



*Original Research*

## Genetic Parameters of Performance Traits in Crossbred Cattle

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### Abstract

The present study was conducted on data pertaining to 264 crossbred cattle from the history-cum-pedigree sheets maintained in the Department of Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana over 19 years (1996 to 2014). The mixed linear model used for analysis was utilized to estimate the genetic parameters of performance traits. Effect of sire group was non-significant on all performance traits. Period of calving significantly affected age at first calving (AFC) and first service period (FSP) only, while season of calving showed significant effect on First peak yield (FPY) and first dry period (FDP). AFC significantly affected first lactation milk yield (FLMY) and FPY. The overall least squares means were 2331.18±52.16 kg, 314.72±9.88 days, 10.86±0.16 kg, 102.46±4.88 days, 1227.41±18.81 days, 131.80±4.82 days and 415.26±4.87 days, for FLMY, FLL, FPY, FDP, AFC, FSP and FCI, respectively. Heritability estimates for FLMY, FLL, FPY, FDP, AFC, FSP and FCI were 0.17±0.19, 0.28±0.19, 0.26±0.22, 0.38±0.23, 0.16±0.14, 0.02±0.17 and 0.12±0.18, respectively. The AFC was found to have low to high positive genetic and phenotypic correlation with all others first lactation performance traits. High genetic and phenotypic correlations of FLMY with FPY (0.73±0.12 and 0.51±0.05, respectively) and FLL (0.86±0.18 and 0.58±0.05, respectively) indicated that selection on the basis of FPY will reduce the generation interval, cost of recording and maintaining low producing animal in the herd and will increase the genetic gain in FLMY because of early selection.

**Key words:** Correlations, Crossbred Cattle, Heritability, Performance Traits

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### Introduction

India is predominantly an agricultural country and livestock is an integral and indispensable component of our agricultural system. About 70 percent of the population is engaged in agriculture and rearing of livestock. India is one of the leading countries in cattle population (190.90 million) which is 14.7% of world's cattle population (BAHS, 2013-14). Total crossbred cattle population of India was 39732 thousand



(BAHS, 2013-2014) of which 33760 thousands were females. Total milk production of India in 2012-13 was 132.4 million tones. Exotic/crossbred cows contributed 24.5% and contribution of indigenous/nondescript was 20.7% (BAHS 2013-2014).

The success of dairy industry is much dependent on level of production performance of the animals. Knowledge of genetic and non-genetic factors influencing the performance traits is essential to obtain correct estimates of genetic parameters and for developing a suitable selection criterion. Therefore, the present investigation was undertaken to estimate genetic and phenotypic parameters of different first lactation performance traits and to evaluate the effect of genetic and non-genetic factors on these traits.

### Materials and Methods

The data were collected on Frieswal crossbred cattle from the history-cum-pedigree sheets maintained over the period from 1996 to 2014 in the Department of Animal Genetics and Breeding, LUVAS, Hisar. The data were collected on various performance traits *viz.* first lactation milk yield (FLMY), first lactation length (FLL), first lactation peak yield (FPY), first dry period (FDP), age at first calving (AFC), first service period (FSP) and first calving interval (FCI). A total of 264 first lactation records of cows spread over 19 years were collected. 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. The lactation records with less than 100 days lactation length and less than 500 kg milk yield were excluded from the study. Cows having incomplete and abnormal records due to abortion, still birth and sickness etc. were excluded. Year to year variation within the period was assumed to be non-significant. Each year was divided into four seasons on the basis of fluctuations in the atmospheric temperature and relative humidity *viz.* summer (April to June), rainy (July to Sept.), autumn (Oct. to Nov.) and winter (Dec. to March).

