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Genetic Studies on First Lactation Traits and Life Time Milk Yield in Crossbred Cattle

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Authors' contributions

This work was carried out in collaboration among all authors. Author Shashikant involved in collection, standardization and adjustment of data along with preparation of the manuscript of the research article. Authors CVS and RSB contributed in analysis and interpretation of the data in the present research paper. Authors CBS and BNS involved in checking and correction of the manuscript. Author OS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To study the genetics on first lactation traits and life time milk yield in crossbred cattle.
Place and Duration of Study: Instructional Dairy Farm, G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India, Between March 2021 and April, 2022.
Methodology: Data for this study were collected from the history sheets of crossbred cattle at the instructional dairy farm. The dataset included 976 crossbred cattle from 66 sires over 32 years (1988–2019). Cows with abnormal or incomplete records were excluded.

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Results: The overall least squares mean of first lactation traits viz. age at first calving (AFC), first service period (FSP), first calving interval (FCI), first dry period (FDP), first lactation length (FLL), first lactation milk yield (FLMY) and lifetime milk yield (LTMY) were estimated to be 1153.20± 2.06 days, 192.95±4.90 days, 468.90±5.11days,129.50± 4.38 days, 339.41± 3.64 days,3376.36±50.40 kg and 14930.60±167.65kg, respectively. Season of calving did not significantly affect most traits except age at first calving. Period of calving significantly influenced all traits except first lactation milk yield and lifetime milk yield. Heritability estimates were low, with genetic and phenotypic correlations ranging from very low to high. Variations were mainly due to non-additive genetic variance, suggesting improvements can be achieved through better management and feeding practices.

Conclusion: Therefore, it can be concluded that there is limited scope for selecting cows based on lifetime traits. It is more advantageous to focus on selecting animals based on their performance in earlier lactation traits rather than traits that are expressed later in life.

Keywords: Crossbred cattle; First lactation milk yield; life time traits; least squares means and heritability.

1. INTRODUCTION

"The improvement in indigenous cattle breeds for milk production through the selection and grading-up has not been effective up to the desired levels due to low genetic potential for milk production, inadequate feeding and non-availability of nutrients, poor management, and prevalence of diseases combined with tropical climate. Most of the cattle breeds that exist today have been evolved over centuries due to large variation in soil, climate, agricultural practices and through natural selection mostly for adaptation to agro-climatic conditions, survivability and to a very limited extent these have been selected for milk and for draught quality" [1].

"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 and simultaneously maintaining the diversity are the objectives of cattle breeding in India" [2]. "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 depends upon additive 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" [3]. With this object in view, the present investigation was conducted for estimating the genetic and phenotypic parameters of first lactation and life time milk yield [2].

2. MATERIALS AND METHODS

2.1 Source of Data and Data Editing

Data for this study were collected from the history sheets of crossbred cattle maintained at the instructional dairy (IDF) farm of G B Pant University of Agriculture and Technology, Pantnagar. The cross bred cattle of IDF have a long history and have been maintained at the farm since early seventies. In the beginning, indigenous cattle were crossed with exotic Holstein Friesian, Jersey, Brown Swiss, Red Dane etc., however, as of today, Holstein Friesian and Sahiwal crosses are being maintained. The dataset covered records on 976 cattle from 66 sires over 32 years (1988–2019). Records from cows with abnormalities or incomplete data were excluded. Only sires with at least five daughters and animals with known pedigrees and normal lactations were included. Lactation records shorter than 150 days were deemed abnormal and excluded. The study period was divided into six intervals: the first period of seven years, and the remaining five periods were five years each. Data were categorized by year into three seasons viz. Winter (November-February), Summer (March-June) and Rainy (July-October) to assess first lactation milk yield. The traits analyzed included age at first calving, first service period, first calving interval, first dry period, first lactation length, first lactation milk yield, and lifetime milk yield.

2.2 Statistical Analysis

The data being non-orthogonal, with unequal subclass numbers, were analyzed using least squares analysis of variance without interactions [4]. The model assumed that different components fitted were linear, independent, and additive. Non-genetic factors, including first lactation milk yield groups, periods, and seasons of calving, were considered fixed effects. Duncan's multiple range test was used for pair-wise comparisons of least squares means. Before estimating genetic parameters, data were adjusted for significant effects [5]. Heritability was estimated using the paternal half-sib correlation method along with the standard error [6,7]. Genetic and phenotypic correlations among traits were derived from variance/covariance analysis using half-sib data and also standard errors for genetic and phenotypic correlations were estimated [6,8,9].

