Age at first calving was divided into three groups namely 900 days and below, 901 days to 1000 days and more than 1000 days.

Genetic factors include genetic group of sires based on exotic inheritance of sires namely 50%, 50 to 62.5%, 62.5 to 75% and Frieswal. Bulls were received from three sources *viz.* Project Directorate on Cattle (PDC) Meerut, Bharathiya Agro Industries Foundation (BAIF) Pune and Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana. Batches of sires were nine as per the date of supply.
Mixed model analysis of data was carried out by Least-square maximum likelihood programme (Harvey, 1990) to study the effects of genetic and non-genetic factors.

For first lactation milk yield

$Y_{ijklmno} = \mu + C_i + P_j + A_k + G_l + S_m + B_n + e_{ijklmno}$

Where,
$Y_{ijklmno}$ = first lactation milk yield of the oth individual belongs to nth batch, mth source, lth genetic groupof sire calved kth age group, jth period and ith season

For monthly test day milk yields

$MTDMY_{ijklmno} = \mu + C_i + P_j + A_k + G_l + S_m + B_n + e_{ijklmno}$
Where,
$MTDMY_{ijklmno}$ = Monthly test-day milk yield of the oth individual belongs to nth batch, mth source, lth genetic groupof sire calved kth age group, jth period and ith season
μ = Population mean
C_i = Fixed effect of ith season (i=1to 3) of calving
P_j= Fixed effect of jth period (j=1to 8) of calving
A_k = Fixed effect of kth age group (k=1 to 3) of calving
G_l = Random effect of lth genetic group (l=1 to 4)
S_m = Random effect of mth source of sire (m=1 to 3)
B_n = Random effect of nth batches of sire (n=1 to 9)

The statistical significance of various fixed effects tested by Duncan's multiple range tests [2]. Estimation of heritability: Paternal half-sib correlation method was used to estimate the heritability of different characters and their genetic correlations [3]. The standard error of heritability was estimated [4]. A genetic and phenotypic correlation was calculated from the analysis of variance and covariance among sire groups [3]. The standard error of phenotypic correlations was obtained according to formula [5]. The statistical significance of correlations was tested by't' test [6].

Results and Discussion

The highest MTDMY was found for second recording (10.81± 0.07 Kg) and the least value was that of last recording or the 10th value (5.14 ± 0.06 Kg). The average first lactation milk yield in crossbred cattle was 2579.24 ± 16.93 Kg. The least square means are presented in Table I.

Table 1: Average Monthly Test Day Milk yield of first lactation of crossbred cattle of Kerala

Trait	Number of Observation	Mean ± SE Kg.
MTDMY 1	829	10.46 ± 0.08
MTDMY 2	829	10.81 ± 0.07
MTDMY 3	828	10.47 ± 0.07
MTDMY 4	815	9.98 ± 0.07
MTDMY 5	804	9.39 ± 0.07
MTDMY 6	790	8.69 ± 0.06
MTDMY 7	779	7.97 ± 0.06
MTDMY 8	779	7.14 ± 0.06
MTDMY 9	751	6.16 ± 0.05
MTDMY 10	719	5.24 ± 0.06
FLMY	775	2579.24 ± 16.93

Genetic group of sire

All four genetic groups had no significant effect on MTDMYs in crossbred cattle of Kerala. 50% of exotic inheritance in blood level of indigenous cattle gave optimum production performance in our economic traits like AFC, FLMY, service period and etc, compare to cows with higher level of exotic inheritance [7]. Though the level of 50 to 62.5% exotic inheritance was considered as best for crossbred cattle of India [8], this study shows that there is no significant advantage in going beyond 50% exotic inheritance level of bulls. Holstein Friesian inheritance varied between 50-62.5% and the rest from Tharparkar was the next best crossbred group [9]. The new breed has been developed by crossing Holstein Friesian (50 percent), Jersey (25 percent) and Gir (25 percent) breeds [10]. One of the probable reason can be segregation of exotic genes in the crossbred cattle population due to continuous *inter se* mating. This must have made the exotic level of different groups of crossbred more homogenous as they were under *inter se* breeding for long.

Sources of sire

Sources of sires had no significant effects on MTDMYs and FLMY. Three different sources namely PDC, GADVASU and BAIF are used as sources of sires. It indicating that the three centers maintain test bulls of similar genetic superiority.

