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Original Research Article

Genetic and phenotypic parameter s of first lactation and life time traits in crossbred cattle

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Data for the present investigation were collected from history sheet of crossbred cattle maintained at instructional dairy farm of G. B. Pant University of Agriculture and Technology, Pantnagar. The data pertained to 1198 crossbred cattle from 102 sires were distributed over a period of 48 years from 1966 to 2010. Cows with abnormal and incomplete records were excluded from the study. The overall least squares mean of first lactation traits viz. AFC, FLMY, FLP, FDP and FCI were estimated to be1153.10 ± 24.84 days, 2733± 73.14kg, 320.46± 5.52 days, 113.06± 5.12 days, and 433.542 ± 7.91days respectively. The life time milk yield and life time lactation length were estimated as 10705.64±692.90kg and 1111.74±53.95 days respectively. Sire effect was significant on all the first lactation and life time traits. In contrast different genetic groups were found to have no significant influence on all the traits except first service period, similarly, season of calving was also found non-significant influence on all the traits except first lactation and life time milk yield. The period of calving were found to have significant influence on all the traits except first lactation milk yield. The heritability estimates of different first lactation traits were observed from low to high. The genetic and phenotypic correlations among all the traits were observed very low to high. The results of present study pointed out that most of variations in the traits were due to non-additive genetic variance. Therefore, improvement in these traits can be brought by the better management practices at the farm.

Key words: Crossbred cattle, first lactation milk yield, life time traits, least square means and heritability.

INTRODUCTION

The low milk production of indigenous cow is due to low genetic potential of milk production, inadequate feeding and non availability of nutrients, poor management, and prevalence of diseases combined with tropical climate. Another important reason of low production is rearing of cattle for draught purposes. Though the indigenous breeds of cattle in India are late maturing and poor milk producers but they possess disease resistance, have ability to utilize coarse fodders and also adapted to harsh tropical climate. Increase in production and productivity at simultaneously maintaining the diversity is the objectives of cattle breeding in India. The improvement in indigenous cattle breeds for milk production through selection and grading up has not been effective up to the desired levels. Considering the need for the large and the rapid increase in milk production, crossbreeding of local cattle with exotic dairy breeds was therefore thought to be the only option. The potential for genetic improvement in a trait largely depend upon genetic variation existing in a population of interest. The variability for a particular trait in a population is measured by heritability estimates of traits under given environmental condition. Variance and covariance are of prime importance to the breeder for estimating the genetic parameters and then utilizing these estimates for selection of animals.

Estimates of genetic parameters are needed for the prediction of breeding values and planning of selection strategies for desired genetic advancement with this object in view, the present investigation was conducted for estimating the genetic and phenotypic parameters of first lactation and life time performance traits.

MATERIALS AND METHODS

Data for the present investigation were collected from history sheet of crossbred cattle at instructional dairy farm of G. B. Pant University of Agriculture and Technology, Pantnagar. The data pertained to 1198 crossbred cattle from 102 sires were distributed over a period of 48 years from 1966 to 2010. Cows with abnormal and incomplete records were excluded from the study. Only the sires having records on at least 5 daughters were included in the present study. The records of only those animals with known pedigree and normal lactation were considered. The lactation records of less than 150 days were considered as abnormal and were not included in the analysis. The total duration of the present study was divided into 10 equal periods of five years each. Each year was divided into three seasons namely winter (November-February), Summer (March–June), and Rainy (July – October). In order to classify the data for different genetic group periods and seasons of calving were considered for all the traits. The traits considered in the present study were age at first calving, first service period, first lactation period, first dry period, first calving interval, first lactation milk yield, lifetime milk yield and life time lactation yield. Records on various first lactation and lifetime traits of crossbred cattle being in non-orthogonal nature were analyzed by Least Squares Analysis (LSA) technique of fitting constants for the estimation of genetic parameters as well as to examine the simultaneous effects of different genetic and non-genetic factors affecting any traits.