3. RESULTS AND DISCUSSION

3.1 Effect of Season, Period of Birth and FLMY Groups on Economic Traits and Least Squares Means in Crossbred Cattle

"The least squares analysis of variance to estimate different non-genetic effects are presented in Table 1. The effect of season was found to have non-significant influence on all the traits except age at first calving. The cows calved in summer season (March–June), had lower values for the. AFC, FSP, FCI, FDP and LTMY traits than the cows calved in another season. They, however, had higher values for the FLL and FLMY. It was found that cows calved in rainy season (July – October) had higher FSP, FCI, and FDP traits than the cows calved in other seasons. The cows calved in winter (November-February), had highest age at first calving. These findings corroborated with the findings of" [10,2,11,12,13,14,15,16]. However, [10,17,18,19,2] reported "significant effect of season on various lactation, reproduction and lifetime traits".

"The period of calving significantly influenced all first lactation traits except FLMY. The mean performance of age at first calving was observed lowest in period 4 (2005-09) and highest in period 6 (2019-19). The mean performance of the first service period was observed highest in period 3 (2000-04) and it was lowest in period 6 (2015-19) of calving. The mean performance of the first calving interval and first dry period were observed highest in period 3 (2000-04) and it was lowest in period 6 (2015-19) of calving. The mean performance of FLL was observed highest in period 2 (1995-99) and it was lowest in period 3 (2000-04) of calving. The mean value of first lactation yield was observed highest for the period 2 (1995-99) it was lowest in period 4 (2005-09) of calving. The mean value of life time lactation yield was observed highest for the period 5 (2010-14) it was lowest in period 6 (2015-19) of calving. These results were in close agreement with the findings" of [10,2,14,12,20]. However, [21,22,17,18,19] "reported non-significant effect of period on various production and reproduction traits".

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.

The first lactation milk yield group significantly influenced all first lactation traits except age at first calving. The mean performance of AFC was observed lowest in group-2 and highest in group-4. The mean performance of FSP was observed highest in group-6 and it was lowest in group-1. The mean performance of the first calving interval was observed highest in group-6 and it was lowest in group-2 and FDP were observed highest in group-1 and it was lowest in group-2. The mean performance of the FLL was observed highest in group-6 and it was lowest in group-1. The mean value of FLL was observed highest for the group-6, and it was lowest in group-1. The mean value of LTMY was observed highest for the group-6 and it was lowest in group-1.

Means and standard errors for first lactation traits and life time milk yield are presented in Table 2. The overall least squares mean of first lactation traits viz. AFC, FSP, FCI, FDP, FLL and FLMY were estimated to be 1153.20± 2.06 days, 192.95±4.90 days, 468.90±5.11days, 129.50± 4.38 days, 339.41± 3.64 days, and 3376.36±50.40 kg, respectively. These estimates were in close agreement with those reported by [9,10,22,17,18,19,2,13,14]. The lifetime milk yield was estimated as 14930.60±167.65 kg. Various researchers have also reported similar results in crossbred cattle [2,11,12,13,14].

Table 1. Analysis of variance (ANOVA) for economic traits in crossbred cattle

Source of Variation	DF	Mean Sum of Squares (MSS Values)						
		AFC(Days)	FSP (Days)	FCI (Days)	FDP (Days)	FLL (Days)	FLMY (kg)	LTMY (Kg)
Season	2	7972*	12871NS	13648NS	14356NS	3628NS	202259NS	2427148NS
PERIOD	5	58058**	71874**	66060**	88388**	12288*	139616NS	324798268NS
FLMY Groups	5	4552NS	437312**	441906**	20330*	461827**	181060551**	428776750**
ERROR	963	2420	10935	11425	9179	4147	86645	13917380

*** P ≤ 0.01; * P ≤ 0.05; NS= not significant*

Table 2. Least squares means for the effect of season, period of birth and FLMY groups on economic traits in crossbred cattle

