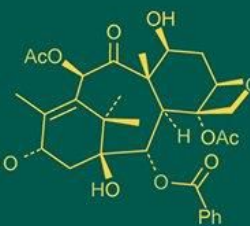
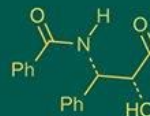
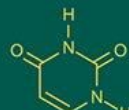
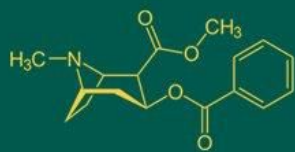


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Genetic and non-genetic determinants of performance traits in Haryana cattle

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Abstract

The current study examined the impact of non-genetic factors on lactation traits and estimated genetic parameters in Haryana cattle based on data from 3,368 animals. Least squares analysis indicated that period of calving (POC) and season of calving (SOC) had highly significant ($P < 0.01$) impacts on traits investigated; Total Lactation Milk Yield (TLMY), 300-Day Milk Yield (300DMY), Lactation Length (LL), Service Period (SP), Dry Period (DP), and Lactations Completed (LC). Least squares mean for TLMY and 300DMY were 1066.13 ± 9.38 kg and 1005.22 ± 7.65 kg, respectively. LL, SP, and DP were estimated as 320.94 ± 1.96 , 189.65 ± 2.50 , and 149.22 ± 1.42 days, respectively. It was concluded that summer calving was associated with increased LL, SP, and DP along with higher TLMY (1092.09 ± 16.07 kg) and LL (340.19 ± 3.36 days), whereas autumn calvers possessed relatively shorter periods. The mean LC at the farm was found to be 3.36 ± 0.05 , with the maximum value of (4.72 ± 0.11) . Genetic parameters were estimated by WOMBAT software by employing a univariate animal model with repeated records. Heritability estimates were moderate for TLMY (0.32 ± 0.06), 300DMY (0.29 ± 0.05), LL (0.27 ± 0.05), SP (0.20 ± 0.04), DP (0.22 ± 0.04), and LC (0.35 ± 0.06). The repeatability estimates varied from 0.21 for SP to 0.43 for LC. The results revealed moderate genetic control of the traits, which indicates moderate improvement via selective breeding, in conjunction with efficient management of calving season and duration.

Keywords: Production traits, reproduction traits, non-genetic factors, heritability, repeatability, Haryana cattle

Introduction

Livestock has been an integral component of animal husbandry in India, and it accounts for 30.23% of agricultural Gross Value Added (GVA) and 5.5% of the national economy (DAHD, 2025). India's global predominance in total milk production (239.30 million tonnes) is due to its highest bovine population (415 million) in world (BAHS, 2024). India's overall cattle population is 193.46 million, with indigenous cattle population of 142.11 million (Livestock Census 2019), accounting for 73.46% of the total cattle population. There are currently 54 recognized breeds of cattle distributed across the country (ICAR-NBAGR, 2025). In spite of decline of the indigenous cattle population by 6%, (Livestock Census 2019), milk production from indigenous /non-descript cattle has increased by 44.76 for the year 2023-2024 as compared to previous year (BAHS, 2024). Haryana cattle is a well-known dual-purpose indigenous cattle breed of Haryana state (Shetkar *et al.* 2021), with milk yield of 809 to 1,731 kg (Misra *et al.* 1981, Upadhyay and Madan 1985)^[26, 37, 41]. This breed is also known for its exceptional endurance in hot tropical climates, resistance to tropical diseases, and low maintenance costs. In addition to this Haryana cattle breed is also becoming more and more popular because its milk contains the A₂ allele, which is thought to be beneficial to human health (Mishra *et al.* 2009)^[25]. In India, this breed has been contributed in the production of synthetic crossbred cattle like Hardhenu and Vrindavani. Though highly contributory, Haryana cattle are often neglected in preference for high-yielding exotic or crossbreds, resulting in extensive under-estimation of their genetic potential. The production potential of these animals has deteriorated over a period of time due to lack of selection and progeny tested bulls. With the significance of the local cattle breeds as part of the environment and with the resilience that comes with them to climate change, as well as limited resources, there is need to highlight

