



Genetic Parameters of Lactation Disorders Associated Milk Losses in Dairy Cattle

Rajbir Singh¹, Deepak Kumar Verma¹, Rakesh Kumar Atrey²,
Manoj Kumar Bansala³, Raj Kumar¹, Kartik Tomar⁴, Kuldeep Kumar¹

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ABSTRACT

Background: Lactation disorders in dairy cattle significantly affect milk production, reproductive performance and overall economic returns. These disorders lead to substantial losses through reduced milk yield, increased treatment cost and decreased productivity. Limited information under Indian conditions is available on such lactations disorders.

Methods: The study was conducted at IIMT University, Meerut, for duration of two years using records from the State Livestock-cum-Agriculture Farm, Hastinapur (Meerut), Uttar Pradesh. A total of 983 calving records from 258 Haryana cows covering 30 years (1992-2021). Heritability was estimated using the paternal half-sib correlation method, while repeatability was calculated through regression of second lactation on first lactation performance. Milk loss was estimated by comparing 305-day milk yield between affected and not affected groups of cows.

Result: The heritability estimates of lactation disorders were generally low, ranging from 0.06 to 0.23, indicating a strong environmental influence, while repeatability estimates ranged from 0.12 to 0.41. Among the disorders, prolapse exhibited comparatively higher heritability and repeatability. Milk loss was highest in abnormal calving (41.50%), followed by metritis (18.52%) and mastitis (8.80%), indicating the substantial economic impact of these disorder.

Key words: Dairy cattle, Genetic parameters, Heritability, Lactation disorders, Milk loss, Repeatability.

INTRODUCTION

India has emerged as the largest milk-producing nation in the world, with total milk production reaching nearly 239.3 million tonnes in 2023-24, reflecting a growth of about 4% over the previous year (Business Standard, 2024). Despite this remarkable increase in total production, the average milk yield per animal remains comparatively low due to the predominance of indigenous and non-descript bovines with limited genetic potential and variable adoption of scientific dairy management practices (Global Agriculture, 2024). In recent decades, intensive selection for higher milk yield has significantly improved productivity; however, it has also led to increased susceptibility to lactation disorders such as mastitis, metabolic diseases and reproductive problems. These disorders not only affect animal health and welfare but also cause substantial economic losses due to reduced milk yield, discarded milk, increased treatment costs and premature culling (Ratwan and Mandal, 2016).

Lactation disorders in dairy cattle are complex quantitative traits influenced by multiple genes with small additive effects and strong environmental interactions. Recent genetic studies have demonstrated that traits associated with udder health, metabolic diseases and reproductive disorders generally exhibit low to moderate heritability, indicating limited but exploitable genetic variation for improvement through selection. However, accurate estimation of genetic parameters such as heritability and repeatability is essential for reliable genetic evaluation, as these parameters determine the consistency

¹School of Agricultural Sciences, IIMT University, Meerut-250 001, Uttar Pradesh, India.

²Department of Animal Husbandry and Dairying, Janta Vedic College, Baraut-250 611, Uttar Pradesh, India.

³Department of Agriculture, Dolphin (PG) Institute of Biomedical and Natural Sciences, Dehradun-248 007, Uttarakhand, India.

⁴Department of Agriculture Science, Dr. Bhimrao Ambedkar University, Agra-282 003, Uttar Pradesh, India.

Corresponding Author: Deepak Kumar Verma, School of Agricultural Sciences, IIMT University, Meerut-250 001, Uttar Pradesh, India. Email: choudharydeepak876@gmail.com

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of disease expression across lactations and the accuracy of breeding value prediction. Modern studies further confirm that inclusion of health and functional traits in genetic evaluation systems improves selection efficiency for reducing milk losses associated with disease incidence in dairy cattle populations (de Haas *et al.*, 2021; Kadarmideen *et al.*, 2000).

Milk yield losses associated with lactation disorders such as mastitis, metritis and reproductive abnormalities are not only direct production losses but also indicators of underlying genetic susceptibility in dairy cattle populations. Bayesian genetic studies have reported heritability estimates

for reproductive and udder health traits in the range of approximately 0.06 to 0.12, confirming weak to moderate genetic control and strong environmental influence (Hossein-Zadeh and Ardalan, 2011).