To study the effect of genetic factor i.e. sire group and non-genetic factors i.e. period and season of calving on different performance traits and to obtain sire and residual variance-covariance components for various first lactation performance traits, least squares analysis technique (Harvey, 1990) was used with 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  $m^{\text{th}}$  progeny of  $j^{\text{th}}$  sire belonging to  $i^{\text{th}}$  sire group (Sire groups were made on the basis of year in which their first daughter calved. Different sire groups were used in different periods.);  $k^{\text{th}}$  period and  $l^{\text{th}}$  - season of calving;  $\mu$ - Overall population mean;  $G_i$ - fixed effect of  $i^{\text{th}}$  sire group ( $i=1$  to 7);  $T_{ij}$ - random effect of  $j^{\text{th}}$  sire within  $i^{\text{th}}$  sire group assumed to be NID ( $0, \sigma_s^2$ );  $P_k$ - fixed effect of  $k^{\text{th}}$  period of calving ( $k = 1$  to 5);  $S_l$ - fixed effect on  $l^{\text{th}}$  season of calving ( $l = 1, 2, 3, 4$ );  $A_{ijklm}$ - age at first calving pertaining to  $Y_{ijklm}^{\text{th}}$  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  $m^{\text{th}}$  progeny of  $j^{\text{th}}$  sire belonging to  $i^{\text{th}}$  sire group,  $k^{\text{th}}$  period and  $l^{\text{th}}$  season of calving assumed to be NID ( $0, \sigma_e^2$ ).

To study the effect of AFC the above model was used after deleting the effect of AFC as covariate. Least squares means were compared using Duncan's multiple range test (DMRT) as modified by Kramer (1957). Heritability estimates for various first lactation performance traits were obtained from sire component of variances using paternal half-sib correlation method (Sires having less than 3 observations were excluded from the study). The standard errors of heritability estimates were obtained using the formula given by Swiger *et al.* (1964). Genetic correlations among different performance traits were calculated from sire components of variances and co-variances and standard errors were estimated using the formula given by Robertson (1959). Phenotypic correlations among various traits were calculated from total variances and covariances and their standard error were computed using the formula given by Snedecor and Cochran (1968).

## Results and Discussion

The analysis of variance and least squares means along with standard error for various first lactation performance traits are presented in Table 1 and 2, respectively.

### Effect of Genetic and Non-Genetic Factors

Effect of sire group was non-significant on all performance traits. Period of calving significantly affected AFC and FSP only, while season of calving showed significant effect on FPY and FDP. AFC significantly affected FLMY and FPY. Kharat *et al.* (2008), Nehra (2011) and Divya (2012) also reported non-significant effect of period of calving on FLMY in crossbred cattle.

**Table 1:** Analysis of variance for various first lactation performance traits

Source of Variations	d.f	Mean Squares						
		AFC	FSP	FLMY	FPY	FLL	FDP	FCI
Sire group	6	70191.2	6762.23	419109.3	7.34	4068.14	2483.9	5966.02
Sire within sire group	47	44361.73	4078.39	456734.3	4.2	4166.45	3827.97	4168.65
Period	4	88806.48**	11209.29*	203518.6	5.57	1928.69	3881.99	7833.53
Season	3	7670.14	2951.13	639869.2	26.82**	2305.86	8820.03*	3100.91
Regression on AFC (L)	1	-	1237.13	2413246.49**	24.20**	6800.7	5182.8	500.73
Error	202	24758.18	4014.95	380654.2	3.18	4039.28	2585.17	4163.47

\* $P < 0.05$ ; \*\* $P < 0.01$

Whereas, Saha *et al.* (2010), SubhaLaxmi *et al.* (2010) and Hasan and Khan (2013) reported significant effect. Non-significant effect of season of calving on performance traits reported in present study was in close agreement with those reported by Nehra (2011) and Divya (2012). The influence of period of calving on AFC was highly significant which is in agreement with the observations made by Kumar *et al.* (2008); Divya (2012) and Chaudhari *et al.* (2013). However, Nehra (2011) found non-significant effect of period of calving on AFC in crossbred cattle. The analysis of variance for FPY revealed that season of calving had significant effect on this trait (Table 1).

### Least Squares Means

The least squares means for FLMY, FLL, FPY, FDP, AFC, FSP and FCI were observed as 2331.18±52.16 kg, 314.72±9.88 days, 10.86±0.16 kg, 102.46±4.88 days, 1227.41±18.81 days, 131.80±4.82 days and 415.26±4.87 days, respectively. The present study is in close conformity to those reported by Kumar *et al.* (2008), Saha *et al.* (2010), SubhaLaxmi *et al.* (2010) and Chaudhari *et al.* (2013) in crossbred cattle.

