Estimation of genetic parameters of monthly test day milk yields in Murrah buffaloes

S. Sharma, S.S. Dhaka, P. Ratwan* and M. Kumar

Department of Animal Genetics and Breeding, Lala Lajpat Rai University of Veterinary and Animal Sciences (LUVAS), Hisar-125004, Haryana
*Corresponding Author Email: poonamratwan@luvas.edu.in

Journal of Livestock Science (ISSN online 2277-6214) 16: 491-497
Received on 28/2/25; Accepted on 30/7/25; Published on 4/8/25
doi. 10.33259/JLivestSci.2025.491-497

Abstract

Data of 1141 records pertaining to Murrah buffaloes maintained at Buffalo Farm, Department of Livestock Production Management (LPM), Lala Lajpat Rai University of Veterinary and Animal Sciences (LUVAS), Hisar were used to estimates the genetic parameters of test day milk yields in Murrah buffaloes. The overall least-squares means of monthly test day milk yields were 4.13±0.15 kg (TD5), 10.30±0.30 kg (TD35), 10.46±0.30 kg (TD65), 10.49±0.33 kg (TD95), 9.65±0.30 kg (TD125), 9.46±0.44 kg (TD155), 8.33±0.33 kg (TD185), 7.65±0.35 kg (TD215), 6.74±0.35 kg (TD245), 5.60±0.26 kg (TD275), and 5.04±0.23 kg (TD305). Effect of non-genetic factors i.e. period of calving, season of calving and parity was significant on most of the test day milk yields. Heritability estimates for test day milk yields varied from 0.10 ± 0.09 (TD305) to 0.46 ± 0.11 (TD95). Genetic correlations among 305-day milk yield (305DMY) and test day milk yields ranged from 0.11±0.04 (TD5) to 0.99±0.12 (TD65), with a similar pattern observed in the phenotypic correlations ranging from 0.11±0.03 (TD5) to 0.70±0.25 (TD215). The study concluded that the selection of elite buffaloes should be based on the mid-lactation milk yields.

Key words: Genetic correlation; heritability; Murrah; phenotypic correlation; test day milk yield

Introduction

India being a top most producer of milk reached 230.6 million tonnes production in 2022-23 (DAHD, 2023). Buffaloes contribute about 45% of the total milk production in the country. Buffaloes may prove as a more viable option in the dairy industry as compared to cattle due to their adaptability to a variety of ecological conditions because of higher milk yield and fat content (Alshdaifat et al., 2024). Murrah is one of the best buffalo breed not only in India but in the whole world. This "black gold" is a native of Rohtak, Hisar and Jind of Haryana and Nabha and Patiala districts of Punjab states of India and Punjab province of Pakistan.

Test day milk yield is the estimate comprising of the total milk produced within a period of 24 hours. Schaeffer et al. (2000) revealed the effectiveness of test day models edged over the other models for the genetic evaluation in Canada. Going for a full-length 305 days' milk yield has become idle in the era of early selection plus the need of multiple records delays the process further (Santos et al., 2013). In 2003, El Faro and Albuquerque reported that consideration of specific period based models outscore the use of intangible lactation models. Nowadays, the use of test day model (TDM) rather than lactation model (LM) is more interesting in genetic evaluation of dairy animals in the majority of industrialised nations due to the variety of lactation days of these animals. Utilising test day (TD) information under TDM for animal genetic studies has several benefits, due to the fluctuating lactation periods of dairy cattle in the majority of developing nations today (Geetha et al., 2007). Thus, the present work was undertaken to estimate the genetic parameters of monthly test day milk yields in Murrah buffaloes.

Materials and methods

Source of data: The history sheets and daily milk recording registers kept at Buffalo Farm, Department of Livestock Production Management, Lala Lajpat Rai University of Veterinary and Animal Sciences (LUVAS), Hisar were used to record information on performance traits of Murrah buffaloes up to six lactations. A total of 1141 records spread over a 12-year period from 2010 to 2021 were recorded.

Classification of data: The twelve-year duration was divided into three periods, each with four consecutive years: 2010-2013 (period 1), 2014-2017 (period 2), and 2018-2021 (period 3). Based on the region's geo-climatic conditions, each year was divided into four calving seasons: summer (April to June), monsoon (July to September), autumn (October to November), and winter (December to March).