Batches of sire

The batches of sires had significant effect on few MTDMYs and FLMY. 12 batches progenies of test bulls had maximum milk production 2774.80±112.00 kg whereas 4th batch progenies of test bulls had minimum milk production 2170.99±127.71 kg. Significant effect of batches on FLMY in crossbred cattle of Kerala [11]. The increasing first lactation milk yield of progenies of different batches shows the continuous genetic improvement in breeding bulls of subsequent batches.

Effect of non-genetic factors

Period of calving

Least square analysis of variance shows period of calving had highly significant effect on 3rd MTDMY and FLMY. Then significant effect on 4th, 5th and 9th MTDMYs. In Karan Fries cattle also reported that period of calving had high significant effect on MTDMY [12]. In the present study influence of period of calving was significant for MTDMYs of mid lactation period. As the mid lactation period is the time of maximum production, influence of all non-genetic factors will be evident during this time. The highly significant effect of period of calving on MTDMY and FLMY can be due to continued change of sires and subsequent changes in genetic superiority of bulls used for breeding.

Season of calving

First MTDMY was significantly high for the cows calved on post monsoon season. This may be due to favorable climate and management conditions available during pregnancy. But the effect of season was not significant for any of the other MTDMY and FLMY. The influence of differences between seasons may not be sufficient enough to reflect in test day milk production. In Karan Fries cows, reported that season of calving had highly significant effect on all the monthly test day milk yields [12, 13]. In Murrah buffaloes observed that non-significant effect of season of calving on MTDMYs except 5th, 8th, 9th and 11th MTDMYs [14]. Season of calving has no significant effect on all the MTDMYs in Murrah buffaloes [15].

Age at first calving

AFC had no significant effect on MTDMYs and FLMY. This is in agreement with Karan Fries cattle [16]. Average FLMY was not significantly affected by age at calving. This is in agreement with the studies in Phule Triveni cows [17]. The increase in FLMY of cows with longer AFC was noticed by different research workers can be due to incomplete fulfillment of growth of cows at the time of first calving. In the present study the AFC of crossbreds are high enough to complete major part of growth of the animal. That may be the reason for non-significant effect of AFC in the present study.