Statistical Analysis

As the data in the present study were non-orthogonal in nature with unequal subclass numbers, they were subjected to least squares analysis of variance without interactions using different models to examine the effect of genetic as well as non-genetic factors on various first lactation traits as per standard procedures of Harvey (1990). The model was based on the assumption that different components fitting in the model were linear, independent and additive. While sire was treated as random effect, the other genetic and non-genetic factors (genetic group, season and period) were taken as fixed effects in the model. Prior to estimation of genetic parameters, the data were adjusted for each significant effect of the source of variation. The data after adjustment for different significant effects were utilized for estimation of genetic parameters. Paternal half sib correlation method was used to estimate heritability of different traits (Becker, 1975). The standard error of heritability was estimated by the formula given by Swiger et al. (1964). The genetic and phenotypic correlations among different traits were estimated from the analysis of variance/covariance using half sib data as suggested by Becker (1975). The standard error of genetic correlation was estimated according to the formula given by Robertson (1959). The standard error of phenotypic correlation was estimated according to the formula given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Mean and standard errors for first lactation and life time traits are presented in Table 1. The overall least squares mean of first lactation traits viz. AFC, FLMY, FLP, FDP and FCI were estimated to be1153.10 ± 24.84 days, 2733 ±73.14 kg, 320.46±5.52 days, 113.06±5.12 days, and 433. 542 ± 7.91 days respectively. These estimates are in close agreement with those reported by Bharti (2004), Dubey and Singh (2005) and Mukharjee (2005), Singh et al. (2005), Singh et al. (2008), Tiwari et al. (2010); Moges et al. (2012). The life time milk yield and life time lactation length were estimated as 10705.64±692.90 kg and 1111.74±53.95 days respectively. Bharti (2004); Dubey and Singh (2005) and Mukharjee (2005), Singh et al. (2005); Singh et al.(2008); Tiwari et al. (2010) and Moges et al. (2012) were also reported similar results.

The least squares analysis of variance to estimate different non genetic effects are presented in Table 2. The least squares analysis of variance showed highly significant effect of sire on all first lactation and life time traits which revealed that superior sire could be used effectively for improvement of all the traits.

In the present study the different genetic group was found to have no significant influence on all the traits except first service period. The result indicates that there is no statistically significant difference among the different crosses under the study. These findings were in close agreement with the reports of Mukherjee (2005) and Dubey and Singh (2005) Singh et al. (2005), Singh et al. (2008), Tiwari et al. (2010) and Moges et al. (2012).

The effect of season was found to have non significant influence on all the traits except first lactation and life time milk yield. The cows calved in rainy season (July-October) had significantly lower values for all the traits than the cows calved in other season. It was found that cows calved in winter season (November -February) had higher age at first calving, first lactation period, first dry period, first calving period and first service period than the cows calved in other seasons. The cows calved in Summer season (March-June) had lowest age at first calving, first dry period, first calving interval and first service period. These results are in close agreement with the findings of Mandal and Sachdeva (2001), Mukherjee (2005) and Dubey and Singh (2005). However, Bharti (2004); Singh et al. (2005); Singh et al. (2008); Tiwari et al. (2010) and Moges et al. (2012) reported significant effect of season.