Traits studied: Test day milk yields starting from 5th day of lactation, at the monthly interval i.e. 5th, 35th, 65th, 95th….305th day were considered in the present study. Based on the test day number the trait name was fixed as TD5, TD35, TD65, TD95 up to TD305. Abnormal records, animals having mastitis and chronic illness whose milk production was less than 500 kg and having less than 100 days of lactation length were excluded from the analysis.

Statistical analysis: The effects of various tangible factors on the performance traits were estimated using Henderson's model III (Henderson, 1953) and the least-squares and maximum likelihood computer software (Harvey, 1990) in order to overcome non-orthogonality of data caused by uneven subclass frequencies. The underlying biology of the traits included in the study was explained by the statistical model that follows:

$$Y_{ijklm} = \mu + S_i + P_j + N_k + A_l + e_{ijklm}$$

Where,

Y_{ijklm} = mth record of the individual calved belonging to ith sire having jth period of calving, kth season of calving and lth parity; μ = overall population mean; S_i = random effect of ith sire (1 to n); P_j= fixed effect of jth period of calving (1 to 3); N_k = fixed effect of kth season of calving (1 to 4); A_l = fixed effect of lth parity (1 to 6); e_{ijklm}= random error associated with each observation, assumed to be normally and independent distributed with mean zero and variance σ^2_e. The above model was utilized with and without parity where ever required.

The genetic correlations were estimated by using least squares maximum likelihood model and phenotypic correlations were estimated using IBM SPSS version 23.

Results

Results obtained through analysis of variance are presented in Table 1 and the overall least-squares means of monthly test day milk yields as observed in Murrah buffaloes were 4.13±0.15 kg (TD5), 10.30±0.30 kg (TD35), 10.46±0.30 kg (TD65), 10.49±0.33 kg (TD95), 9.65±0.30 kg (TD125), 9.46±0.44 kg (TD155), 8.33±0.33 kg (TD185), 7.65±0.35 kg (TD215), 6.74±0.35 kg (TD245), 5.60±0.26 kg (TD275), and 5.04±0.23 kg (TD305) as shown in Table 2.

Non-genetic factors affecting the test day milk yields

Statistically significant effects ($p<0.01$) of period of calving were observed at multiple test days, particularly for TD5 ($p<0.01$), TD35 ($p<0.01$), TD65 ($p<0.01$), TD95 ($p<0.01$) and TD125 ($p<0.01$) and significant effect ($p<0.05$) was observed on TD275 and TD305. However, no period of calving had no significant effect on TD155, TD185, TD215, and TD245. Season of calving had highly significant ($p<0.01$) influence on TD35, TD65, TD95, TD125, TD155 and TD185 ($p<0.01$), and significant effect ($p<0.05$) on TD5, TD215 and

TD215. However, TD245 and TD275 were not significantly affected by season of calving. Significant ($p<0.01$) effect of parity was observed on test day milk yieldsviz., TD5, TD35, TD65, TD95, TD125, TD155, TD185, and TD215. However, parity had non-significant effect on TD245, TD275 and TD305 (Table 1).

Genetic parameters of test day milk yields

Heritability estimates for test day milk yields from TD5 to TD305 were 0.25 ± 0.09, 0.32 ± 0.09, 0.31 ± 0.09, 0.46 ± 0.11, 0.41 ± 0.11, 0.27 ± 0.09, 0.39 ± 0.11, 0.46 ± 0.12, 0.39 ± 0.11, 0.11 ± 0.10 and 0.10 ± 0.09, respectively. Genetic and phenotypic correlations among 305-day milk yield (305DMY) and test day milk yields (TD) are presented in Table 3. The phenotypic correlation of 305DMY with test days' ranged from 0.11±0.03 (TD5) to 0.70±0.25 (TD215), while the genetic correlation varied from 0.11±0.04 (TD5) to 0.99±0.12 (TD65). Genetic correlations among the test days ranged from 0.01±0.01 (TD5/TD275) to 0.98±0.25 (TD35/TD155).