**Table 2:** Least squares means with standard errors for various first lactation traits

Effect		Least Squares Mean ± S.E.						
		AFC (days)	FSP (days)	FLMY (Kg)	FPY(Kg)	FLL (days)	FDP (days)	FCI (days)
<b>Over All Mean</b>		1227.41±18.81 (264)	131.80±4.82 (264)	2331.18±52.16 (264)	10.86±0.16 (264)	314.72±9.88 (264)	102.46±4.88 (264)	415.26±4.87 (264)
<b>Sire Group</b>	<b>SG 1 (2000-01)</b>	1397.19±85.49 (12)	173.18±24.23 (12)	1966.42±254.18 (12)	8.63±0.77 (12)	317.10±17.50 (12)	115.42±23.05 (12)	448.29±24.52 (12)
	<b>SG 2 (2002-03)</b>	1242.07±38.87 (60)	140.15±10.29 (60)	2368.54±112.43 (60)	11.02±0.35 (60)	326.40±10.43 (60)	96.69±10.62 (60)	422.31±10.37 (60)
	<b>SG 3 (2004-05)</b>	1181.69±38.35 (68)	113.64±10.37 (68)	2285.29±110.55 (68)	11.03±0.34 (68)	298.03±10.48 (68)	96.59±10.20 (68)	396.23±10.46 (68)
	<b>SG 4 (2006-07)</b>	1268.28±64.91 (18)	100.42±17.68 (18)	2430.49±187.13 (18)	11.54±0.57 (18)	302.06±17.87 (18)	86.17±17.14 (18)	382.90±17.87 (18)
	<b>SG 5 (2008-09)</b>	1200.32±54.25 (40)	138.79±12.30 (40)	2363.24±136.28 (40)	10.98±0.42 (40)	309.73±12.50 (40)	118.23±13.34 (40)	419.10±12.37 (40)
	<b>SG 6 (2010-11)</b>	1199.62±58.95 (41)	130.54±13.50 (41)	2306.56±149.15 (41)	11.20±0.46 (41)	312.51±13.70 (41)	107.47±14.23 (41)	420.64±13.60 (41)
	<b>SG 7 (2012-14)</b>	1102.72±60.80 (25)	125.92±17.32 (25)	2597.68±182.33 (25)	11.59±0.55 (25)	337.30±24.47 (25)	96.62±16.69 (25)	417.38±17.52 (25)
<b>Period of Calving</b>	<b>1996-2002</b>	1180.03 <sup>b</sup> ±64.20 (22)	94.96 <sup>b</sup> ±22.40 (22)	2222.51±219.27 (22)	11.47±0.64 (22)	305.75±22.48 (22)	86.17±18.21 (22)	391.85±22.80 (22)
	<b>2003-2005</b>	1236.46 <sup>a</sup> ±38.53 (85)	164.87 <sup>a</sup> ±12.45 (85)	2196.78±123.35 (85)	10.26±0.36 (85)	328.90±12.50 (85)	121.69±10.42 (85)	445.67±22.70 (85)
	<b>2006-2008</b>	1221.33 <sup>a</sup> ±40.18 (59)	138.21 <sup>a</sup> ±13.68 (59)	2274.51±135.15 (59)	10.78±0.40 (59)	309.48±13.74 (59)	116.20±11.38 (59)	422.10±13.91 (59)
	<b>2009-2011</b>	1241.23 <sup>a</sup> ±47.21 (46)	135.43 <sup>ab</sup> ±15.39 (46)	2506.65±151.58 (46)	11.36±0.44 (46)	318.90±15.45 (46)	90.39±12.70 (46)	410.19±15.66 (46)
	<b>2012-2014</b>	1257.02 <sup>a</sup> ±54.77 (52)	125.57 <sup>b</sup> ±17.40 (52)	2455.43±170.95 (52)	10.42±0.50 (52)	312.66±17.47 (52)	97.83±14.28 (52)	406.50±7.71 (52)
<b>Season of Calving</b>	<b>Summer (April-June)</b>	1236.98±27.20 (73)	135.42±8.79 (73)	2350.86±88.59 (73)	10.87 <sup>ab</sup> ±0.2 6 (73)	309.44±8.85 (73)	112.58 <sup>a</sup> ±7.70 (73)	419.70±8.93 (73)
	<b>Rainy (July-Sept)</b>	1203.70±32.49 (50)	134.37±10.26 (50)	2149.20±102.44 (50)	9.71 <sup>b</sup> ±0.30 (50)	308.04±10.31 (50)	110.45 <sup>a</sup> ±8.75 (50)	415.53±10.42 (50)
	<b>Autumn (Oct-Nov.)</b>	1234.67±31.91 (52)	119.62±9.95 (52)	2445.57±99.55 (52)	11.48 <sup>a</sup> ±0.3 0 (52)	322.74±10.00 (52)	81.00 <sup>b</sup> ±8.52 (52)	403.50±0.11 (52)
	<b>Winter (Dec-Mar)</b>	1234.29±26.17 (89)	137.81±8.28 (89)	2380.08±83.78 (89)	11.36 <sup>a</sup> ±0.2 4 (89)	318.63±8.33 (89)	105.78 <sup>a</sup> ±7.29 (89)	422.36±8.40 (89)