the improvement of their genetics through the application of science. This requires a deep understanding of different performance traits such as milk yield, lactation yield, age at first calving, calving interval, and dry period, which also determine the efficiency and profitability of the dairy enterprises. Since decades dairy cattle breeding involves selection of animals on the basis of breeding goals and mating within better herd mates (Miglior *et al.* 2013; Chagini *et al.* 2019) [5], which needs understanding of different production and reproduction traits in the given population. The basis of genetic evaluation is based on the systematic collection of phenotypic records and accurate estimation of genetic parameters, particularly, heritability (h^2) and repeatability (Erfani-Asl *et al.*, 2015) [12, 24]. These parameters are essential for animal breeders, allowing them to estimate the genetic gain of different economic traits and to make informed selection along with culling decisions. The present study aims to evaluate genetic and phenotypic performance for repeatable traits in Haryana cattle to identify high-performing animals through the estimation of genetic parameters and assessment of the variability in different performance traits. The findings will contribute to breeding strategies along with culling decisions for enhancing milk production and reproductive efficiency thus promoting the utilization of superior germplasm and making a significant contribution towards the conservation and sustainable utilization of India's indigenous livestock heritage that can be utilized as foundation stock for future genetic improvement and conservation programs.

Materials and Methods

Source of Data: The data for the present study were collected from history cum herd inventory registers maintained at the State Livestock and Agriculture Farm, Babugarh, Hapur, Uttar Pradesh, India, over a time period of 55 years (1965-2020). Babugarh is located at 28.72° North and 77.85° East, with a subtropical climate. Summer temperatures reach up to 42°C (April to June), while winter temperature average around 5°C (December to March). The monsoon season lasts from July to August, with an average annual rainfall of 862.7 mm and relative humidity ranging from 67% to 83%.

Basic information

The basic information recorded for Haryana cattle were Sire number, Dam number, Date of calving, Date of birth and Date of Dry. The traits included for present study were Total Lactation Milk Yield in Pail (TLMY) in kg, Total Standard Lactation Milk Yield in Pail (300DMY) in kg, Lactation Length (LL) in days, Service Period (SP) in days, Dry Period (DP) in days and Lactation Completed (LC).

Standardization of records

Records of 834 Haryana cattle over a period of 55 years (from 1965 to 2020) with normal lactation and at least two completed lactations were included in the present study. Data were entered into Google Sheets for standardization, screening, and estimation of repeatable traits, with animal coding applied. Cows with lactation milk production <500 kg or lactation length <100 days were excluded. Outliers were removed to ensure normal distribution, and trait ranges were adjusted based on physiological limits, literature, and skewness and kurtosis values (between -1 and +1).

Classification of non-genetic factors: The data were classified according to the period of calving and season of calving to study the effect of non-genetic factors on the repeatable traits considered for present study. Ten periods of calving and Four seasons of calving Winter (December to March), Summer (April to June), Rainy (July to August) and Autumn (September to November) were considered for the present study.

Classification of Heritability and Repeatability: According to Brah (2020) Heritability and Repeatability was categorised as Low, Moderate and High [3].

Statistical Techniques: Data were analyzed using the least squares analysis model (SPSS Statistics 20.0) to identify significant fixed effects on repeatable traits in Haryana cattle. The model included period of calving (10 classes) and season of calving (4 classes) as fixed effects. Statistical significance was tested at the 5% and 1% levels. The analysis was performed using the least squares method for non-orthogonal data as outlined by Harvey (1960) [15].

The model used was as below

$$Y_{ijk} = \mu + P_i + S_j + e_{ijk}$$

Where;

- Y_{ijk} = k^{th} observation in j^{th} season and i^{th} period of calving
- μ = Overall mean
- P_i = Effect of i^{th} period
- S_j = Effect of j^{th} season
- e_{ijk} = Random error $\sim \text{NID}(0, \sigma^2_e)$

The statistical significance of various fixed effects in the least squares models were to be determined by the 'F' test.