Table-1. Least Square Means with S.E. For First Lactation and life time traits

Source	No. of obs.	AFC (days)	FLMY (kg)	FLP (days)	FDP (days)	FCI (days)	FSP (days)	LTMY (kg)	LTL L (days)
Overall mean	1198	1153.10 ± 24.84	2733.73 ± 73.14	320.46 ± 5.25	113.06 ± 5.12	433.542± 7.91	178.88 ± 8.30	10705.64 ± 692.90	1111.74 ± 53.95
GENETIC GROUP									
G_1 (J × S)	223	1219.47 ± 51.03	2628.37 ± 157.99	327.97 ± 11.27	128.67 ± 11.54	456.65 ± 15.78	206.76 ± 18.28	10254.22 ± 1059.17	1005.84 ± 81.09
G_2 (HF × S)	56	1188.53 ± 57.13	2878.95 ± 177.43	329.29 ± 12.64	97.90 ± 17.91	427.00 ± 29.78	148.22 ± 20.55	11727.63 ± 1155.46	1207.48 ± 88.28
G_3(RD× S)	53	1107.19 ± 56.16	3083.62 ± 174.33	323.24 ± 12.42	104.02 ± 12.76	427.27 ± 17.33	158.79 ± 20.19	13144.40 ± 1139.95	1242.82 ± 87.12
G_4(J x R)	77	1178.93 ± 58.33	2396.43 ± 181.03	315.79 ± 12.90	119.39 ± 13.26	435.19 ± 17.98	192.29 ± 20.97	10170.28 ± 1173.64	1035.49 ± 89.64
G_6 (RD × R)	20	1049.83 ± 76.63	3112.32 ± 239.20	321.88 ± 17.04	120.72 ± 17.58	442.61 ± 23.57	173.04 ± 27.76	14127.66 ± 1475.59	1428.56 ± 112.26
G_7 (HF × H)	19	1104.37 ± 102.62	2215.34 ± 231.27	312.18 ± 22.87	99.84 ± 23.66	412.01 ± 31.51	138.32 ± 37.32	7807.37 ± 1918.97	981.29 ± 145.59
G_8 (HF×J×S)	20	1137.88 ± 75.53	2692.13 ± 235.73	303.03 ± 16.79	104.11 ± 17.32	407.15 ± 23.23	180.80 ± 27.36	8934.86 ± 1457.14	1019.20 ± 110.88
G_9 (HF×RDxS)	132	1174.44 ± 35.32	2805.98 ± 107.56	334.84 ± 7.68	111.90 ± 7.75	446.02 ± 11.03	186.48 ± 12.37	9955.21 ± 826.80	1015.82 ± 63.81
G_{10} (HF×J ×R)	105	1172.78 ± 38.96	2865.44 ± 119.37	331.42 ± 8.52	108.09 ± 8.65	439.51 ± 12.13	175.74 ± 13.76	11120.04 ± 878.26	1123.36 ± 67.63
G_{11} (HF×RD×R)	22	1174.03 ± 65.44	2697.07 ± 203.78	309.65 ± 14.52	122.50± 14.95	432.15 ± 20.16	175.56 ± 23.6	10881.03 ± 1289.92	1163.52 ± 98.34
G_{12} (RD × J × S)	18	1007.48 ± 70.43	2800.12 ± 219.63	313.64 ± 15.64	138.33 ± 16.13	451.97 ± 21.68	224.08 ± 25.48	10354.64 ± 1372.39	1074.98± 104.52
G_{13} (RD × J ×R)	77	1205.60 ± 45.28	2577.19 ± 139.65	313.13 ± 9.93	111.36 ± 10.17	430.50 ± 21.68	174.39 ± 16.14	9972.22 ± 971.19	1123.02 ± 74.53
G_{14}(HF×RD×J× S)	111	1144.53 ± 51.58	2639.36 ± 159.76	304.03 ± 11.39	102.10 ± 11.67	406.13 ± 15.95	170.67 ± 18.49	11091.99 ± 1067.85	1067.32 ± 81.73
G_{15} (RD×J×HxS)	265	1278.43 ± 35.29	2879.99 ± 107.50	340.39 ± 7.6	114.04 ± 7.75	454.46 ± 11.03	199.15 ± 12.37	10343.40 ± 826.55	1066.7 ± 63.80
SEASON									
S1 (Rainy)	402	1155.22 ± 26.93	2761.74 ± 80.11	317.90 ± 5.69	114.62 ± 5.66	432.52 ± 8.52	176.07 ± 9.13	10481.23± 717.67	1106.15 ± 55.77
S2 (Winter)	456	1160.41 ± 26.73	2676.43 ± 79.46	323.19 ± 5.69	117.34 ± 5.61	440.54 ± 8.47	188.52 ± 9.02	10698.01 ±715.31	1101.15 ± 55.76
S3 (Summer)	340	1143.68 ± 28.14	2763.03 ± 84.13	320.30 ± 6.02	107.21 ± 5.97	427.51 ± 8.88	172.09 ± 9.61	10937.67 ±732.58	1127.99 ± 56.86

Table 1 Cont.