Table 2: Least square means of MTDMY of crossbred cattle of Kerala

Items	MTDMY-1	MTDMY-2	MTDMY-3	MTDMY-4	MTDMY-5	MTDMY-6	MTDMY-7	MTDMY-8	MTDMY-9	MTDMY-10	FLMY
overall	10.35±0.15	10.71±0.14	10.25±0.14	9.73±0.13	9.11±0.13	8.44±0.13	7.80±0.12	7.03±0.11	6.16±0.12	5.41±0.13	2510.71±30.49
Season of calving											
Rainy	10.35±0.18^{a} (297)	10.68±0.18 (297)	10.28±0.17 (297)	9.80±0.16 (289)	9.06±0 16 (284)	8.41±0.15 (278)	7.79±0.15 (274)	7.06±0.15 (267)	6.21±0.15 (261)	5.38±0.16 (253)	2503.82±37.27 (274)
Post monsoon	10.59±0.19^{a} (210)	10.82±0.18 (210)	10.27±0.18 (210)	9.63±0.17 (209)	9.18±0.16 (207)	8.47±0.16 (205)	7.77±0.16 (202)	7.08±0.15 (199)	6.19±0.15 (195)	5.55±0.16 (187)	2537.25±39.06 (203)
Summer	10.11±0.18^{b} (307)	10.62±0.17 (307)	10.19±0.17 (306)	9.77±0.16 (303)	9.09±0.15 (299)	8.44±0.15 (293)	7.85±0.15 (290)	6.96±0.14 (287)	6.07±0.14 (283)	5.29±0.15 (267)	2491.06±37.03 (284)
Period of calving											
2002&03	9.66±0.77 (15)	10.71±0.74 (15)	10.30±0.71^{ab} (15)	9.20±0.69^{ae} (15)	8.55±0.65^{ae} (15)	8.23±0.64 (15)	7.53±0.62 (15)	6.94±0.60 (15)	6.19±0.60^{b} (15)	5.95±0.65 (12)	2265.33±154.67^{a} (15)
2004&05	10.86±0.67 (36)	11.41±0.65 (36)	10.17±0.62^{b} (36)	9.21±0.60^{e} (35)	8.62±0.57^{e} (35)	8.16±0.56 (34)	8.05±0.55 (33)	7.59±0.54 (32)	6.94±0.55^{bf} (30)	6.60±0.57 (28)	2451.68±135.38^{a} (36)
2006&07	10.58±0.39 (111)	10.78±0.37 (111)	10.09±0.36^{a} (111)	9.76±0.35^{b} (111)	9.42±0.34^{bc} (109)	8.64±0.34 (108)	7.96±0.33 (104)	7.48±0.33 (103)	6.69±0.33^{cgh} (100)	5.72±0.35 (92)	2504.62±79.51^{c} (111)
2008&09	10.23±0.33 (118)	10.29±0.32 (118)	9.44±0.30^{a} (118)	9.18±0.30^{ba} (116)	9.42±0.34^{bc} (109)	8.10±0.29 (106)	7.26±0.28 (105)	6.61±0.29 (101)	6.12±0.28^{bf} (98)	5.24±0.30 (92)	2374.99±68.56^{b} (114)
2010&11	10.50±0.31 (113)	10.07±0.30 (113)	9.45±0.29^{a} (113)	9.46±0.28^{b} (113)	8.84±0.27^{b} (113)	8.31±0.26 (110)	7.69±0.26 (108)	7.06±0.25 (107)	6.38±0.25^{cdeh} (107)	5.52±0.26 (104)	2492.27±65.08^{c} (110)
2012&13	10.31±0.32 (125)	10.50±0.31 (125)	10.38±0.30^{c} (125)	10.21±0.29^{c} (123)	9.43±0.28^{c} (122)	8.66±0.27 (122)	7.96±0.27 (121)	6.83±0.26 (119)	5.84±0.26^{dfgh} (115)	4.98±0.27 (112)	2626.48±67.48^{d} (107)
2014&15	10.47±0.37 (128)	10.96±0.36 (128)	11.30±0.35^{d} (127)	10.65±0.34^{d} (125)	9.85±0.32^{d} (124)	8.94±0.32 (123)	8.06±0.32 (122)	7.03±0.31 (120)	5.86±0.31^{efgh} (118)	4.68±0.33 (116)	2736.63±78.86^{e} (114)
2016&17	10.19±0.46 (168)	10.92±0.45 (168)	10.84±0.43^{d} (168)	10.18±0.42^{d} (163)	9.45±0.40^{d} (161)	8.49±0.40 (158)	7.89±0.39 (158)	6.71±0.39 (156)	5.22±0.39^{fg} (156)	4.57±0.41 (151)	2633.67±96.37^{e} (154)
Age groups in days											
900 and below	10.54±0.20 (205)	10.82±0.19 (205)	10.32±0.18 (205)	9.88±0.18 (197)	9.12±0.17 (193)	8.37±0.17 (189)	8.43±0 14 (441)	6.92±0.16 (184)	5.98±0.16 (182)	5.28±0.17 (177)	2516.30±40.76 (186)
901 to 1000	10.24±0.21 (152)	10.58±0.21 (152)	10.27±0.20 (152)	9.72±0.19 (152)	9.13±0.18 (148)	8.53±0.18 (146)	7.90±0.18 (144)	7.08±0.17 (142)	6.21±0.17 (140)	5.49±0 18 (131)	2510.99±44.16 (141)