Source	No.	AFC(Days)	FSP (Days)	FCI (Days)	FDP (Days)	FLL (Days)	FLMY (kg)	LTMY (Kg)
Overall	976	1153.20±2.06	192.95±4.90	468.90±5.11	129.50±4.38	339.41±3.64	3376.36±50.40	14930.60±167.65
Season	976	*	NS	NS	NS	NS	NS	NS
Winter	283	1160.27±2.98[a]	206.26±6.34[a]	478.86±6.48[a]	128.44±5.81[a]	350.42±3.90[a]	3602.40±17.80[a]	15455±226[a]
Summer	293	1150.12±2.96[b]	202.56±6.29[a]	480.30±6.43[a]	122.72±5.76[a]	357.58±3.87[a]	3641.90±17.70[a]	15293±224[a]
Rainy	400	1152.39±2.58[b]	214.51±5.48[a]	490.45±5.60[a]	135.70±5.02[a]	354.75±3.37[a]	3594.60±15.40[a]	15442±196[a]
Period	976	**	**	**	**	*	NS	**
1988-1994	218	1116.48±3.82[b]	207.61±8.11[bc]	482.93±8.29[bc]	132.19±7.43[b]	350.74±5.00[bc]	3587.40±22.80[b]	14136±289[c]
1995-1999	168	1162.29±3.88[a]	221.56±8.24[ab]	497.64±8.42[ab]	129.06±7.55[bc]	368.58±5.07[a]	3663.10±23.20[a]	15225±294[b]
2000-2004	162	1162.66±3.98[a]	239.25±8.47[a]	512.32±8.65[a]	168.58±7.76[a]	343.74±5.21[c]	3608.80±23.80[ab]	15274±302[b]
2005-2009	167	1155.48±3.87[a]	217.13±8.23[ab]	492.36±8.41[ab]	142.15±7.54[b]	350.21±5.07[bc]	3584.60±23.20[b]	16771±294[a]
2010-2014	160	1161.95±3.95[a]	185.00±8.39[cd]	459.75±8.58[cd]	108.26±7.69[cd]	351.49±5.17[bc]	3605.30±23.60[ab]	17492±299[a]
2015-2019	101	1166.71±4.97[a]	176.10±10.60[d]	454.20±10.80[d]	93.49±9.68[d]	360.72±6.50[ab]	3628.60±29.70[ab]	13481±377[c]
FLMY Groups	976	NS	**	**	*	**	**	**
≤ 2400	193	1157.98±3.80[a]	148.70±8.07[e]	425.33±8.25[e]	148.19±7.39[a]	277.14±4.97[f]	2039.70±22.70[f]	12794±288[d]
2401-2900	230	1147.85±3.40[a]	150.38±7.22[e]	422.92±7.38[e]	118.12±6.62[b]	304.80±4.45[e]	2666.90±20.30[e]	14314±258[c]
2901-3400	190	1152.19±3.60[a]	174.18±7.65[d]	451.21±7.82[d]	124.35±7.01[b]	326.86±4.71[d]	3148.50±21.50[d]	14698±273[c]
3401-3900	153	1160.71±4.08[a]	211.90±8.67[c]	487.17±8.86[c]	125.02±7.94[b]	362.16±5.34[c]	3611.10±24.40[c]	15074±309[c]
3901-4400	127	1149.30±4.40[a]	237.00±9.36[b]	512.67±9.57[b]	126.89±8.57[ab]	385.78±5.76[b]	4379.30±26.30[b]	17169±334[b]
≥4401	83	1157.56±5.54[a]	324.50±11.80[a]	599.90±12.00[a]	131.20±10.80[ab]	468.75±7.25[a]	5832.30±33.20[a]	18330±420[a]

*** P ≤ 0.01; * P ≤ 0.05; NS= not significant; Means with same superscripts denote non-significant differences*

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

Table 3. Heritability estimates of economic traits in crossbred cattle

Traits	Heritability
Age at first calving	0.137±0.07
First service period	0.156±0.07
First calving interval	0.172±0.07
First dry period	0.207±0.08
First lactation length	0.198±0.07
First lactation milk yield	0.294±0.09
Life time milk yield	0.138±0.171

Table 4. Genetic (above diagonal) and phenotypic (below diagonal) correlations among economic traits in crossbred cattle