PERIOD									
P1(1966-1970)	76	1157.63 ± 88.28	2938.15 ± 276.04	336.21 ± 19.66	111.66 ± 20.31	447.87 ± 27.13	178.40 ± 32.06	11471.47± 1672.90	1231.06± 127.08
P2(1971-1975)	272	1569.11 ± 77.94	2693.28 ± 243.37	334.83 ± 17.33	134.61 ± 17.89	469.44 ± 23.97	193.34 ± 28.25	9786.74 ± 1497.74	1244.78 ± 113.92
P3(1976-1980)	181	1477.89 ± 72.45	2502.12 ± 226.02	333.62 ± 16.10	130.58 ± 16.60	464.21 ± 22.30	187.13 ± 26.22	8444.28 ± 1405.95	1130.64 ± 107.04
P4(1981-1985)	76	1532.04 ± 45.65	2570.79 ± 205.88	348.92 ± 14.67	126.41 ± 15.10	475.34 ± 20.36	194.72 ± 23.88	8138.60 ± 1300.78	1142.26 ± 99.15
P5(1986-1990)	58	1152.34 ± 66.09	2462.06 ± 211.40	341.38 ± 15.06	128.32 ± 15.51	469.71 ± 20.89	165.46 ± 24.52	10208.41± 1329.45	1403.88 ± 101.30
P6(1991-1995)	162	1213.40 ± 67.83	3175.74 ± 216.46	349.23 ± 15.42	131.60 ± 15.89	480.83 ± 21.38	242.79 ± 25.11	11692.05 ±1355.85	1327.72 ± 103.28
P7(1996-2000)	164	861.53 ± 72.16	3053.90 ± 225.09	324.54 ± 16.03	130.22 ± 16.53	454.76 ± 22.21	224.78 ± 26.12	10423.24 ±1401.08	1111.64 ± 106.67
P8(2001-2005)	135	625.04 ± 84.27	2782.74 ± 263.39	283.49 ± 18.76	72.25 ± 19.37	355.75 ± 25.90	113.51 ± 30.58	7337.85 ± 1604.72	821.46 ± 121.96
P9(2006-2010)	74	655.33± 136.02	2424.80± 426.50	231.96± 30.36	51.84± 31.45	283.81± 41.72	186.48± 12.37	18848.08± 2501.51	592.25± 189.48

AFC=Age at First Calving, FLMY=First Lactation Milk Yield,
FLP=First Lactation Period, FDP=First dry period,
FCI=First Calving Interval, FSP=First Service Period,
LTMY=Lifetime Milk Yield, LTLL= Lifetime Lactation length

Table 2. Least square analysis of variance for first lactation and lifetime traits

Source of variance	Mean sum of square (MS Value)								
	d.f.	**AFC**	**FLMY**	**FLP**	**FDP**	**FCI**	**FSP**	**LTMY**	**LTLL**
s sire	101	109266.68**	1004042.82**	5136.70**	5184.92**	10725.01**	13248.71**	63563151.37**	380004.38**
Genetic group	13	23902.43	879428.14	2517.11	8916.37	14779.87	25701.34**	16430912.70	65550.13
Season	2	142904.69	1098040.04**	3590.57	12840.29	6856.20	9942.06	41394507.39**	188951.90
Period	8	475514.81**	1196190.48	9659.44**	19608.43**	31241.88**	36738.45*8	133599983.77**	674027.97**
Error	1073	63796.09	629790.16	3191.15	3434.75	5987.95	8522.96	20608587.67	117695.90

Significant ** P<0.01
*P<0.05

The period of calving significantly influenced all first lactation production and life time traits except first lactation milk yield. The present results are in close agreement with the reports.

The mean performance of age at first calving was observed lowest in first period P8 and highest in periodP4. The mean performance of the first lactation milk yield and first lactation period were observed highest in period P6 and it was lowest in period P9 of calving and similar trend also observed for first lactation period. The mean performance of the first dry period was observed highest in period P2 and it was lowest in period P9 of calving. The mean value of first calving interval was observed highest for the sixth period. The mean

Table 3. Heritability, Genetic (above diagonal) and Phenotypic (below diagonal) correlations estimates of first lactation and lifetime traits in cross bred cattle