Estimation of Genetic Parameters: The univariate repeatability model was run using the Wombat program (Meyer, 2007) [23] to estimate variance components, heritability, repeatability, and breeding values for repeatable traits. The model accounts for multiple records per animal, with repeatability reflecting the correlation between these records. It estimates both breeding values and permanent environmental effects. The model equation is:

$$y = X_b + Z_a + W_{pe} + e$$

Where;

- y = vector of records (e.g., lactation milk yield, lactation length)
- b = vector of fixed effects
- a = vector of random animal effects
- pe = vector of random permanent environmental effects
- e = vector of random residual effects

Result

Data structure and least square analysis

For present study least square mean for Total Lactation Milk Yield (TLMY), Total Standard Lactation Milk Yield (300DMY), Lactation Length (LL), Service Period (SP), Dry Period (DP) and Lactations completed (LC) along with effect of non-genetic factors on Haryana cattle is presented in Table 1. The dataset included 3368 animals of Haryana cattle. The

non-genetic factors which were used for different traits (TLMY, 300 DMY, LL, DP, SP and LC were period of calving (POC) and season of calving (SOC). The effect of period of calving (POC) as well as season of calving (SOC) were found to be highly significant ($P<0.01$) in the studied population (Table 1)

Performance of Genetic Parameters: Univariate animal mode for different traits (TLMY, 300 DMY, LL, DP, SP and LC) with repeated observations using the WOMBAT was run to estimate the Genetic parameters (Heritability and Repeatability) in the studied population. The estimates of Heritability and Repeatability for different repeated traits are presented in Table 2.

Discussion

Total Lactation Milk Yield: The overall total lactation milk yield (TLMY) was found to be 1066.13 ± 9.38 kg in studied population. The effect of period of calving (POC) as well as season of calving (SOC) were found to be highly significant ($P<0.01$) in the studied population (Table 1). The highest mean TLMY (1339.46 ± 21.41) was observed for the 4th POC (1985-90). However, the lowest TLMY (909.28 ± 38.29 kg) was observed for the 2nd POC (1975-80). Considering the effect of season of calving (SOC) on TLMY, it was revealed that the summer season (April –June) had favourable effect than other seasons considered in present study. It was revealed that animals that calved in the summer season had an average TLMY of 1092.09 ± 16.07 kg. However, favorable calving season (based upon total number of calving at the farm) was found to be the winter season which is in agreement with findings of Rahman *et al.* (2021) in Badri cattle, Wondifraw *et al.* (2013) in cross bred (H.F. x Deoni) cattle and Ilatsia *et al.* (2007) in Sahiwal cattle. However, Dangi *et al.* (2013) and Nehra (2004) have reported non-significant effects of season of calving (SOC) on total lactation milk yield which is in contrary to present findings [7, 17, 28, 42, 45].

Total Standard Lactation Milk Yield: The overall Total Standard Lactation Milk Yield (300 DMY) in kg in the studied population of Haryana cattle was found to be 1005.22 ± 7.65 kg. The fixed factors which were used for 300 DMY as dependent variables were period of calving (POC) and season of calving (SOC). The Period of calving (POC) as well as (SOC) were found to be highly significant ($P<0.01$) for studied population for 300 DMY (Table 1). The highest mean for 300 DMY (1263.37 ± 17.46 kg) was found for 4th POC (1985-90). However, the lowest 300 DMY (829.87 ± 31.23 kg) was found for the 2nd POC (1975-80). Animals that were calved during the autumn season (October to November) had significantly ($P<0.01$) higher 300DMY (1051.04 ± 14.01 kg) mean, as compared to other seasons' mean value. However, the lowest mean performance for 300DMY (970.98 ± 13.11 kg) was revealed by those animals that calved during summer season (April to June) at the farm. Research reports of, Singh and Gurnani (2004) in Karan Fries cattle as well as in Karan Swiss cattle, Gupta *et al.* (2019) in Kankrej cattle and Dash *et al.* (2023) in Sahiwal cattle that period of calving (POC) had significant effect on 300DMY, is in agreement with present findings. The findings of this study are consistent with those of Atil *et al.* (2001) in HF that season of calving exhibits significant effects on 300 DMY. Similarly, Gupta *et al.* (2019) in Kankrej cattle has

reported non-significant effect of season of calving on 300 DMY which is also in contrast to present findings [1, 8, 14, 38].