Consequently, the study of genetic parameters of lactation disorders and their associated milk loss implications is crucial for developing effective breeding strategies aimed at improving dairy cattle productivity and reducing economic losses.

MATERIALS AND METHODS

The study was conducted at IIMT University, Meerut, on Haryana cows. The study was carried out for duration of two years using records from the State Livestock-cum-Agriculture Farm, Hastinapur (Meerut), Uttar Pradesh. A total of 983 calving records pertaining to 258 adult cows were utilized for the study. The data covered a period of 30 years from 1992 to 2021. Only those cows which had completed at least one lactation were included in the study. Information was collected from various farm records including history sheets-cum-pedigree sheets of cows maintained at the farm.

Location and climatic conditions

The region receives an average annual rainfall of 750-950 mm, with most precipitation occurring during the monsoon season (July-September), along with occasional winter showers. The climate is tropical, characterized by maximum temperatures of about 42°C during summer (April-June), followed by the monsoon period. Winters extend from December to March, during which temperatures range between 4°C and 30°C.

Management and feeding practices

Animals were maintained under a balanced feeding system comprising dry roughage, green fodder and concentrate mixture. Dry roughage in the form of wheat straw and green fodder based on seasonal availability, including green maize, green jowar and berseem, was provided to the animals. Mineral mixture supplementation was provided in accordance with the age and physiological status of the animals. Standard farm management practices related to feeding, milking, sanitation and animal care were strictly followed throughout the study period.

Animal health care and preventive management

Animal health care practices were rigorously implemented to assess their association with lactation disorders. Sick animals were promptly identified and treated under the supervision of a qualified veterinarian. Preventive health care measures, including routine vaccination against major infectious diseases as per recommended schedules, were consistently followed.

Breeding practices

The breeding policy followed at the farm involved selective breeding using Haryana bulls obtained from high-yielding dams. The selection and culling of females as well as the

selection of young male calves for breeding purposes were mainly based on the milk yield performance of their dams.

Factors of study

The lactation disorders considered in the present study included abnormal calving, utero-vaginal prolapse and retention of placenta, metritis, anoestrus, repeat breeding, mastitis and blood in milk. The incidence of all these disorders was recorded and analyzed. However, the estimation of economic losses due to reduced milk yield was restricted to the three major disorders, namely abnormal calving, metritis and mastitis, owing to their comparatively higher incidence and greater impact on milk production. Milk loss was estimated as the difference in milk production (305 days or less) between affected and not affected groups of cows.

The 30-year data were categorized according to parity, period and season of calving to assess the incidence of lactation disorders.

Parity of lactation

The parities of lactation were examined up to the last parity available in the history sheet of the cow. Since the number of cows in higher parities was relatively small, fifth and above parities were combined into a single group for statistical analysis.

Period of calving

Since the data covered a 30-year period (1992-2021), the entire duration was divided into five equal periods to study the changes in incidence of disorders over time.

Season of calving

Months with similar climatic conditions were grouped into four seasons: winter (December-March), summer (April-June), rainy (July-September) and post-monsoon (October-November).

Parameters of study

These are two genetic parameters:

- Heritability
- Repeatability

Statistical analysis

The incidence of lactation disorders was calculated as the percentage of cows affected under different levels of parity, period and season.

Estimation of heritability and repeatability

The genetic parameters estimated in the present study were heritability and repeatability.

• Heritability

Estimated using the paternal half-sib correlation method based on first lactation data as variation among daughters of common sires reflects additive genetic variance for lactation disorders in dairy cattle using following model:

$$Y_{ij} = \mu + S_j + e_{ij}$$

Where:

Y_{ij} = Record of j^{th} daughter of i^{th} sire.

S_j = Effect of the j^{th} sire.

e_{ij} = Random error.

