RESEARCH ARTICLE Asian Journal of Dairy and Food Research, Volume 45 Issue 2: 358-363 (April 2026)

Estimation of Genetic Parameters for Milk Yield Traits in Frieswal Cattle

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10.18805/ajdfr.DR-2281

ABSTRACT

Background: Milk yield is very important economic trait of dairy business which directly affect the productivity and profitability of farm. Therefore, it is of utmost important to study various parameters affecting the milk yield. Considering the importance of this trait the present investigation was carried out to study various parameters affecting milk yield in Frieswal cattle.

Methods: The present investigation was carried out on data of 3425 Frieswal cattle (Holstein Friesian × Sahiwal cattle) maintained at Military Farm, Pimpri, Pune, Maharashtra. Total 9094 lactation records were collected from 3425 cows born to 239 sires from 1983 to 2018. The data were normalized and analyzed using SAS9.13 software.

Result: The genetic parameters were estimated for early and lifetime traits. The heritability of early traits like birth weight, first and second lactation milk yield, first and second lactation length and first dry period were 0.38±0.08, 0.33±0.07, 0.31±0.07, 0.10±0.05, 0.06±0.01 and 0.06±0.04, whereas for lifetime traits like milk yield per day of productive life up to three lactations (MYPDPL3), milk yield per day of productive life up to five lactations (MYPDPL5), milk yield per day of total life up to three lactations (MYPDTL3) and milk yield per day of total life up to five lactations (MYPDTL5) were 0.33± 0.07, 0.36±0.11, 0.43±0.07 and 0.44±0.10, respectively. The genetic correlation between birth weight and first lactation length was -0.97±0.19 and the second lactation length was 0.51±0.26. The genetic correlation of first lactation length with lifetime traits MYPDPL3, MYPDTL3, MYPDPL5 and MYPDTL5 were 0.09±0.26, 0.18±0.24, 0.49±0.31, 0.61±0.27 while for second lactation length with lifetime traits MYPDPL3, MYPDTL3, MYPDPL5 and MYPDTL5 were 0.10±0.32, 0.28±0.30, 0.10±0.39, 0.12±0.36, respectively. The genetic correlation of first lactation milk yield with lifetime traits MYPDPL3, MYPDTL3, MYPDPL5 and MYPDTL5 was estimated as 0.92±0.05, 0.91±0.05, 0.69±0.14 and 0.69±0.12 Similarly, the genetic correlation between second lactation milk yield and lifetime traits was found to be 0.96±0.03, 0.93±0.04, 0.99±0.05 and 0.93±0.07.

Key words: Frieswal cattle, Genetic parameters, Heritability, Milk yield.

INTRODUCTION

India is the world's largest livestock holding country with a population of approximately 536 million livestock animals including cattle, buffaloes, goats, sheep and pigs. The livestock sector is an essential component of the Indian economy, providing livelihoods to millions of farmers and contributing significantly to the country's GDP. It is an important allied sector of the agriculture contributing to about 25.6% of total agricultural GDP. The major contribution in livestock sector is from dairy farming. India has a livestock population of about 535.78 million which includes 192.49 million of cattle and 109.85 million of buffaloes (20th Livestock Census of India). The dairy sector of livestock has shown remarkable growth in recent years with satisfying the increasing demand for milk domestically and internationally. However, in India this sector faces several challenges such as low productivity, inadequate infrastructure and lack of technology adoption. To overcome these issues the government of India has initiated various dairy development programs with a prime focus on crossbreeding to increase milk production in the early 70s'. Frieswal is one of the important cattle breeds developed under the cross-breeding program during the third five-year plan implemented by AICRP on cattle. It was developed by crossing Sahiwal with Holstein Friesian at Central Institute for Research on Cattle, Meerut in collaboration with the military of defense. The major objective of project on Frieswal (5/8 Holstein Friesian and 3/8 Sahiwal) cattle, was to develop the cows with 4000 kg of milk with 4% butter fat in lactation of 300 days. The Frieswal cows are maintained at 37 Military Farms all over India.

The improvement of milk yield in dairy cows is influenced by a combination of genetic and non-genetic factors. Understanding their roles is essential for designing effective strategies to enhance milk production. The Frieswal breed has potential for growth and improvement

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How to cite this article: Chopade, M.M., Jahageerdar, S., Katkade, B.S., Deshmukh, R.S. and Sawane, M.P. (2026). Estimation of Genetic Parameters for Milk Yield Traits in Frieswal Cattle. *Asian Journal of Dairy and Food Research*. **45(2):** 358-363. doi: 10.18805/ajdfr.DR-2281.