Lactation Length

The least square means for Lactation Length (LL) in days for Haryana cattle and effect of non- genetic factors is presented in Table 1. The overall least-square estimate for lactation length (LL) was found to be 320.94 ± 1.96 (days). The fixed factors considered for lactation length (LL) trait, as dependent variables were period of calving (POC) and season of calving (SOC). Effects of period of calving and season of calving were found to be highly significant ($P<0.01$) for lactation length (Table 1.) in present study which is in accordance with the findings of Dhawan *et al.* (2015). The highest (340.93 ± 4.08 days) and lowest (286.52 ± 3.92 days) mean values of LL were observed for animals for 7th (2000-05) and 10th (2015-20) period of calving, respectively. Animals calved during the summer season (April - June) revealed the highest lactation length (340.19 ± 3.36 days) as compared to other seasons. However, the shortest lactation period (310.21 ± 3.59 days) was recorded for autumn calvers (October - November) in present study [11].

Service Period

The least square means for Service Period (SP) in days and effect of non- genetic factors in Haryana cattle is presented in Table 1. Overall, the least-square estimate for Service Period (SP) was found to be 189.65 ± 2.50 (days). The fixed factors used in our present study for service period (SP) as dependent variables were period of calving (POC) and season of calving (SOC). Effects of period of calving and season of calving were found to be highly significant ($P<0.01$) for Service Period (Table 1.) in the studied population which was in agreement with findings of Kuthu *et al.* (2007), Dangi *et al.* (2013) and Gupta *et al.* (2019) in different breeds of cattle. The highest (223.39 ± 10.22 days) and lowest (145.27 ± 5.01 days) mean values of service period were observed for animals for 2nd (1975-80) and 10th (2015-20) class intervals of period of calving, respectively. Animals calved during the summer season (April - June) revealed the highest service period (221.23 ± 4.29 days) as compared to other seasons. The lowest service period (166.78 ± 4.58 days) was observed for autumn calvers (October - November) [7, 14, 21].

Dry Period

The least square means for Dry Period (DP) in days and effect of non- genetic factors on Haryana cattle is presented in Table 1. Overall, the least-square estimate for Dry Period (DP) was found to be 149.22 ± 1.42 days in the investigated population. Fixed factors used for dry period (DP) as dependent variables were period of calving (POC) and season of calving (SOC). In our present study the period of calving (POC) and season of calving (SOC) revealed to be highly significant ($P<0.01$) (Table 1.), which is in agreement with findings of Shetkar *et al.* (2021) in Haryana cattle. However, findings of Ratwan *et al.* (2019) revealed that, period of calving and season of calving exhibit non-significant effect on dry period in Sahiwal cattle, which is in contrast to present findings. Gupta *et al.* (2019) have reported that the period of calving showed highly significant effect on the dry period while season of calving showed non-significant effect to this trait. Dangi *et al.* (2013) showed that the season of calving had a significant ($P<0.05$) effect on the dry period, while period of calving showed non-significant effect on the dry period [7, 14, 32, 37].

The highest (190.73 ± 7.64 days) and lowest (131.93 ± 3.24 days) mean values of dry period were observed for animals for 1st (1967-75) and 10th (1995-00) class intervals of period of calving, respectively. Animals calved during the summer season (April - June) revealed the highest dry period (161.40 ± 2.43 days) as compared to other seasons. The lowest dry period (138.43 ± 2.60 days) was observed for autumn calvers (October - November).