S.No	Traits	AFC	FLMY	FLP	FDP	FCI	FSP	LTMY	LTLL
1	AFC	**0.14 ± 0.04**	-0.260 ± 0.25	0.147 ± 0.25	-0.003 ± 0.27	-0.092 ± 0.24	0.139 ± 0.26	0.135 ± 0.26	0.195 ± 0.188
2	FLMY	0.073 ±0.03	**0.12 ± 0.04**	0.323 ± 0.23	-0.238 ± 0.29	0.062 ± 0.25	0.098± 0.03	0.125 ± 0.19	0.156± 0.19
3	FLP	-0.024 ± 0.03	0.66 ± 0.02	**0.12 ± 0.04**	0.282 ± 0.29	0.812± 0.10	0.581 ± 0.20	-0.024 ± 0.19	0.191 ± 0.20
4	FDP	0.042 ± .0209	-0.143 ± 0.03	-0.075 ± 0.03	**0.10 ± 0.03**	0.789 ± 0.115	0.306 ± 0.25	-0.136± 0.21	-.082 ± 0.21
5	FCI	0.030 ± 0.029	0.37 ± 0.025	0.667± 0.016	0.692 ± 0.015	**0.15 ± 0.04**	0.58 ± 0.16	-0.098± 0.18	0.073 ± 0.18
6	FSP	0.011 ± 0.028	0.23 ± 0.010	0.417 ± 0.023	0.682 ± 0.015	0.811 ± 0.009	**0.11± 0.03**	0.347 ± 0.197	0.45 ± 0.19
7	LTMY	-0.27 ± 0.029	0.252 ± 0.03	0.131 ± 0.028	-0.098 ± 0.028	0.21 ± 0.028	0.051 ± 0.030	**0.36 ± 0.05**	0.83 ± 0.052
8	LTLL	-0.073± 0.03	0.132 ± 0.03	0.180 ± 0.028	-0.119 ± 0.028	0.041± 0.024	0.059± 0.028	0.640 ± 0.028	**0.38 ± 0.06**

performance of the first service period was observed highest in period P6 and it was lowest in period P8 of calving. These results are in close agreement with the findings of Mandal and Sachdeva (2001), Mukherjee (2005) and Dubey and Singh (2005). However, Bharti (2004) Singh et al. (2005), Singh et al. (2008), Tiwari et al. (2010) and Moges et al. (2012) reported non significant effect of period.

The mean value of life time milk yield was observed highest for the ninth period. The mean value of total lactation length was observed highest for the fifth period. However, no consistent trend was found, fluctuations being observed over the period of calving. The variability in all the traits over the periods might be due to differences in managemental practices followed during different periods of time.These results are in close agreement with the findings of Mandal and Sachdeva (2001), Mukherjee (2005) and Dubey and Singh (2005).

The heritability estimates for age at first calving, first service period, first lactation period, first dry period, first calving interval, first lactation milk yield, lifetime milk yield, and life time lactation length were 0.14±0.04, 0.12±0.04, 0.12±0.04, 0.10±.0.03, 0.15±0.04, 0.11±0.03, 0.36±0.05 and 0.38±0.06 respectively. In general, the heritability estimates of first lactation and lifetime traits under the present study were observed from very low to medium, which revealed that non genetic variability for these traits is existing and these traits can be improve through better feeding and management. Similar estimate of heritability was reported by Bharti (2004) in FXS, Singh and Gurnani (2004) in FXT and BSXS, Mukharjee (2005) in FXS Singh et al. (2005), Singh et al. (2008), Tiwari et al. (2010), and Moges et al. (2012). However, higher estimates of heritability than the present study were reported by Dubey and Singh (2005) in crossbreds.

The genotypic and phenotypic correlation among these traits are presented in Table 3. The genetic correlation of age at first calving with first lactation milk yield, first dry period and first calving interval were negative. However, positive genetic correlations were observed with first lactation period, first service period, lifetime milk yield and life time lactation length.

The genetic correlation of first lactation milk yield with first lactation period, first calving interval, first service period, lifetime milk yield, and life time lactation length were observed positive. The genetic correlation of first lactation period with first dry period, first calving interval, first service period, and life time lactation length were observed positive with very low to high magnitude. However, negative genetic correlation was observed with lifetime milk yield. The genetic correlations of first dry period with first calving interval, and first service period were observed positive. However, negative genetic correlations were estimated with lifetime milk yield and life time lactation length.

The genetic correlations of first calving interval with first service period and life time lactation length were observed positive. However, negative genetic correlations were estimated with lifetime milk yield and life time lactation length. The genetic correlations of first service period with lifetime milk yield and life time lactation length were observed highly positive. The genetic correlation of lifetime milk yield with life time lactation length was observed highly positive. This finding was in close agreement with the reports of Singh and Gurnani (2004) in FXT and BSXS Singh et al. (2005), Singh et al. (2008), Tiwari et al. (2010) and Moges et al. (2012) but did not agree with the reports of Dubey and Singh (2005) in crossbred. The phenotypic correlation was found to be positive but low and agreed with the reports of Akhtar (1998) in crossbred and Singh and Gurnani (2004) in FXT and BSXS.

The phenotypic correlations of age at first calving with first lactation milk yield, first lactation period, first dry period, first calving interval and first service period were found positive with very low magnitude.