Table 1. Analysis of variance of test day milk yields in Murrah buffaloes

Source of variation	Mean Sum of Squares										
	TD5	**TD35**	**TD65**	**TD95**	**TD125**	**TD155**	**TD185**	**TD215**	**TD245**	**TD275**	**TD305**
Sire	2.80	8.22	8.09	8.93	7.88	13.55	6.97	7.20	7.34	5.35	4.05
Period	17.33**	43.78**	77.62**	29.88**	21.73**	0.51	4.59	5.32	5.38	15.31*	12.54*
Season	9.43*	21.73**	38.11**	29.59**	56.68**	64.35**	32.72**	10.53*	8.26	11.55*	3.98
Parity	9.69**	53.95**	32.32**	41.63**	33.29**	26.99**	13.40**	11.90**	3.49	2.56	3.28
Error	3.29	4.87	4.86	4.42	4.19	8.71	3.86	3.70	4.21	4.53	4.12

Where TD: test day milk yield, *$p<0.05$, **$p<0.01$

Table 2. Least-squares means and standard errors of test day milk yields in Murrah buffaloes

	TD5 (kg)	**TD35 (kg)**	**TD65 (kg)**	**TD95 (kg)**	**TD125 (kg)**	**TD155 (kg)**	**TD185 (kg)**	**TD215 (kg)**	**TD245 (kg)**	**TD275 (kg)**	**TD305 (kg)**
Overall Mean (μ)	4.13±0.15 (1002)	10.3±0.30 (993)	10.46±0.30 (983)	10.49±0.33 (976)	9.65±0.30 (957)	9.46±0.44 (936)	8.33±0.33 (913)	7.65±0.35 (880)	6.74±.35 (844)	5.6±0.26 (718)	5.04±.23 (497)
Period of calving											
2010-13	3.95^{a}±.22 (305)	9.46^{a}±0.36 (302)	9.36^{a}±0.36 (298)	9.82^{a}±0.38 (299)	9.08^{a}±0.36 (296)	9.47±0.53 (288)	8.04±0.38 (282)	7.39±0.40 (266)	6.47±.40 (251)	5.03^{a}±.36 (196)	4.45^{a}±.37 (144)
2014-17	3.87^{a}±.18 (327)	10.32^{b}±.32 (326)	10.82^{b}±.32 (323)	10.73^{b}±.35 (320)	9.87^{b}±.33 (314)	9.51±0.48 (312)	8.39±0.35 (306)	7.59±0.37 (295)	6.89±.37 (282)	5.82^{b}±.30 (244)	5.34^{b}±.29 (181)
2018-21	4.56^{b}±.22 (370)	11.11^{c}±.36 (365)	11.21^{b}±.36 (362)	10.93^{b}±.38 (357)	10.01^{b}±.36 (347)	9.41±.52 (336)	8.56±0.38 (325)	7.97±0.40 (319)	6.86±.40 (311)	5.96^{b}±.35 (278)	5.32^{b}±.36 (172)
Season of calving											
Summer (Apr. to Jun.)	4.11^{a}±0.20 (204)	10.36^{a}±0.34 (202)	10.42^{a}±0.34 (201)	10.46^{a}±0.36 (199)	9.33^{a}±0.34 (198)	8.88^{a}±0.49 (197)	7.91^{a}±0.36 (195)	7.39^{a}±0.38 (187)	6.74±0.38 (179)	5.80^{ab}±0.32 (157)	5.32±0.31 (116)