Lactations completed: The least square means for Lactations completed (LC) and effect of non-genetic factors on Haryana cattle is presented in Table 1. Overall, the least-square estimate in present study for Lactations completed (LC) was found to be (3.36 ± 0.05). Fixed factors used for Lactations completed as dependent variables were period of calving (POC) and season of calving (SOC). Effects of period of calving and season of calving for Lactations completed were found to be highly significant ($P < 0.01$) in the studied population (Table 1.). The highest (4.72 ± 0.11) and lowest (2.09 ± 0.27) mean values of LC were observed for animals for 6th (1995-00) and 1st (1967-75) class intervals of period of calving, respectively. It was observed that animals calved during the rainy season (April - June) revealed the highest lactation completed (3.76 ± 0.10) as compared to other seasons. The lowest lactation completed (3.09 ± 0.09) was observed for the animals calved in summer season (April - June). The least squares analysis of variance for various repeatable traits revealed that all the traits under study were significantly ($P < 0.01$) affected by period of calving and season of calving, in which the animals were calved. The significant influence of the period of calving as well as the season of calving may be result of variations in the prevailing microclimatic conditions, feed and fodder availability during various periods and seasons, leading to influence of repeatable traits in the studied population of Haryana cattle.

Performance of Genetic Parameters: Univariate animal model for different traits (TLMY, 300 DMY, LL, DP, SP and LC) with repeated observations using the WOMBAT was run to estimate the genetic parameters (Heritability and Repeatability) in the studied population. The estimates of Heritability and Repeatability for different repeated traits are presented in Table 2.

Heritability

The estimates of heritability for traits, DP (0.09 ± 0.03), LL (0.09 ± 0.04), SP (0.11 ± 0.04), LC (0.10 ± 0.03) and TLMY (0.20 ± 0.05), were found to be low, however, it was moderate for 300DMY (0.25 ± 0.05) in the studied population. In our present study the estimate of direct additive heritability for dry period (DP) was found to be low in range ($h^2 \leq 0.20$) which is in accordance with the findings of Rehman *et al.* (2008) in Sahiwal cattle (0.05), Kumar *et al.* (2009) in Haryana cattle (0.09), Sah *et al.* (2010) in Kankrej cattle (0.09), Rehman and Khan (2012) in Sahiwal cattle (0.14), Verma *et al.* (2018) in Red Sindhi cattle (0.08), Kumar *et al.* (2019) in Haryana cattle (0.09), Gupta *et al.* (2019) in Kankrej cattle (0.16) and Yadav *et al.* (2024) in Hardhenu cattle (0.03). However, findings of Javed *et al.* (2001) in Sahiwal cattle (0.29), Goshu *et al.* (2014)^[18, 19, 20, 33, 34, 35, 43, 47] in HF (0.24) cattle, suggest that heritability for Dry Period falls under moderate range, which is not in agreement with our findings. This variation in estimates of heritability could be ascribed to various factors, including different data size,

genetic diversity within the population under study, managerial and environmental factors, and different parameter estimation techniques (Ayalew *et al.*, 2017). From the present study, it is revealed that the trait, dry period, exhibits relatively lower genetic variability in the existing population, indicating that it could be improved with the provision of balanced nutrition along with right management practices at the farm^[2, 13, 14].

The estimate of direct heritability of the trait lactation length (LL) in the studied population was found to be low ($h^2 \leq 0.20$) in range, which is in agreement with findings of Ojango and Pollot (2001) in Holstein Friesian cattle (0.09), Lakshmi *et al.* (2010) in Frieswal cattle (0.06), Kumar *et al.* (2019) in Haryana cattle (0.09). However, moderate estimate ($0.20 < h^2 \leq 0.40$) of LL trait heritability reported by Paul *et al.* (2003) in Kankrej cattle (0.29) and Sah *et al.* (2010) in Kankrej cattle (0.21) is not in agreement with our findings. However, Pandey *et al.* (2001) in Haryana cattle have reported high range of heritability for LL (0.44). The lower estimate for the heritability of LL in the Haryana population indicates that additive genetic variations did not significantly influence the individual differences for the trait considered for study in the studied population. In other words, the estimate of heritability indicates that the sire effect had little to no contribution to the variation for the LL trait, indicates that these heritable effects are generally less important than non-genetic effects in this studied herd. Present study result could suggest that there is little room for improvement that may have been due to genetic factors hence management practices together with nutrition is very important for the improvement in LL of surveyed population^[22, 29, 30, 31, 35].