However, negative phenotypic correlations were

estimated with lifetime milk yield and life time lactation length. The phenotypic correlations of first lactation milk yield with first lactation period, first calving interval and first service period, lifetime milk yield and life time lactation length were found positive with very low to high magnitude. However, negative phenotypic correlation was estimated with first dry period.

The phenotypic correlations of first lactation period with first calving interval, first service period, lifetime milk yield and life time lactation length were found positive. However, negative phenotypic correlation was estimated with first dry period. The phenotypic correlations of first dry period with first calving interval and first service period were observed positive. However, negative phenotypic correlations were estimated with lifetime milk yield and life time lactation length. The phenotypic correlation of first calving interval with, first service period, lifetime milk yield and life time lactation length were observed positive.

The phenotypic correlations of first service period with lifetime milk yield and life time lactation length were observed highly positive. The phenotypic correlation of lifetime milk yield with life time lactation length was observed highly positive. This finding was in close agreement with the reports of Akhtar (1998) in crossbred and Singh and Gurnani (2004) in FXT and BSXS, Singh and Gurnani (2004) in FXT and BSXS, Singh et al. (2005), Singh et al. (2008),Tiwari et al. (2010), and Moges et al. (2012), but did not agree with the reports of Dubey and Singh (2005) in crossbred.

On the basis of this study, it may be concluded that very little opportunity exist for selection of cows for life time traits. It is desirable to select the animals on the performance of earlier lactation traits rather than traits express later in life.

Competing interests

The authors declare that they have no competing interests

REFERENCES

Akhter J (1998). Evaluation of genetic parameters of first lactation traits and their use in construction of multi-trait selection indices for crossbred cattle. Ph. D. (Animal breeding) Thesis, G.B. Pant University of Agriculture and Technology, Pantnagar.

Bajetha Garima, Singh CV(2011). Estimates of genetic and phenotypic parameters of first lactation and life time performance traits in crossbred cattle. Indian. J. Dairy. Sci., 6: 1-7.

Becker WA(1975). Mannual of quantitative genetics. 3rd edition. Pub. Program in Genetics, Washington State University, Washington, USA.

Bharti(2004). Genetic studies on some economic traits using animal model and construction of selection indices. Ph.D. Thesis, G.B. Pant Univ. of Agric. and Tech., Pantnagar

Dubey PP, Singh CV (2005). Estimates of genetic and phenotypic parameters considering first lactation and lifetime performance traits in Sahiwal and crossbred cattle. Indian .J. Ani. Sci., 11 :1289-1294.

Harvey W R(199). User guide for LSMLMW and MIXMDL package. Mixed model least squares and maximum likelihood computer programme. PC-2 Version. Mimeograph, Columbia, Chio, USA

Mandel A, Sachdeva GK(2001). Factors affecting production and reproduction traits in crossbred cattle. Indian J. Ani. Sci., 8 :745-747.

Moges TG, Singh CV , Barwal RS (2012). Genetic and phenotypic parameters of first lactation and life time performance traits in crossbred cows. Indian. J. Dairy. Sci., 1: 1-3.

Panse VG , Sukhatme PV(1967). Statistical methods for Agricultural workers, ICAR, Krishi Bhawan, New Delhi.

Robertson A (1959). The sampling variance of the genetic correlation coefficient. Biom., 15: 469-485.Crossref

Singh MK, Gurnani M(2004). Genetic analysis of production and reproduction traits in Karan Fries and Karan Swiss cattle. Indian .J. Ani. Science., 2: 225-228.

Singh VK, Singh CV, Kumar D, Kumar A(2005). Genetic Evaluation of Some Economic Traits in Sahiwal and Its Crossbreds. Indian. J. Dairy. Sci., 3:1-5.

Singh VK, Singh CV, Kumar D, Sharma RJ(2008). Genetic parameters for first lactation and lifetime performance traits in crossbred cattle. Indian. J. Ani. Sc., 5: 497-500.

Swiger LA, Harvey WR, Everson DO, Gregory KE (1964). The variance of intraclass correlation involving groups with one observation. Biom., 20 : 818-826.Crossref

Tiwari M, Kumar D, Singh CV, Singh B, Gupta HP(2010). Estimation of genetic parameters of first lactation and life time traits in Sahiwal and its crossbreds. Indian Vet. J., 6: 872-574.