

Effect of Genetic and Non-genetic Factors on Lactation Traits in Jersey x Sahiwal Crossbred Cattle under Progeny Testing Programme of Chittoor

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ABSTRACT

Data on lactation traits collected from first lactation performance records of 4,877 daughters sired by 176 Jersey x Sahiwal crossbred bulls, maintained by selected field farmers under field Progeny Testing Programme across 24 mandals in Chittoor district, Andhra Pradesh (India), over a period of 10 years (2014 to 2023) were used for genetic analysis of lactation traits viz. 305-day milk yield (305DMY), total milk yield (TMY), lactation length (LL) and peak yield (PY). The overall least-square means for these traits were 2276.46±8.57 kg, 2300.23±9.20 kg, 283.93±0.49 days and 10.23±0.03 kg, respectively. The effect of sire, period and season of calving were found to be highly significant ($p < 0.01$) for all lactation traits. Heritability estimates for these traits ranged from 0.15 to 0.53. Genetic correlations among the traits were highly positive, ranging from 0.72 to 0.99, while phenotypic correlations were moderate to high, varying from 0.21 to 0.87, except between lactation length and peak yield.

Key words: Genetic and non-genetic factors, Genetic and Phenotypic correlations, Heritability, Jersey x Sahiwal crossbred cattle, Lactation traits. *Ind J Vet Sci and Biotech* (2025): 10.48165/ijvsbt.21.4.07

INTRODUCTION

Agriculture is the backbone of the Indian economy. India holds the top position, contributing 24% to the total global milk production (FAOSTAT, 2021-22). In 2022-23, milk production reached 230.58 million tonnes, with a Compound Annual Growth Rate (CAGR) of 5.85% over the past nine years (BAHS, 2023). In India, selection of dairy cattle for milk yield is generally based on lactation performance records. So, proper evaluation of lactation traits is needed to estimate genetic parameters precisely. The phenotypic expression of these traits is influenced by various genetic and non-genetic factors. Without reliable data on these traits, estimating genetic parameters becomes challenging, limiting the ability to establish effective selection criteria and breeding policies for improving animal performance. Hence, present study was carried out to assess the influence of important genetic and non-genetic factors, viz., effect of sire, period of calving and season of calving and to estimate the genetic and phenotypic parameters, viz., heritability, genetic and phenotypic correlations for various lactation traits in Jersey x Sahiwal crossbred cattle. The findings are expected to provide valuable insights for developing breeding strategies to enhance the genetic potential of this crossbred population.

MATERIALS AND METHODS

The study was designed for the genetic evaluation of lactation traits in Jersey x Sahiwal crossbred cattle under the field Progeny Testing Programme in Chittoor district, Andhra Pradesh, India. Data utilised for this study were collected

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from first lactation performance records of 4,877 daughters sired by 176 Jersey x Sahiwal crossbred bulls, maintained by selected field farmers across 24 mandals over a period of 10 years (2014 to 2023). Data collection started once the daughters matured and completed their first lactation. Since the female progeny born during or just prior to 2014 were not available for lactation, data from 2014 to 2015 could not be included. Additionally, records affected by culling, abortion, stillbirth, or other pathological conditions were also excluded. Data were classified into four classes according to period of calving, viz., Period 1 (2016-2017), Period 2 (2018-2019), Period

3 (2020-2021) and Period 4 (2022-2023). According to season of calving data were classified into three seasons, viz., winter (November to February), summer (March to June) and rainy (July to October). The traits considered for the present study were 305-days milk yield (305DMY), total milk yield (TMY), lactation length (LL) and peak yield (PY).

Statistical Analysis

The influence of genetic and non-genetic factors on different lactation traits were analyzed using Least squares analysis (Harvey, 1990) technique by fitting constants. The random effect of sire was considered in the model. The following model was considered with the assumptions that the different factors being fitted into the model are linear, independent and additive.

$$Y_{ijkl} = \mu + B_i + P_j + S_k + e_{ijkl}$$

Where,

Y_{ijkl} = i^{th} 305-days milk yield/Total milk yield/Lactation length/Peak yield of cattle which is progeny of i^{th} sire, calved in j^{th} period and k^{th} season

μ = overall mean

B_i = random effect of i^{th} sire

P_j = effect of j^{th} period of calving ($j = 1, 2, 3, 4$)

S_k = effect of k^{th} season of calving ($k = 1, 2, 3$)

e_{ijkl} = random error associated with each observation assumed to be NID ($0, \sigma_e^2$)

Paternal half-sib analysis (Becker, 1975) method was used to estimate the genetic and phenotypic parameters of lactation traits.

RESULTS AND DISCUSSION

The least-squares mean along with standard errors and effect of genetic and non-genetic factors for different lactation traits under this study are presented in Table 1. The overall least-squares mean for 305-DMY, TMY, LL and PY were observed to be 2276.46±8.57 kg, 2300.23±9.20 kg, 283.93±0.49 days and 10.23±0.03 kg, respectively.