Result of direct heritability estimates for service period (SP) in present study was in agreement with findings of Kumar *et al.* (2009) in Haryana cattle (0.10), Rajeev and Kumar (2021) in Frieswal cattle (0.10) and Dash *et al.* (2023) in Sahiwal cattle (0.11), however, moderate estimate is reported by Goshu *et al.* (2014) in HF cattle (0.26). In contrast to our findings, Kumar *et al.* (2019) in Haryana cattle and Gupta *et al.* (2019) in Kankrej cattle have reported a low estimate (0.05) of heritability for service period. Considering the trait, service period, does not represent higher levels of genetic variation, proper handling and efficient feeding will be critical for enhancing the trait^[8, 13, 14, 19, 20].

In the population of Haryana cattle under study, the estimate of direct heritability for lactation completed (LC) was low in range, suggesting that additive genes did not significantly affect individual phenotypic differences from one another. Therefore, it could be suggested that there isn't plenty of space for improvement by means of mating and selection within the herd. To further strengthen, management techniques and appropriate, balanced feeding are required.

Lower heritability estimate for TLMY in present study was in accordance with the findings of Kumar *et al.* (2009) in Haryana cattle (0.16), Das *et al.* (2013) in Sahiwal X HF Local breed X HF (0.18), Ayalew *et al.* (2017) in HF (0.17), Worku *et al.* (2022) in Sahiwal cattle and Yadav *et al.* (2024) in Hardhenu cattle (0.16). However, Pandey *et al.* (2001) in Haryana cattle (0.47) and Ratwan *et al.* (2019) in Jersey-Sahiwal cross (0.50) estimated higher values for TLMY than present study. Present study indicates that additive genes did not significantly contribute to individual differences in phenotype. Furthermore, estimation of heritability is influenced by method of estimation, data size and environmental factors^[2, 19, 30, 32, 46, 47].

The estimate of direct heritability for (300 DMY) in present study is moderate (0.20-0.40) in range, which is in agreement with the findings of Pandey *et al.* (2001) in Hariana cattle (0.36), Gupta *et al.* (2019) in Kankrej Cattle (0.31) and Dash *et al.* (2021)^[8, 14] in Sahiwal (0.29). However, lower range of heritability, estimated by Lakshmi *et al.* (2010) in Frieswal cattle (0.18), Rehman and Khan (2012) in Sahiwal cattle (0.10) is not in agreement with present findings. Higher estimates than present study is also reported by Ratwan *et al.* (2016) in Jersey -Sahiwal cross cattle (0.58). Result of direct heritability for 300DMY trait exhibits relatively more genetic variation. So, individual selection and/or progeny testing could be a tool for bringing out desirable changes in this trait, although there will be a significant role of managerial practices and balanced nutrition^[22, 30, 32, 33].

Repeatability(r): The estimates of repeatability was found to be low for DP (0.18±0.01), moderate for SP (0.26±0.02), LL (0.28±0.02), LC (0.27±0.02) and high for TLMY (0.45±0.02) and 300 DMY (0.46±0.02) in the studied population of Hariana cattle.

In the present study the estimate of repeatability for dry period (DP) was found to be low ($r \leq 0.20$) which was in agreement with the findings of Rehman *et al.* (2012) in Sahiwal cattle (0.14). However, the finding of Thakkar *et al.* (2019) in Kankrej cattle (0.48) and Vinothraj *et al.* (2016) in Jersey X Red Sindhi cattle (0.42) is not in agreement with our findings. Mustafa *et al.* (2002) have reported lower estimates of repeatability of DP (0.029), in Red Sindhi cattle than present study. The low range of repeatability estimate suggests that variation in DP is more of temporary nature rather than genetic influence of cows in the given herd^[33].