• Repeatability

Estimated by regression of second lactation performance on first lactation performance as described by Lush (1950). The cows after completing first lactation were divided in two groups namely affected and not affected to a particular disorder and estimating the percentages susceptibility of two groups of the cows in the second lactation. Repeatability estimation in lactation disorders is used to measure the consistency of disease occurrence across lactations. The repeatability (t) was estimated as:

$$t = X - Y/100$$

Where:

t = Repeatability.

X = First lactation.

Y = Second lactation.

RESULTS AND DISCUSSION

The genetic parameters, namely heritability and repeatability of various lactation disorders, were estimated and are presented in Table 1, showing generally low heritability and comparatively higher repeatability across disorders.

Heritability estimates

The heritability estimates for abnormal calving, obtained through the paternal half-sib method, was found to be very low (0.07), indicating that this trait is largely governed by environmental factors Goshu and Singh (2013) and Narwaria *et al.* (2015). Similar low heritability estimates Banik (2005) and Atrey *et al.* (2005). The heritability estimate for utero-vaginal prolapse was observed to be medium (0.23), indicating the presence of exploitable genetic variability for reducing its incidence through selection. Comparable findings were reported by Yousuf *et al.* (2017) observed a heritability estimate of 0.245 ± 0.012 in Murrah buffaloes at ICAR-NDRI, Karnal. These findings are in agreement with Shao *et al.* (2021), who reviewed reproductive traits in bovine and buffalo and reported heritability estimates for dystocia and related reproductive traits ranging from near zero to moderate levels depending

on breed and trait. Retention of placenta showed low heritability (0.21), suggesting a predominant environmental influence. Similar findings have been reported by Tomar and Tripathi (1991, 1992) for buffaloes. These findings are in agreement with Hossein-Zadeh and Ardalan (2011) reported heritability estimates for retained placenta ranging from approximately 0.07 to 0.08 across lactations, confirming weak genetic control. Metritis exhibited low heritability (0.16), indicating that improvement in this trait is mainly possible through better management rather than genetic selection. Similar results were reported by Hossein-Zadeh and Ardalan (2011) reported the heritability values for metritis ranging from about 0.07 to 0.10, confirming low additive genetic variance. Anoestrus showed very low heritability (0.09), suggesting that its occurrence is largely influenced by environmental factors, particularly feeding and management practices. These findings are in agreement with (Rana *et al.*, 2021). These results agree with Kadarmideen *et al.* (2016), who reported heritability estimates ranging from 0.012 to 0.126 for fertility and disease traits using threshold models in dairy cattle. Repeat breeding was also found to have very low heritability (0.06), indicating that fertility traits are more affected by environmental variations. Improvement in conception rate can therefore be achieved through better management practices. Mastitis exhibited low heritability (0.09), indicating low additive genetic variability and limited scope for genetic improvement through selection. Thus, better management practices are essential to control its incidence. These results are in agreement Faid-Allah (2018) and Narayana *et al.* (2018). The heritability of blood in milk was also very low (0.10), indicating negligible genetic variability and limited effectiveness of selection in reducing its incidence. This finding corroborates the results the heritability of blood in milk was also very low (0.10), indicating negligible genetic variability and limited effectiveness of selection in reducing its incidence (Taraphder *et al.*, 2011).

Repeatability estimates

The repeatability estimates for different lactation disorders indicated varying levels of consistency across lactations. Abnormal calving showed low repeatability (0.18), suggesting that the type of calving in future gestations cannot be predicted based on previous performance. These results agree with Kadarmideen *et al.* (2016),

Table 1: Estimates of heritability and repeatability of different lactation disorders.

Lactation disorders	Heritability	Repeatability
Abnormal calving	0.07	0.18
Prolapse	0.23	0.41
Retention of placenta	0.21	0.29
Metritis	0.16	0.19
Anoestrus	0.09	0.13
Repeat breeding	0.06	0.19
Mastitis	0.09	0.20
Blood in milk	0.10	0.12