Effect of Genetic and Non-Genetic Factors on various Lactation Traits

Effect of Sire

The effect of sire was found to be highly significant ($p \leq 0.01$) for all lactation traits under study, which was in agreement with the findings of Pantelici *et al.* (2014), Verma *et al.* (2016) and Ratwan *et al.* (2016). However, Al-Samarai *et al.* (2015) reported non-significant effect of sire on lactation length. The significant influence of sire highlights its critical role in influencing the milk production potential of the progeny, further emphasizing the importance of selecting high genetic merit bulls in breeding programs to improve milk yield in Jersey x Sahiwal crossbred cattle.

Effect of Period of Calving

Period of calving was found to have highly significant ($p \leq 0.01$) effect on all the lactation traits studied. Similar findings were reported by Wondifraw *et al.* (2013), Japheth *et al.* (2015), Verma *et al.* (2016) and Ratwan *et al.* (2016) for 305-day milk yield; Bhutkar *et al.* (2014), Pantelici *et al.* (2014), Al-Samarai *et al.* (2015), Dangar and Vataliya *et al.* (2015), Japheth *et al.* (2015), Ratwan *et al.* (2016) and Kumar *et al.* (2017) for total milk yield; Wondifraw *et al.* (2013), Pantelici *et al.* (2014), Al-Samarai *et al.* (2015) and Japheth *et al.* (2015) for lactation length and Lakshmi *et al.* (2010), Bhutkar *et al.* (2014) and Kumar *et al.* (2017) for peak yield. In contrast, non-significant effect of period of calving was reported by Pundir *et al.* (2007) for 305DMY; Pundir *et al.* (2007) and Hassan and Khan (2013) for TMY; Bhutkar *et al.* (2014) for LL and Kumar *et al.* (2017) for PY. The significant influence of the period of calving observed in this study highlights the influence of environmental and management conditions during different calving periods on milk production traits, which indicates the importance of adopting consistent and uniform management practices throughout the year to minimize variations in milk yield associated with calving periods.

Effect of Season of Calving

Season of calving had a significant ($p \leq 0.01$) influence on various lactation traits in this study. Similar findings were reported by Japheth *et al.* (2015) and Ratwan *et al.* (2016) for 305-DMY and for TMY; Komatwar *et al.* (2010) for LL, and Kumar *et al.* (2017) for PY. In contrast, non-significant effect of season on 305-DMY was reported by Wondifraw *et al.* (2013), Verma *et al.* (2016) and Shalan and Manaa (2022); on TMY by Dangar and Vataliya (2015) and Shalan and Manaa (2022); on LL by Bhutkar *et al.* (2014), Verma *et al.* (2016) and Ratwan *et al.* (2016), and on PY by Bhutkar *et al.* (2014). In this study, animals calved during the winter season exhibited the highest milk yields compared to those calved during the summer and rainy seasons. This observation aligned with the findings of Bhutkar *et al.* (2014) and Ratwan *et al.* (2016). The superior milk yield during winter could be attributed to better fodder availability and cooler environmental conditions during this period, supporting optimal milk production.

Heritability Estimates, Genetic and Phenotypic Correlations

The heritability estimates, genetic and phenotypic correlations among different lactation traits are summarized in Table 2.

Heritability Estimates

The heritability estimates for 305-DMY, TMY, LL and PY were observed to be 0.50±0.01, 0.53±0.01, 0.42±0.04, and 0.15±0.03, respectively. Heritability of 305-DMY was in close agreement with the findings of Ratwan *et al.* (2016) in Jersey crossbred cattle. However, Kumar *et al.* (2017) and Kaur *et al.* (2023) reported lower heritability values for 305-DMY, varying from

Table 1: Least-squares mean (\pm SE) for different lactation traits of Jersey x Sahiwal crossbred cattle