The present study encountered a moderate (0.28) estimate of repeatability for the trait lactation length (LL, consistent with the findings of Syrstad *et al.* (1993) in Hariana cattle, Rahman

et al. (2012) in Sahiwal cattle (0.33), and Thakkar *et al.* (2019)^[39, 40, 42, 44] in Kankrej cattle (0.24). However, the findings of Mustafa *et al.* (2002) in Red Sindhi cattle (0.03) is not in agreement with present findings^[27].

In present study the estimate of repeatability for service period was found to be moderate (0.26) in range which is in agreement with the findings of Thakkar *et al.* (2019) in Kankrej cattle (0.22). However, findings of Mustafa *et al.* (2002) in Red Sindhi (0.17) and Rahman *et al.* (2012) in Sahiwal cattle (0.14) are not in agreement with our findings. In general, modest repeatability estimates for SP, LL and LC suggests that selection for these traits based on early performance records is reliable (Ayalew *et al.* 2017)^[12].

In present study the estimate of repeatability for 300DMY was found to be upper side of moderate range (0.46) in range which is in agreement with the findings of Thakkar *et al.* (2019) in Kankrej cattle (0.49). Chawala *et al.* (2017) has reported repeatability for 300DMY as (0.70) in Mpwapwa Cattle. However, findings of Salem *et al.* (2016) in H.F. cattle (0.18), Worku *et al.* (2021) in Karan Fries cattle (0.37), are lower than present findings. In present study the estimate of repeatability for TLMY was found to be upper side of moderate (0.45) in range which is in agreement with the findings of Cliek *et al.* (2009) in H.F. cattle (0.51), Rahman *et al.* (2012) in Sahiwal cattle (0.40), Thakkar *et al.* (2019) in Kankrej cattle (0.49). However, Mustafa *et al.* (2002) in Red Sindhi cattle (0.36) and Worku *et al.* (2021) in Karan Fries cattle (0.34) have reported lower range of repeatability for TLMY, which is not in agreement with present study^[41].

Upper side of moderate range repeatability estimates for 300DMY and TLMY suggest that data from first parity may be used for early prediction of estimated breeding value and selection as well as culling. Early selection would retain good producers, which would be advantageous for improving the herd's overall performance^[27, 36, 40, 42, 46].