Submitted: 07-10-2024 **Accepted:** 31-12-2024 **Online:** 28-02-2025

in dairy sector which can contribute significantly to the country's economic development. Genetic parameters estimation like heritability and correlation plays a crucial role in improving the efficiency and profitability of dairy production systems. Lifetime milk yield is a crucial trait in dairy cattle breeding programs as it reflects the animal's overall production potential over its lifetime. Estimating genetic parameters for lifetime milk yield is essential for identifying high-performing animals and selecting them for breeding purposes. This can help to improve the overall milk production efficiency of the herd. The genetic and phenotypic correlation of various traits with lifetime milk yield can also help researchers to identify cows with high milk production potential early in their life. This can allow farmers to manage the cows more effectively, providing them with the appropriate nutrition and healthcare to maximize their milk production. Considering the fact the present investigation is carried out to estimate the genetic parameters of milk yield traits in Frieswal cattle.

MATERIALS AND METHODS

Location and climatic condition of the farm

The Military farm is located at Pimpri Chinchwad, Pune city of Maharashtra, at latitude 18.6121°N and longitude 73.8097°E. It comes under tropical wet and dry climates with average temperatures ranging from 21.7°C to 28°C. The average annual rainfall is 100 mm (3.92 inches) with average monsoon rainfall (June-September) of 262 mm (10.27 inches). There are extreme variations in perceived humidity throughout the year *i.e*., 35% in March to 88 % in July and August (climate-data.org, https://en.climate-data.org/asia/india/maharashtra/pune-31/).

Management practices

Military farm Pimpri, Pune is old Frieswal cattle farm. The farm is well maintained by military department and nutritional requirement of animals is met through a balanced combination of green and dry fodder and concentrates mixture supplementation. Total milk yield was obtained from daily milk register where morning and evening milk for each animal was recorded separately along with monthly milk yield at the end of each month. High yielding cows (above 35 kg / day) were milked thrice a day and fed with extra production ration. The immunization schedule for FMD, Brucellosis and Hemorrhagic Septicemia, regular health checkups and production and reproduction status recording are followed strictly. Heat detection is carried out daily during the morning hours and the cows are examined for pregnancy after 45 to 65 days of insemination.

Source and collection of data

The data for the present study were collected on Frieswal cattle maintained at Military Dairy Farm, Pimpri, Pune (India) for the period of 1983 to 2018. A total of 9094 lactation records belonging to 3425 Frieswal cows born to 239 sires were recorded.

Data standardization

The records of cows which were affected with disease or debilited or died before completion of first three lactations were omitted from the study. The data were standardized by removing the cows having age at first calving above 1250 days, lactation length below 100 days and above 365 days, lactation milk yield below 1000 kg and inter- calving period below 250 days.

Descriptive analysis

The data were transformed into log and square root transformation to check whether there are any changes in the distribution. The descriptive statistics *viz*. the number of observations, minimum, maximum, mean, standard errors and coefficient of variation (CV) were estimated using the *PROC MEAN* procedure of SAS 9.13 for different traits.

Estimation of genetic parameters for milk yield per day of productive life and milk yield per day of total life

The genetic parameters were estimated for early lactation and lifetime milk traits by using "Echidna" mixed model software. The mixed model analysis using Least Squares Maximum Likelihood (LSML) Program (Harvey,1990) was used for estimation of genetic parameters for early lactation traits and lifetime performance traits. The early traits considered were the birth weight (BW), first lactation length (LL1), second lactation length (LL2), first lactation milk yield (LMY1), second lactation milk yield (LMY2) and first dry period (DP1). Whereas, the lifetime traits were milk yield per day of productive life up to three lactations (MYPDPL3), milk yield per day of productive life up to five lactations (MYPDPL5), milk yield per day of total life up to three lactations (MYPDTL3) and milk yield per day of total life up to five lactations (MYPDTL5). The milk yield per day of productive life and total life up to three and five lactations were estimated according to Vinothraj *et al.* (2016) as below:

Milk yield per day of productive life up to three lactations (MYPDPL3)

It was obtained by dividing the total milk yield of first three lactations by the total days from initiation of first lactation to completion of third lactation and expressed in kg.

Milk yield per day of total life up to three lactations (MYPDTL3)

It was obtained by dividing the total milk yield of first three lactations by total days from birth to completion of three lactations and expressed in kg.