Traits	AFC	FSP	FCI	FDP	FLL	FLMY	LTMY
AFC	-	0.407±0.35	0.391±0.34	-0.132±33	0.689±0.31	0.464±0.29	0.224±0.38
FSP	0.071±0.03	-	0.995±0.01	0.678±0.16	0.516±0.23	0.789±0.18	0.523±0.34
FCI	0.078±0.03	0.984±0.01	-	0.701±0.15	0.495±0.23	0.758±0.17	0.494±0.32
FDP	0.037±0.02	0.719±0.02	0.729±0.02	-	-0.273±0.30	0.241±0.26	0.048±0.33
FLL	0.068±0.03	0.569±0.02	0.579±0.03	-0.136±0.03	-	0.728±0.14	0.607±0.28
FLMY	0.007±0.03	0.414±0.03	0.407±0.02	-0.029±0.03	0.623±0.02	-	0.594±0.22
LTMY	0.008±0.02	0.097±0.03	0.096±0.03	-0.074±0.02	0.228±0.03	0.373±0.03	-

3.2 Heritability Estimates of Economic Traits in Crossbred Cattle

The heritability estimates for AFC, FSP, FCI, FDP, FLL, FLMY and LTMY, were 0.137±0.07, 0.156±0.07, 0.172±0.07, 0.207±0.08, 0.198±0.07, 0.294±0.09 and 0.138±0.171 respectively. In general, the heritability estimates of first lactation traits and lifetime milk yield traits under the present study were observed low, which revealed that non-genetic variability for these traits is existing and these traits can be improve through better feeding and management practices. Similar estimate of heritability was reported by [21] in Holstein Friesian x Sahiwal, [23] in Holstein Friesian x Tharparkar and Brown Swiss x Sahiwal, [22,17,18,19,2,14] for crossbred cattle. However, higher estimates of heritability than the present study were reported by [10,24,25,26,20] in crossbreds.

3.3 Genetic and Phenotypic Correlations among Economic Traits in Crossbred Cattle

The genotypic and phenotypic correlations among these traits are presented in Table 3. The genetic correlations of AFC with FSP, FCI, FLL, FLMY and LTMY were positive. However, negative genetic correlation was observed with FDP.

The genetic correlations of FSP with FCI, FDP, FLL, FLMY, and LTMY were observed positive. The genetic correlations of FCI with FDP, FLL, FLMY and LTMY were observed positive with medium to high magnitude. The genetic correlations of FDP with FLMY and LTMY were observed positive. However, negative genetic correlation was estimated with FLL.

The genetic correlations of FLL with FLMY and LTMY were observed positive. The genetic correlation of FLMY with LTMY was observed positive. The present findings were in close agreement with the reports of [22,17,18, 19,23,27,25] in crossbred cattle. The positive genetic correlation between FLMY and LTMY were also reported for crossbred cattle by [2 and 14] but were low to medium which did not conform with the estimates in the present study. The phenotypic correlations were found to be positive from very low to high and agreed with the reports of [27] in crossbred and [23] in FxT and BSxS.

The phenotypic correlations of AFC with FSP, FCI, FDP, FLL, FLMY and LTMY and were positive. The phenotypic correlations of FSP with FCI, FDP, FLL, FLMY, and LTMY were observed positive. The phenotypic correlations of FCI with FDP, FLL, FLMY and LTMY were observed positive with very low to high magnitude. The phenotypic correlations of FDP with FLL, FLMY and LTMY were observed negative. The phenotypic correlations of FLL with FLMY and LTMY were observed positive. The phenotypic correlation of FLMY with LTMY was observed positive. The finding in the present study were in close agreement with the reports of [27] in crossbred and [24] in FxT and BSXS, [22,17,18,19,25]. The present study corroborated with the [2,14,28] but did not agree with the reports of [10] in crossbred cattle.

4. CONCLUSION

The genetic analysis of first lactation traits and lifetime milk yield in crossbred cattle provides valuable insights into the least squares means, heritability and genetic correlations of economically important traits. The present findings highlight the complex interaction between genetic and non-genetic factors in shaping lactation performance and lifetime productivity in crossbred cattle and moreover, these findings are crucial for developing breeding strategies and management practices that enhance the efficiency and sustainability of crossbred dairy cattle populations. On the basis of this study, it might be concluded that very little opportunity exists 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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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