Figures in parenthesis are number of observations; Mean with different superscripts differ significantly among themselves

FLMY and FLL reported by Kharat *et al.* (2008) and Hasan and Khan (2013) were on lower side whereas those reported by Singh *et al.* (2008), Nehra (2011) and Goshu *et al.* (2014) were on higher side. Estimate for FDP was supported by the findings of Chaudhari *et al.* (2013) in crossbred cattle. Comparatively, higher FDP was observed by Sinha *et al.* (2009), Hasan and Khan (2013) and Ghosu *et al.* (2014). The AFC obtained in the present study is in lower side than those reported by Singh *et al.* (2008) and Hasan and Khan

(2013) in crossbred cattle. While, Kumar *et al.* (2008), Saha *et al.* (2010), Nehra (2011) and Divya (2012) reported lower AFC than the present study. The least squares mean of FLMY 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. The AFC was lowest in sire group 7 and highest in sire group 1. Thus by introducing further group of sires there was reduction in AFC so selection was in favourable direction.

### Estimation of Heritability

The genetic and phenotypic parameters were estimated to know the genetic variability existing among the traits to formulate breeding plans. Heritability estimates for FLMY, FLL, FPY, FDP, AFC, FSP and FCI were  $0.17 \pm 0.19$ ,  $0.28 \pm 0.19$ ,  $0.26 \pm 0.22$ ,  $0.38 \pm 0.23$ ,  $0.16 \pm 0.14$ ,  $0.02 \pm 0.17$  and  $0.12 \pm 0.18$ , respectively and depicted in Table 3.

**Table 3:** Estimates of heritability (diagonal), genetic correlation (above diagonal) and phenotypic correlation (below diagonal) among various first lactation traits in crossbred cattle

	AFC	FSP	FLMY	FPY	FLL	FDP	FCI
AFC	<b>0.16±0.14</b>	0.19±0.49	0.71±0.41	0.60±0.37	0.68±0.34	0.21±0.41	0.63±0.64
FSP	0.64*±0.047	<b>0.02±0.17</b>	0.47±0.17	0.44±0.22	0.57±0.15	0.44±0.17	0.92±0.13
FLMY	0.19**±0.061	0.44**±0.055	<b>0.17±0.19</b>	0.73±0.12	0.86±0.18	0.34±0.19	0.49±0.17
FPY	0.21**±0.060	-0.06±0.062	0.51**±0.053	<b>0.26±0.22</b>	0.47±0.21	-0.10±0.21	0.38±0.23
FLL	0.72**±0.043	0.69**±0.045	0.58**±0.050	0.35**±0.058	<b>0.28±0.19</b>	-0.39±0.19	0.53±0.16
FDP	0.68**±0.045	0.47**±0.055	-0.14*±0.061	-0.14*±0.061	-0.20**±0.061	<b>0.38±0.23</b>	0.55±0.15
FCI	0.80**±0.037	0.94**±0.021	0.42**±0.056	0.37**±0.057	0.72**±0.043	0.50**±0.054	<b>0.12±0.18</b>