Milk yield per day of productive life up to five lactations (MYPDPL5)

It was obtained by dividing the total milk yield of first five lactations by the total days from initiation of first lactation to completion of fifth lactation and expressed in kg.

Milk yield per day of total life up to five lactations (MYPDTL5)

It was obtained by dividing the total milk yield of first five lactations by total days from birth to completion of five lactations and expressed in kg.

RESULTS AND DISCUSSION

Heritability estimates of early lactation traits and lifetime traits

Heritability of early lactation traits was low ranging from 0.06±0.04 for DP and 0.06±0.01 for LL to 0.38±0.08 for birth weight (Table 1). The estimated low heritability for these traits indicated limited role of genes and these traits are more under environmental control and can be influenced to a great extent by management practices followed at the farm. The low heritability of lactation length may be due to several factors such as differences in total records, number of records per animal, data editing and statistical model (Du *et al.,* 2020). The lower heritability estimate for the lactation length was also reported by Choudhary *et al.* (2003) in Sahiwal cattle as 0.132±0.131 , Dash *et al.* (2018) in Karan Fries cattle as 0.11±0.05 and Singh *et al.* (2020). However, moderate heritability estimate for the LL was observed by Narwaria *et al.* (2015) as 0.22±0.07 and Dash *et al.* (2023) as 0.29±0.05 in Sahiwal cattle. Similarly, the low estimate of heritability for the dry period was observed by Ulutaş and Sezer (2009) in Simmental cattle 0.04±0.70).

The heritability estimates for lifetime milk yield ranging from 0.33±0.07 for MYPDPL3 to 0.44±0.10 for MYPDTL5 (Table 1). The moderate heritability estimates may be due to large population size and randomization of environmental effects and indicate that these traits are under influence of additive genetic variance and further improvement in these traits can be carried out by using appropriate selection criteria. Ambhore *et al.* (2017) estimated the heritabilities of LTMY3, LTMY4 and actual lifetime milk yield (ALTMY), Productive life and herd life as 0.41±0.26, 0.47±0.06, 0.43±0.05, 0.14±0.16 and 0.12±0.05, respectively in Phule Triveni cattle. Similarly, Reddy *et al.* (2012) reported even higher heritability (0.66) for lifetime milk yield in Ongole cattle. However, Jairath *et al.* (1994) in Canadian Holstein reported lower heritability estimates for lifetime milk yield, productive life and milk yield per day of productive life as 0.13, 0.08 and 0.32, respectively. Moderate heritability estimates for milk yield was also reported by Tamer *et al.* (2017) in Holstein cows (0.33±0.02) of Egypt and Choudhary *et al.* (2003) in Sahiwal cattle (0.274±0.173). However, Singh *et al.* (2015) and Ankuya *et al.* (2016) reported the higher heritability estimates in crossbred cattle (0.43±0.14) and Kankrej cattle (0.45±0.17), respectively.

Genetic and phenotypic correlations between early lactation traits

The genetic correlations were estimated between early lactation traits and lifetime traits (Table 1). The genetic

Table 1: Genetic correlations, phenotypic correlations and Heritabilities for early lactation traits and lifetime traits.

	BW	LL1	LL2	LMY1	LMY2	DP1	MYPDPL3	MYPDTL3	MYPDPL5	MYPDTL5
BW	0.38±0.08	-0.97±0.19	0.51±0.26	0.02±0.17	0.38±0.16	-0.01±0.31	0.18±0.16	0.26±0.15	-0.03±0.23	-0.06±0.21
LL1	0.16±0.07	0.10±0.05	0.51±0.45	0.20±0.25	0.09±0.26	-0.22±0.44	0.09±0.26	0.18±0.24	0.49±0.31	0.61±0.27
LL2	-0.04±0.06	0.10±0.04	0.06±0.01	0.24±0.32	0.31±0.29	NE	0.10±0.32	0.28±0.30	0.10±0.39	0.12±0.36
LMY1	0.07±0.08	0.32±0.05	0.13±0.05	0.33±0.07	0.97±0.04	-0.39±0.33	0.92±0.05	0.91±0.05	0.69±0.14	0.69±0.12
LMY2	-0.06±0.08	0.10±0.06	0.44±0.04	0.22±0.06	0.31±0.07	-0.82±0.46	0.96±0.03	0.93±0.04	0.99±0.05	0.93±0.07
DP1	-0.02±0.06	0.01±0.04	0.25±0.04	-0.08±0.05	0.25±0.05	0.06±0.04	-0.21±0.33	-0.31±0.30	-0.37±0.39	-0.24±0.35
MYPDPL3	0.03±0.08	-0.09±0.06	0.03±0.05	0.47±0.05	0.67±0.03	0.01±0.05	0.33±0.07	0.94±0.02	0.85±0.07	0.83±0.07
MYPDTL3	-0.05±0.09	0.10±0.06	0.10±0.06	0.47±0.05	0.60±0.04	-0.16±0.06	0.81±0.02	0.43±0.07	0.92±0.08	0.91±0.05
MYPDPL5	0.16±0.11	-0.19±0.08	0.04±0.08	0.41±0.07	0.54±0.05	0.04±0.08	0.86±0.02	0.73±0.04	0.36±0.11	0.99±0.02
MYPDTL5	0.14±0.12	-0.09±0.09	0.12±0.08	0.42±0.07	0.51±0.06	-0.13±0.08	0.74±0.04	0.78±0.03	0.83±0.02	0.44±0.10