Effects	305-DMY	TMY	LL	PY
Overall mean	2276.464 \pm 8.576 (4877)	2300.239 \pm 9.208 (4877)	283.934 \pm 0.495 (4877)	10.239 \pm 0.036 (4877)
Sire	**	**	**	**
Period	**	**	**	**
Period - 1 (2016-2017)	2255.042 \pm 23.456 ^c (436)	2423.499 \pm 25.185 ^b (436)	280.287 \pm 1.354 ^a (436)	11.078 \pm 0.099 ^d (436)
Period - 2 (2018-2019)	2242.171 \pm 11.429 ^c (1974)	2302.489 \pm 12.272 ^a (1974)	285.618 \pm 0.660 ^b (1974)	10.284 \pm 0.048 ^c (1974)
Period - 3 (2020-2021)	2168.963 \pm 12.142 ^a (1672)	2224.020 \pm 13.038 ^a (1672)	289.422 \pm 0.701 ^c (1672)	9.681 \pm 0.051 ^a (1672)
Period - 4 (2022-2023)	2230.679 \pm 18.669 ^b (795)	2250.949 \pm 20.046 ^a (795)	280.410 \pm 1.078 ^a (795)	9.912 \pm 0.079 ^b (795)
Season	**	**	**	*
Season - 1 (Winter)	2307.844 \pm 15.924 ^b (1344)	2337.262 \pm 17.098 ^b (1344)	287.530 \pm 0.919 ^c (1344)	10.320 \pm 0.067 ^a (1344)
Season - 2 (Summer)	2300.839 \pm 13.000 ^b (2205)	2314.980 \pm 13.958 ^{ab} (2205)	282.981 \pm 0.751 ^a (2205)	10.098 \pm 0.055 ^{ab} (2205)
Season - 3 (Rainy)	2220.709 \pm 15.471 ^a (1328)	2248.476 \pm 16.612 ^a (1328)	281.292 \pm 0.893 ^b (1328)	9.299 \pm 0.066 ^b (1328)

Figures in parenthesis represent number of observations. Means with different superscripts within the column differ significantly from each other. **Highly significant ($p \leq 0.01$); *Significant ($p \leq 0.05$).

0.12 to 0.40 in various cattle breeds and its crosses. Heritability estimate for TMY was closely consistent with the estimate of 0.50 reported by Ratwan *et al.* (2016) in Jersey crossbred cattle. On the other hand, Banik and Gandhi (2010), Saha *et al.* (2010) and Gorbani *et al.* (2011) reported comparatively lower heritability estimates for TMY, ranging from 0.10 to 0.41 in different dairy cattle breeds. In comparison to the present study, Lakshmi *et al.* (2010) and Al-Samarai *et al.* (2015) observed significantly lower heritability estimates of 0.08, 0.06 and 0.06 for lactation length. The heritability estimate of PY was in accordance with the value of 0.16 reported by Lakshmi *et al.* (2010) in HF x Sahiwal cattle. In contrast, Ratwan *et al.* (2016) found noticeably greater heritability value of 0.41 in various breeds of dairy cattle.

Genetic and Phenotypic Correlations

Genetic correlations among different lactation traits ranged from 0.72 to 0.99, whereas phenotypic associations varied from 0.21 to 0.87. Genetic and phenotypic correlations of 305-DMY with TMY, LL and PY were highly positive, indicating strong relationships among these traits. These results were consistent with the findings of Goshu *et al.* (2014) and Ratwan *et al.* (2016). Similarly, TMY showed highly positive genetic and phenotypic associations with LL and PY, which were in accordance with the reports of Shekhar (2010) and Tadesse (2014). Moderate to high positive genetic (0.72 \pm 0.001) and low positive phenotypic (0.21 \pm 0.001) associations were observed between lactation length and peak yield, suggesting that genes influencing LL also moderately affect PY, though their

phenotypic association is relatively weaker. These results were comparable to the genetic correlation of 0.62 \pm 0.20 reported by Ratwan *et al.* (2016) in Jersey crossbred cattle. In contrast, Shekhar (2010) reported a highly negative genetic correlation of -1.008 between these traits in Jersey x Red Sindhi crossbred cattle.

Table 2: Heritability estimates (Bold, within the diagonal), Genetic (above the diagonal) and Phenotypic (below the diagonal) correlations among different lactation traits of Jersey x Sahiwal crossbred cattle

Traits	305-DMY	TMY	LL	PY
305-DMY	0.50\pm0.01	0.99 \pm 0.001	0.97 \pm 0.005	0.91 \pm 0.006
TMY	0.87 \pm 0.001	0.53\pm0.01	0.97 \pm 0.005	0.89 \pm 0.026
LL	0.77 \pm 0.006	0.77 \pm 0.007	0.42\pm0.04	0.72 \pm 0.001
PY	0.75 \pm 0.001	0.73 \pm 0.001	0.21 \pm 0.001	0.15\pm0.03

CONCLUSION

In this study, sire had a highly significant ($p \leq 0.01$) influence on all lactation traits, highlighting the importance of sire selection in driving genetic improvement for milk production. Moderate to high direct heritability estimates for all lactation traits show significant space for further genetic improvement under current environmental and management conditions. Additionally, highly positive genetic and phenotypic correlations among all lactation traits suggest a pleiotropic effect of genes, indicating that selecting cattle for improvement in one trait can simultaneously bring improvement in others. To maximize genetic progress and



economic benefits, it is crucial to incorporate these findings into breeding programs by focusing on traits with high heritability and strong genetic correlations. Furthermore, efficient management practices, especially during adverse environmental conditions, play a vital role in optimizing milk production efficiency and ensuring the sustainability of dairy farming systems.

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