\* Significant at ( $P < 0.05$ ); \*\* Significant at ( $P < 0.01$ )

The heritability estimate of FLMY in the present study was low. Estimates of similar magnitude were also reported by Singh *et al.* (2008), 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). Moderate estimates of heritability for FLL were also reported by Saha *et al.* (2010) and Goshu *et al.* (2014). However, lower estimates of heritability of FLL were reported by Kumar *et al.* (2008), SubhaLaxmi *et al.* (2010) and Nehra (2011).

The heritability estimate for FDP was moderate. The estimates of present study are in close agreement with those reported by Chaudhari *et al.* (2013) in crossbred cattle. However, Singh and Gurnani (2004) and Singh *et al.* (2008) reported lower estimate of heritability for this trait. The heritability estimate of AFC is in close agreement with heritability estimate reported by Singh *et al.* (2008) in crossbred cattle. While, higher estimate of heritability were reported by Nehra (2011), Chaudhari *et al.* (2013) and Ghosu *et al.* (2014). The estimates of heritability for FSP was low. Similar, results were reported by Singh and Gurnani (2004) and Saha *et al.* (2010). The heritability estimate of FCI was also low. Similar magnitudes were reported by Singh *et al.* (2008) and Chaudhari *et al.* (2013). The high environmental variance in the

reproductive traits might be reason for low heritability and the improvement in these traits could also be achieved by effective implementation of corrective measures of management and feeding.

### Estimation of Genetic and Phenotypic Correlations

The AFC was found to have low to high positive genetic and phenotypic correlation with all others first lactation traits. Contrary to the results of phenotypic correlations of AFC with other first lactation traits in present study, Chaudhari *et al.* (2013) and Goshu *et al.* (2014) reported low phenotypic correlation of AFC with all other traits except with FDP. High genetic and phenotypic correlations of FLMY with FPY ( $0.73 \pm 0.12$  and  $0.51 \pm 0.05$ , respectively) and FLL ( $0.86 \pm 0.18$  and  $0.58 \pm 0.05$ , respectively) indicated that selection on the basis of FPY will reduce the generation interval, cost of recording and maintaining low producing animal in the herd and will increase the genetic gain in FLMY because of early selection. FLMY had moderate to high positive genetic correlation with all other first lactation traits. The corresponding phenotypic correlations were significant positive whereas, significant and negative with FDP. High genetic and phenotypic correlations of FLMY with FPY and FLL reported in the present study were supported by Dalal *et al.* (2002), Kumar *et al.* (2008), Saha *et al.* (2010) and Chaudhari *et al.* (2013). The positive association of FLMY with FSP explains that with increase in service period the phase of pregnancy will shift and thus production will increase. Since this association is not favorable, an optimum service period needs to be decided so that favorable trend in it does not adversely affect the production performance of individual.

FLL had moderate to high positive genetic and phenotypic correlations with FSP, FPY and FCI. Similar, results were also reported by Dalal *et al.* (2002), Saha *et al.* (2010) and Chaudhari *et al.* (2013). Whereas, negative genetic and phenotypic correlations of FLL with FDP were supported by Dalal *et al.* (2002), Singh *et al.* (2008), Chaudhari *et al.* (2013) and Goshu *et al.* (2014). Negative phenotypic correlation of FPY with FDP was also reported by Dalal *et al.* (2002). Moderate to high positive genetic and phenotypic correlations among FSP, FDP and FCI were supported by Dalal *et al.* (2002), Chaudhari *et al.* (2013) and Goshu *et al.* (2014).

### Conclusion

Low to moderate heritability among production traits pointed out that additive genetic variance exist in the population for these traits, which can be exploited through family selection and /or progeny testing. This moderate estimate of heritability suggests that good possibility exists for further improvement of this trait through proper selection programme. The estimates of heritability for reproduction traits were low. The high environmental variance in the reproductive traits might be reason for low heritability and the improvement in these traits could also be achieved by effective implementation of corrective measures of management and feeding.

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