(Upper triangle - Genetic correlations, Lower triangle - Phenotypic correlations and across diagonal - Heritability estimates).

Note: NE - Not estimable (BW - Birth weight, LL1 - First lactation length, LL2 - Second lactation length, LMY1 - First lactation milk yield, LMY2 - Second lactation milk yield, DP1 - First dry period, DP2 - Second dry period, MYPDPL3 - Milk yield per day of productive life up to three lactations, MYPDTL3 - Milk yield per day of total life up to three lactations, MYPDPL5 - Milk yield per day of productive life up to five lactations, MYPDTL5 - Milk yield per day of total life up to three lactations).

correlation between birth weight and first lactation length was negative. Usually, it is assumed that the calves with high BW grow well and attain maturity early. However, the calves with lower birth weight over a period of time makeup their growth and attain the maturity similar to the calves with higher body weight. Also, a long-time gap in the birth weight and expression of a particular trait also nullifies the effect if any. The low phenotypic correlation between second lactation length and birth weight might be due to factors like effect of management and environment on these traits. Deb *et al.* (2005) reported that there was low correlation of BW with first lactation length (0.065) in local cow, Friesian cow × Local (0.015) and Jersey × Local (0.076).

The moderate genetic and phenotypic correlation between most of the lactation length and lactation milk yield indicated that both these traits share some common genes between them and performing selection on the basis of one trait will increase the genetic values of other trait. Relatively higher estimates of the genetic and phenotypic correlation between the lactation length and lactation milk yield was obtained by Chaudhary *et al.* (2003) as 0.722±0.260 and 0.674 ± 0.044 in Sahiwal cattle. However, Banik and Gandhi (2010) in Sahiwal cattle reported low genetic and phenotypic correlation (0.029 and 0.013) between lactation length and LMY.

The estimated genetic and phenotypic correlation between first lactation length and first dry period was -0.22±0.44. and 0.01±0.04. It is the known fact that when the lactation length increased due to infertility or high milk yield reason, the dry period between the two lactations got decreased. The positive but low phenotypic correlation between the lactation length and dry period indicated that the dry period might be increased by negligence in managemental practices. Similar results were reported by Ulutaş and Sezer (2009) in Simmental cattle (-0.05±0.112 and -0.17±0.293) and Banik and Gandhi (2010) in Sahiwal cattle (-0.016 and -0. 002.The genetic correlation between LMY1withDP1 was -0.39±0.33. The present findings indicated that the decrease in dry period leads to increase in lactation milk yield due to increase in the number of lactation days. Similar trend was observed for phenotypic correlation between lactation milk yield and dry period (-0.08±0.05). It means that the other managemental practices of the farm were up to the mark as no further increase in dry period was observed. The result obtained in the present study was in agreement with Dev and Dahiya (2018) in crossbred cattle (-0.62±0.23 and -0.40±0.02) and Chaudhary *et al.* (2019) in Tharparkar cattle (-0.928±0.32 and -0.33±0.05). Similarly, Godara *et al.* (2015) reported the negative genetic correlation of dry period with age at first calving, calving interval, first lactation milk yield etc in murrah buffalo.