Monsoon (Jul. to Sept.)	3.88^{a}±0.17 (371)	10.05^{a}±0.32 (368)	10.15^{a}±0.31 (365)	10.17^{a}±0.34 (365)	9.31^{a}±0.32 (354)	9.31^{ab}±0.47 (342)	8.22^{b}±0.35 (328)	7.72^{b}±0.37 (314)	6.74±0.37 (297)	5.44^{ab}±0.3 (248)	4.93±0.28 (166)
Autumn (Oct. to Nov.)	4.16^{ab}±0.19 (199)	10.05^{a}±0.33 (196)	10.19^{a}±0.33 (195)	10.32^{ab}±0.35 (194)	9.53^{c}±0.33 (190)	9.37^{b}±0.49 (184)	8.27^{b}±0.36 (180)	7.52^{ab}±0.37 (175)	6.45±0.37 (168)	5.28^{a}±0.31 (138)	4.84±0.31 (87)
Winter (Dec. to Mar.)	4.35^{b}±0.19 (228)	10.73^{b}±0.32 (227)	11.09^{b}±0.32 (222)	11.03^{b}±0.35 (218)	10.45^{b}±0.33 (215)	10.30^{c}±0.48 (213)	8.93^{c}±0.35 (210)	7.96^{b}±0.37 (204)	7.02±0.37 (200)	5.90^{b}±0.30 (175)	5.06±0.28 (128)
Parity											
First	3.43^{a}±0.19 (299)	9.12^{a}±0.34 (298)	9.84^{a}±0.34 (296)	9.66^{a}±0.36 (295)	9.15^{a}±0.34 (292)	8.87^{a}±0.50 (289)	8.16^{a}±0.37 (286)	7.29^{a}±0.39 (282)	6.67±0.39 (269)	6.03±0.35 (244)	5.62±0.37 (188)
Second	3.90^{b}±0.17 (266)	10.37^{b}±0.32 (264)	10.77^{b}±0.32 (264)	10.59^{b}±0.34 (263)	10.14^{b}±0.32 (259)	9.33^{ab}±0.48 (256)	8.69^{ab}±0.35 (254)	7.96^{b}±0.37 (243)	7.05±0.37 (234)	6.14±0.33 (195)	5.24±0.34 (139)
Third	4.15^{b}±0.18 (181)	10.90^{c}±0.32 (179)	11.24^{c}±0.32 (177)	11.23^{c}±0.35 (174)	10.46^{c}±0.33 (170)	10.03^{bc}±0.49 (164)	9.05^{b}±0.36 (158)	8.13^{b}±0.38 (151)	7.01±0.38 (144)	5.78±0.35 (116)	5.3±0.38 (67)
Fourth	4.00^{b}±0.20 (116)	10.84^{c}±0.34 (115)	11.04^{c}±0.34 (113)	11.01^{c}±0.36 (113)	10.25^{b}±0.34 (110)	10.03^{bc}±0.51 (105)	8.79^{b}±0.38 (100)	8.20^{b}±0.40 (93)	6.78±0.4 (91)	5.65±0.37 (77)	5.33±0.41 (47)
Fifth	3.97^{b}±0.24 (71)	10.86^{c}±0.38 (70)	10.97^{ab}±0.38 (68)	11.18^{c}±0.4 (66)	10.39^{bc}±0.38 (64)	10.42^{c}±0.57 (62)	8.99^{b}±0.42 (59)	8.19^{b}±0.43 (58)	6.66±0.44 (55)	5.75±0.43 (45)	5.25±0.49 (30)
Sixth	4.70^{c}±0.30 (69)	10.13^{c}±0.43 (67)	10.90^{ab}±0.44 (65)	10.74^{c}±0.44 (65)	10.36^{bc}±0.42 (62)	9.86^{bc}±0.63 (60)	8.38^{ab}±0.46 (56)	7.92^{b}±0.47 (53)	6.92±0.49 (51)	5.56±0.50 (41)	5.77±0.56 (26)