who reported repeatability estimates ranging from 0.013 to 0.168 for disease traits, indicating low consistency across lactations. Utero-vaginal prolapse exhibited medium repeatability (0.41), indicating a possibility of recurrence in future lactations. These findings are in agreement with Shao *et al.* (2021), who reported moderate repeatability for certain reproductive traits. Retention of placenta showed low repeatability (0.29), indicating that environmental factors play a more significant role than genetic factors. Almost zero repeatability estimates have also been reported by Hossein-Zadeh and Ardalan (2011). Metritis exhibited low repeatability (0.19), suggesting that environmental factors are more influential and that prediction of future incidence based on past records is not feasible. Similar near-zero estimates were reported by Kadarmideen *et al.* (2016). Anoestrus showed low repeatability (0.13), indicating low intra-cow variability and limited importance in selection programmes. This finding agrees with Rana *et al.* (2021). Repeat breeding also had low repeatability (0.19), suggesting that environmental factors predominantly influence this trait and that future performance cannot be reliably predicted from past records. Similar results were reported by Yousuf *et al.* (2017). Repeat breeding also had low repeatability (0.19), suggesting that environmental factors predominantly influence this trait and that future performance cannot be reliably predicted from past records. Mastitis exhibited low

repeatability (0.20), indicating that selection against susceptibility in early lactations may not effectively reduce incidence in later lactations and prediction based on past records is unreliable. Similar result by Dohare *et al.* (2021).

Blood in milk also showed low repeatability (0.12), indicating low intra-cow variability and supporting the findings of Mukherjee *et al.* (1993).

Milk losses due to lactation disorders

Milk losses due to lactation disorders were estimated by comparing 305-day milk yield between not affected and affected groups of cows, expressed both in absolute and percentage terms (Table 2-4). The percentage milk loss across different lactations is also illustrated in Fig 1, indicating higher losses in abnormal calving compared to metritis and mastitis.

Loss of milk due to abnormal calving

The results indicated that cows affected by abnormal calving reduced 613.2 kg milk, whereas normal cows produced 1047.9 kg milk during 305 days, resulting in a reduction of 434.9 kg milk. This accounted for a 41.50 per cent decrease in milk production. The reduction in milk yield was observed across all lactations, ranging from 258.2 kg in fifth and later lactations to 640.0 kg in fourth lactation, without a consistent trend across lactations. The percentage loss varied from 25.87 to 63.24 per cent. Similar findings by Kumar *et al.* (2017) reported that cows affected by

Table 2: Mean 305-day lactation milk yield (kg) in the cows with normal and abnormal calving.

Effects	Normal calvings	Abnormal calvings	Difference (kg)	Difference (%)
Overall	1047.9 (760)	613.2 (46)	434.9	41.50
Parity 1	1002.5 (197)	639.8 (17)	362.7	36.18
2	1121.7 (162)	521.2 (9)	600.5	53.53
3	1103.8 (148)	822.5 (5)	281.3	25.48
4	1012.0 (94)	372.0 (7)	640.0	63.24
5	998.2 (159)	740.4 (8)	258.2	25.87

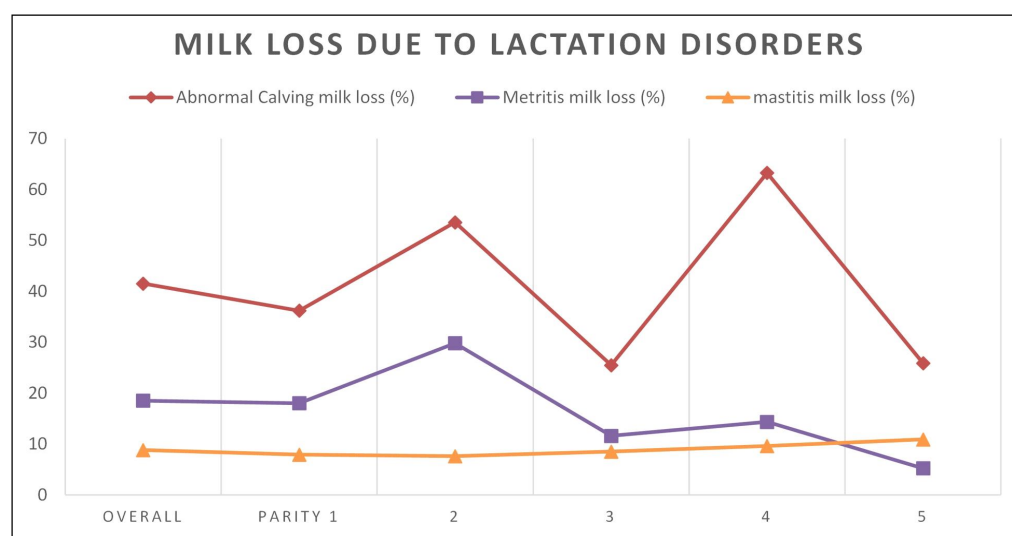


Fig 1: Milk loss due to lactations disorders.