Genetic and phenotypic correlations between early lactation traits and lifetime traits

The moderate to high positive genetic correlation was observed between lactation length and lifetime production traits up to fifth lactation. However, the phenotypic correlations between firstlactation lengths, second lactation length and lifetime production traits up to lactation three and lactation five was found negative to low. The overall genetic correlations were found to be higher than phenotypic correlation for first lactation length, second lactation length and lifetime traits. Similar results were obtained by Tamboli *et al.* (2021) in Nili Ravi buffaloes. It was observed that there was strong positive genetic correlation between the first two lactation milk yields with the lifetime traits. The results indicated that if the milk yield is high in the first two lactations the lifetime milk yield will be more. The strong positive (nearly equal to one) correlation between the second lactation milk yield and lifetime milk yield suggested that the second lactation milk yield may be considered as criteria for the selection of Frieswal cattle for lifetime milk production.

The phenotypic correlation between first two lactation milk yield with lifetime milk yield traits up to three lactations and five lactations were found to be high. The positive and high phenotypic correlation offers the scope for effective selection for the trait based on its phenotype, which would improve the other correlated traits automatically. The overall genetic correlations were found to be high than the phenotypic correlation. Abbas *et al.* (2010) in Sahiwal cows reported the estimate of genetic and phenotypic correlation between first lactation milk yield and lifetime milk yield, productive life and herd life as 0.646±0.09, 0.073±0.15, 0.038±0.16 and 0.654, 0.02, 0.019, while Kharat *et al.* (2009) showed very high and significant correlation of first lactation milk yield with lifetime milk yield (0.99) in Holstein Friesian crossbred cows. Lodhi *et al.* (2016) estimated the genetic and phenotypic correlations between first lactation milk yield and lifetime milk yield as 0.125±0.19 and 0.252±0.03 and between first lactation milk yield and lifetime lactation length as 0.156±0.19 and 0.132 ±0.03, respectively in crossbred cattle. The negative genetic correlations between DP and lifetime traits indicate that reduced dry period has positive impact on lifetime milk yield due to more lactation days. The results of present investigation are in line with Abbas *et al.* (2010) in Sahiwal cows who reported genetic and phenotypic correlation between first dry period and lifetime milk yield as 0.193±0.15. Lodhi *et al.* (2016) estimated the genetic and phenotypic correlations between first dry period and lifetime milk yield as -0.136±0.21 and-0.098±0.028 and between first dry period and lifetime lactation length as -.082±0.21 and -0.119±0.028, respectively.

Genetic and phenotypic correlation between lifetime traits

It was observed that there was strong positive genetic and phenotypic correlation between the lifetime traits under study. The positive and high correlation between these traits indicated that the selection of the later traits based on the performance of early expressed trait would be highly effective and recommended for improvement through their

correlated response. Similar reports were observed by Chauhan *et al.* (1993) reported high genetic correlation between lifetime milk yield and herd life, productive life and total number of lactation (ranging from 0.94 to 0.97) whereas the phenotypic correlation between the lifetime milk yield and herd life, productive life and total number of lactations was moderate to high (ranging from 0.2 to 0.7). Ambhore *et al.* (2017) also reported moderate to high genetic correlation with herd life and productive life (0.90 and 0.92) in Phule Triveni cattle. The genetic and phenotypic correlation between LTMY3, LTMY4 and ALTMY was found to be moderate (ranging between 0.42 to 0.47 and 0.28 to 0.52).

Thus, Lifetime milk yield is a comprehensive metric trait that combines productivity, efficiency and sustainability. While improving lifetime yield has significant benefits, it must be pursued carefully to balance productivity with animal health and welfare. Integrating genetic advancements with excellent management practices is the key to optimizing lifetime milk yield without adverse consequences.

CONCLUSION

The heritability estimates of lifetime milk yield traits were found moderate to high in Frieswal cattle (0.33±0.07, 0.43±0.07, 0.36±0.11 and 0.44±0.10) and suggested that these traits are under the influence of additive gene action and there is further scope for improvement by effective selection program. Similarly, the high genetic correlation between first and second lactation milk yield with lifetime milk yield traits indicates that the improvement in these early lactation traits causes substantial improvement in lifetime performance in Frieswal cattle.

ACKNOWLEDGEMENT

We than kLt.Col Military Farm, Pimpri, Pune, Maharashtra and Principal Scientist, Department of Fish genetics and Biotechnology, ICAR-Central Institute of Fishery Education, Versova, Mumbai for providing data and analysis facilities, respectively. I am also thankful to Mr. Nitin Patil for developing software for data collection.

Conflict of interest

The authors declare no conflict of interest.

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