1001 and above	10.27±0.17 (457)	10.72±0.16 (457)	10.27±0.20 (152)	9.60±0.15 (452)	9.08±0.14 (449)	8.43±0 14 (441)	7.82±0.14 (434)	7.09±0.13 (427)	6.28±0.14 (417)	5.45±0.14 (399)	2504.83±34.30 (434)
Genetic group											
50%	10.46±0.27 (124)	10.75±0.26 (124)	10.03±0.25 (124)	9.63±0.24 (124)	9.08±0.23 (122)	8.35±0.23 (119)	7.70±0.22 (116)	7.03±0.21 (114)	6.21±0.21 (112)	5.52±0.23 (103)	2509.82±55.26 (116)
50% to 62.5%	10.17±0.25 (113)	10.57±0.24 (113)	10.01±0.23 (113)	9.50±0.22 (112)	8.84±0.22 (110)	8.15±0.21 (109)	7.56±0.21 (108)	6.83±0.20 (105)	6.06±0.20 (102)	5.52±0.23 (103)	2438.98±51.19 (108)
62.5% to 75%	10.40±0.19 (400)	10.88±0.18 (400)	10.39±0.17 (400)	9.81±0.17 (392)	9.14±0.16 (386)	8.49±0.16 (380)	7.77±0.15 (374)	7.05±0.15 (368)	6.14±0.15 (361)	5.40±0.16 (352)	2512.63±38.31 (371)
Frieswal (FSL)	10.37±0.26 (177)	10.63±0.25 (177)	10.56±0.24 (176)	9.99±0.23 (173)	9.38±0.22 (172)	8.78±0 21 (168)	8.18±0.21 (168)	7.22±0.20 (166)	6.22±0.20 (164)	5.43±0.22 (155)	2581.40±52.97 (166)
Source of sire											
PDC	10.15±0.23 (204)	10.77±0.23 (204)	10.04±0 22 (203)	9.56±0.21 (200)	8.93±0.20 (199)	8.22±0.20 (194)	7.57±0.19 (192)	6.90±0 19 (189)	6.14±0.19 (186)	5.50±0.20 (177)	2463.66±48.44 (190)
BAIF	10.34±0.16 (504)	10.58±0.16 (504)	10.32±0.15 (504)	9.76±0.15 (495)	9.15±0.14 (489)	8.57±0.14 (481)	7.93±0.14 (473)	7.13±0.13 (464)	6.17±0.13 (454)	5.37±0.14 (435)	2535.13±33.84 (470)
GADVAS	10.57±0.25 (106)	10.77±0.24 (106)	10.38±0.23 (106)	9.88±0.22 (106)	9.25±0.21 (102)	8.54±0.21 (101)	7.91±0 20 (101)	7.07±0.20 (100)	6.16±0.20 (99)	5.35±0.21 (95)	2533.34±50.90 (101)
Batches of sire											
4	8.80±0.63 (49)	8.70±0.61 (49)	8.50±0.59 (49)	9.88±0.22 (48)	7.95±0.54 (48)	7.08±0.53 (47)	6.13±0.52^{a} (46)	5.16±0.50^{c} (45)	4.64±0.51^{a} (44)	4.00±0.54^{bcdefg} (39)	2170.99±127.71^{a} (49)
5	10.04±0.48 (50)	10.12±0.46 (50)	10.02±0.44 (50)	8.60±0.57 (50)	8.63±0.41 (50)	8.12±0.41 (50)	7.70±0.40^{bcg} (47)	6.64±0.40^{abdei} (46)	5.70±0.40b^{cbh} (43)	5.34±0.42^{ab} (41)	2503.61±97.23^{bc} (50)
6	9.89±0.38 (115)	10.46±0.37 (115)	10.43±0.36 (115)	9.46±0.43 (115)	9.06±0.33 (112)	8.40±0.33 (112)	7.85±0.32^{bcg} (111)	6.89±0.32^{abdei} (110)	6.04±0.32^{bh} (108)	5.60±0.34^{a} (99)	2545.89±78.49^{bc} (115)
7	10.11±0.36 (85)	10.80±0.35 (85)	10.67±0.33 (85)	9.82±0.35 (84)	9.00±0.31 (81)	8.24±0.31 (76)	7.66±0.30^{b} (74)	6.77±0.30^{a} (73)	5.61±0.30^{acdg} (71)	4.85±0.31^{chl} (68)	2451.42±73.58^{b} (84)
8	10.29±0.36 (105)	11.14±0.34 (105)	10.64±0.33 (105)	9.84±0.32 (103)	9.32±0.31 (102)	8.63±0.30 (100)	8.10±0.30^{cde} (98)	7.33±0.29^{bfg} (96)	6.43±0.29^{befi} (95)	5.55±0.31^{adk} (89)	2537.55±75.78^{cdg} (93)
9	10.31±0.42 (59)	11.03±0.40 (59)	10.30±0.39 (59)	9.63±0.32 (58)	9.08±0.36 (57)	8.47±0.36 (56)	8.23±0.35^{dfh} (56)	7.88±0.34^{gh} (55)	6.71±0.33^{eh} (55)	5.80±0.35^{aeim} (54)	2540.56±87.94^{eg} (52)
10	10.57±0.39	11.05±0.38	10.12±0.36	9.68±0.38	9.08±0.33	8.37±0.33	7.77±0.32^{egh}	7.28±0 32^{df}	6.38±0.32^{dfh}	5.55±0.33^{flm}	2476.63±81.41^{ed}