Table 3: Mean 305-day lactation milk yield (kg) of the normal cows and those affected by metritis.

Effects	Not affected	Affected	Difference (kg)	Difference (%)
Overall	1054.93 (708)	859.57 (71)	195.36	18.52
Parity 1	1024.5 (186)	839.8 (20)	184.7	18.03
2	1112.6 (150)	781.2 (24)	331.4	29.79
3	1122.9 (138)	992.5 (11)	130.4	11.61
4	1018.2 (89)	872.0 (7)	146.2	14.36
5	992.2 (145)	940.4 (9)	51.8	5.23

Table 4: Mean 305-day lactation milk yield (kg) of the normal cows and those affected by mastitis.

Effects	Not affected	Affected	Difference (kg)	Difference (%)
Overall	1052.4 (685)	959.4 (164)	93.0	8.8
Parity 1	998.9 (180)	919.9 (39)	79.0	7.9
2	1135.0 (143)	1048.4 (33)	86.6	7.6
3	1082.2 (132)	989.8 (30)	92.4	8.5
4	1052.2 (86)	950.8 (27)	101.4	9.6
5	1009.8 (144)	899.9 (35)	109.9	10.9

abnormal parturition had significantly lower milk yield (2723.75 ± 67.88 kg) compared to normally calved cows (3310.08 ± 35.36 kg), resulting in a substantial reduction in production performance along with adverse effects on reproductive efficiency.

Loss of milk due to metritis

The average 305-day milk yield of not affected cows was 1054.93 kg, where as affected cows produced 859.57 kg, resulting in a loss of 195.36 kg milk (18.52 per cent reduction). The reduction in milk yield due to metritis was highest (29.79 per cent) in second calvers and lowest (5.23 percent) in fifth and later calvers. Similar findings have been reported by Fourichon *et al.* (1999), who reported daily milk losses ranging from 0.3 to 2.3 kg in Holstein cows. Jeon and Galvão (2018) reported that metritis is a prevalent postpartum uterine disease in dairy cows that leads to significant reductions in milk production, along with impaired reproductive performance, prolonged uterine involution and increased metabolic stress, resulting in overall economic losses in dairy herds.

Loss of milk due to mastitis

The average 305-day milk yield of cows affected by mastitis was 959.4 kg, whereas not affected cows produced 1052.4 kg, indicating a loss of 93.0 kg milk (8.8 per cent reduction). The reduction in milk yield due to mastitis was observed across all lactations, with lower losses in first calvers and higher losses in later lactations. The difference ranged from 79.0 kg in first calvers to 109.9 kg in fifth lactation cows. These findings are in agreement with earlier studies reporting reduced milk production in mastitis-affected (Das *et al.*, 2018; Kerslake *et al.*, 2018; Romero *et al.*, 2018; Mohanty *et al.*, 2018) reported that mastitis affected lactation performance and caused a

reduction of about 4-5% in milk yield with altered lactation curve pattern in Jersey cows.

CONCLUSION

The study had concluded that most lactation disorders exhibited low heritability, indicating a predominant influence of environmental and management factors, while repeatability estimates were generally low to moderate, suggesting limited consistency across lactations. Among the disorders, prolapse showed comparatively higher heritability and repeatability, indicating better scope for genetic improvement. The analysis of milk loss indicated that abnormal calving resulted in the highest reduction in milk yield, followed by metritis and mastitis, highlighting their significant economic impact. Based on the findings of the study suggest that improvement in lactation disorders can be achieved more effectively through better management practices.

Conflict of interest

All authors declare that they have no conflict of interest.

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