Table 1: Least square means for different performance traits in Hariana cattle

Fixed Factors	Groups	N	Mean					
			TLMY (kg)	300DMY (kg)	LL (days)	SP (days)	DP (days)	LC
Overall		3368	1066.13±9.38	1005.22±7.65	320.94±1.96	189.65±2.5	149.22±1.42	3.36±0.05
Period of calving	1967-75	64	931.33 ^{abc} ±50.48	862.24 ^{ab} ±41.17	308.78 ^{bcd} ±10.54	222.75 ^c ±13.47	190.73 ^c ± 7.64	2.09 ^a ±0.27
	1975-80	112	909.28 ^{ab} ±38.29	829.87 ^{ab} ±31.23	332.63 ^{bce} ±8.00	223.39 ^c ±10.22	186.34 ^c ± 5.79	3.19 ^{bcd} ±0.20
	1980-85	117	1037.46 ^{acd} ±37.41	937.58 ^{ac} ±30.51	337.49 ^{ce} ±7.81	217 ^c ± 9.99	161.29 ^b ± 5.66	2.13 ^a ±0.20
	1985-90	364	1339.46 ^f ±21.41	1263.37 ^f ±17.46	314.18 ^{bcd} ±4.47	171.44 ^b ±5.71	139.81 ^a ± 3.24	2.85 ^{bc} ±0.11
	1990-95	485	1313.61 ^f ±18.55	1218.06 ^f ±15.13	326.01 ^{bce} ±3.87	181.01 ^b ±4.95	136.96 ^a ± 2.81	3.51 ^{bde} ±0.10
	1995-00	358	1193.88 ^e ±21.43	1086.56 ^e ±17.47	331.72 ^{bce} ±4.47	183.42 ^b ±5.72	131.93 ^a ± 3.24	4.72 ^e ±0.11
	2000-05	437	1046.76 ^{cd} ±19.54	946.53 ^{ac} ±15.94	340.93 ^{ce} ±4.08	204.27 ^c ± 5.22	141.39 ^a ± 2.96	2.9 ^{bc} ±0.10
	2005-10	492	1034.98 ^{acd} ±18.22	1020.75 ^d ±14.86	317.09 ^{bcd} ±3.81	170.85 ^b ± 4.86	132.28 ^a ± 2.76	4.33 ^f ±0.10
	2010-15	464	941.51 ^{abc} ±18.99	926.32 ^{ac} ±15.49	314.05 ^a ±3.97	177.06 ^b ±5.07	138.2 ^a ± 2.87	3.66 ^{de} ±0.10
	2015-20	475	913.05 ^{ab} ±18.77	960.43 ^c ±15.13	286.52 ^b ±3.92	145.27 ^a ±5.01	133.25 ^a ± 2.84	4.22 ^f ±0.10
Season of calving	Winter (Dec-March)	1480	1075.62 ^b ±11.92	1022.88 ^b ±9.72	320.27 ^b ±2.49	193.84 ^b ±3.18	152 ^b ± 1.80	3.17 ^a ±0.06
	Summer (April-June)	702	1092.09 ^b ±16.07	970.98 ^a ±13.11	340.19 ^a ±3.36	221.23 ^c ±4.29	161.4 ^c ± 2.43	3.09 ^a ±0.09
	Rainy (July-Sept)	555	1017.66 ^a ±18.18	975.99 ^a ±14.83	313.09 ^b ±3.80	176.73 ^a ±4.85	145.05 ^a ± 2.75	3.76 ^c ±0.10
	Autumn (Oct-Nov)	631	1079.16 ^b ±17.17	1051.04 ^b ±14.01	310.21 ^b ±3.59	166.78 ^a ±4.58	138.43 ^a ± 2.60	3.42 ^b ±0.09

TLMY: Total Lactation Milk Yield; 300DMY: Total Standard Lactation Milk Yield; LL: Lactation Length; SP: Service Period; DP: Dry Period; LC: Lactations completed.

Means with different alphabets in column of subgroup differ significantly ($P < 0.01$) within a given fixed factor.

Table 2: Measures of genetic parameters of different traits in Haryana cattle

S.NO.	Traits	Heritability	Repeatability
1	TLMY	0.20±0.05	0.45± 0.02
2	300 DMY	0.25±0.05	0.46± 0.02
3	DP	0.09±0.03	0.18±0.01
4	SP	0.11±0.04	0.26± 0.02
5	LL	0.09±0.04	0.28± 0.02
6	LC	0.10±0.03	0.27± 0.02

Note: For abbreviation of traits, see footnote of Tables 1.

Conclusions

Present study was conducted to evaluate effect of non-genetic factors on production and reproduction traits along with estimation of heritability and repeatability of respective traits in Haryana Cattle. In the studies herd it was observed that period of calving (POC) and season of calving (SOC) had highly significant ($P<0.01$) impacts on traits investigated. It was concluded that summer calving was associated with increased LL, SP, and DP along with higher TLMY and LL, in comparison to autumn calvers. Moderate estimates of heritability and repeatability revealed that the influence of the environment on these traits was high. Moderate heritability of the traits is suggestive that selective breeding, in conjunction with efficient management may be helpful for improvement in the respective traits. Moreover, the repeatability estimates for Total Lactation Milk Yield, and Total Standard Lactation Milk Yield, suggestive that selection can be made based on the first lactation record and that waiting for subsequent lactation periods is not necessary. In general, appropriate plans should be developed to improve the environmental and management conditions of Haryana dairy cattle herds, and the selection goals should be evaluated and revised as per breeding policy of the farm.

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- **Statement of animal rights:** The manuscript does not contain clinical studies or patient data.

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