	(107)	(107)	(107)	(107)	(107)	(107)	(107)	(106)	(102)	(101)	(98)
11	11.41±0.43 (137)	11.36±0.42 (137)	10.46±0.40 (136)	9.55±0.35 (132)	9.63±0.38 (131)	9.03±0.37 (128)	8.09±0.36^{ef} (126)	7.35±0.37^{fi} (123)	6.61±0.36^{gh} (122)	5.79±0.38^{fhki} (120)	2594.94±89.03^{ef} (122)
12	11.76±0 54 (107)	11.69±0.52 (107)	11.13±0.50 (107)	10.17±0.39 (104)	10.25±0.46 (102)	9.62±0 47 (100)	8.69±0.46^{f} (101)	7.99±0.45^{fh} (99)	7.30±0.45^{hi} (99)	6.17±0.47^{agfl} (96)	2774.80±112.00^{f} (98)

Genetic parameters

Heritability

a) Monthly test-day milk yields

Heritability estimates of various MTDMYs ranged from 0.004±0.107 in 9thtest day to 0.531±0.136 in 4th test day. Higher estimates of 0.44 ± 0.09 heritability on 3rdand 5thtest day in Karan Fries cows [13]. Lower estimates of heritability as 0.18±0.08 in Murrah buffaloes on 3rd test day [18]. The lower heritability estimates were noticed for 8th, 9th and 10thMTDMY indicating the higher environmental influences during the period. The comparatively higher heritability estimates during 3rd, 4th, 5th and 6th test day milk yields make those values as good indicator for selection. It also indicated that higher milk production period of lactation is least influenced by, environmental factors when compared to earlier and late lactation periods.

b) First lactation milk yield

Heritability estimates for FLMY was 0.601±0.145. Few studies having similar range of heritability as 0.60 ± 0.12 in Sahiwal cattle [19]. Higher heritability estimate of FL305DMY indicate that first lactation milk yield is highly influenced by genetic variation of animal rather than environmental factors. It offers a suitable value as an aid to selection of superior animals for breeding.

Genetic and phenotypic correlation

The genetic correlations of different MTDMYs with FLMY were found to be higher with the highest value observed for 9th test day (0.85). Higher genetic correlations of FLMY with TDMYs have been reported in sahiwal [13, 20]. The phenotypic correlations of MTDMYs with FLMY were found to be higher and it was ranged from 0.63 (5th test day) to 0.88 (5th test day). Higher estimate of phenotypic correlations of FLMY with TDMYs were reported in Karan Fries and Sahiwal cattle [13, 20]. The correlations of other MTDMY were not estimable. Higher estimates of genetic and phenotypic correlations of MTDMYs with FLMY revealed that MTDMY and FLMY can be used as selection criteria for cow or sire evaluation in crossbred cattle of Kerala.

Table 3: Heritability estimates of various MTDMYs and FLMY and genetic and phenotypic correlation of MTDMYs with FLMY.

Sr. No	Trait	$h^2 \pm$ SE	Genetic	Phenotypic
1	MTDMY-1	0.301±0.120	0.52±0.20	0.65±0.02
2	MTDMY-2	0.307±0.120	0.73±0.02	0.76±0.01
3	MTDMY-3	0.511±0.133	NA	NA
4	MTDMY-4	0.531±0.136	NA	NA
5	MTDMY-5	0.498±0.135	-0.01±0.45	0.88±0.00
6	MTDMY-6	0.422± 0.133	NA	NA
7	MTDMY-7	0.245±0.122	0.14±0.35	0.81±0.01
8	MTDMY-8	0.061±0.109	NA	NA
9	MTDMY-9	0.004±0.107	0.85±2.36	0.63±0.01
10	MTDMY-10	0.084±0.119	NA	NA
11	FLMY	0.601±0.145	-	-

The correlations of other MTDMY were not estimable.

Conclusion

The influence of various genetic and non-genetic factors on this is also important. Hence depiction of the factors that influence MTDMY and FLMY is studied in crossbred cattle of Kerala. This will help to define appropriate model for eliminating effect of different genetic and non-genetic factors on our traits of interest to improve the accuracy of selection.

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