TD: Test day milk yield; Means superscripted by different letters differ significantly among themselves; figures in parenthesis are number of observations

Table 3. Genetic (below diagonal) and phenotypic (above diagonal) correlation between the 305DMY and test day milk yields in Murrah buffaloes

	305DMY	TD5	TD35	TD65	TD95	TD125	TD155	TD185	TD215	TD245	TD275	TD305
305DMY		0.11**±0.03	0.53**±0.20	0.61**±0.32	0.63**±0.12	0.65**±0.21	0.49**±0.23	0.67**±0.29	0.70**±0.25	0.61**±0.32	0.48**±0.30	0.34**±0.12
TD5	0.11±0.04		0.11**±0.10	0.07*±0.02	0.07*±0.03	0.07*±0.02	0.02±0.01	0.03±0.01	0.09**±0.04	0.03±0.10	-0.006±0.01	0.05±0.02
TD35	0.80±0.16	0.10±0.01		0.65**±0.21	0.56**±0.12	0.54**±0.12	0.39**±0.11	0.45**±0.25	0.42**±0.23	0.33**±0.21	0.17**±0.08	0.17**±0.12
TD65	0.99±0.12	0.06±0.02	0.36±0.19		0.67**±0.32	0.60**±0.30	0.41**±0.21	0.52**±0.45	0.48**±0.23	0.42**±0.24	0.27**±0.11	0.21**±0.10
TD95	0.97±0.11	0.12±0.10	0.75±0.18	0.82±0.13		0.67**±0.27	0.46**±0.32	0.57**±0.35	0.51**±0.31	0.42**±0.23	0.31**±0.15	0.28**±0.11
TD125	0.83±0.11	0.23±0.12	0.72±0.18	0.80±0.15	0.71±0.10		0.49**±0.23	0.59**±0.25	0.55**±0.22	0.44**±0.24	0.34**±0.017	0.23**±0.11
TD155	0.88±0.23	0.02±0.03	0.98±0.25	0.40±0.25	0.77±0.20	0.48±0.21		0.48**±0.21	0.44**±0.18	0.35**±0.21	0.18**±0.08	0.25**±0.22
TD185	0.97±0.10	0.10±0.01	0.84±0.18	0.83±0.16	0.81±0.14	0.67±0.12	0.23±0.20		0.66**±0.28	0.56**±0.22	0.45**±0.21	0.28**±0.18
TD215	0.97±0.08	0.18±0.13	0.75±0.19	0.75±0.16	0.69±0.14	0.94±0.12	0.31±0.20	0.97±0.08		0.65**±0.31	0.50**±0.30	0.33**±0.23
TD245	0.87±0.14	0.04±0.02	0.59±0.26	0.85±0.20	0.85±0.18	0.73±0.18	0.41±0.29	0.42±0.13	0.25±0.11		0.58**±0.32	0.48**±0.27
TD275	0.78±0.47	0.01±0.01	0.91±0.47	0.82±0.41	0.63±0.35	0.42±0.50	0.94±0.81	0.32±0.34	0.31±0.33	0.90±0.27		0.54**±0.21
TD305	0.24±0.11	0.32±0.20	0.26±0.10	0.15±0.04	0.21±0.10	0.25±0.12	0.32±0.26	0.25±0.08	0.37±0.15	0.36±0.09	0.42±0.25	

Where 305DMY: 305 days' milk yield, TD: test day milk yield, *$p<0.05$, **$p<0.01$

Discussion

The overall least-squares means of monthly test day milk yields were observed as 4.13±0.15 kg (TD5), 10.30±0.30 kg (TD35), 10.46±0.30 kg (TD65), 10.49±0.33 kg (TD95), 9.65±0.30 kg (TD125), 9.46±0.44 kg (TD155), 8.33±0.33 kg (TD185), 7.65±0.35 kg (TD215), 6.74±0.35 kg (TD245), 5.60±0.26 kg (TD275), and 5.04±0.23 kg (TD305) in Murrah buffaloes. The lactation period can be considered as early lactation from TD5 to TD95, mid lactation from TD125 to TD215 and late lactation from TD245 to TD305. The early lactation starting from 4.13±0.15 kg (TD5) to 10.49±0.33 kg (TD95) showed the accelerated phase of milk production until it reached the highest (10.49±0.33 kg) value, supported with the finding of Borquis et al. (2010) and Sangwan et al. (2016), however, the rate of increase was slower in the findings of Geetha et al. (2007) and Tonhati et al. (2008). The mid lactation period yielded 9.65±0.30 kg (TD125) to 7.65±0.35 kg (TD215) was phase of constant milk production maintained the optimum yield and results were comparable to the results of Sahoo et al. (2015) and Singh et al. (2016), however the yield has shown improvement in milk production as compared with Chakraborty et al. (2010) whose parameters of mid lactation were declining steeply. The late lactation period showed a declining phase starting from 6.74±0.35 kg (TD245) to 5.04±0.23 kg (TD305) and was in correspondence with the findings of Kumar et al. (2012), Patil et al. (2016), Patil et al. (2017) and Rana et al. (2021). The notable improvement in early and mid-lactation yields, especially at test days TD35 and TD95, underscores the successful implementation of selective breeding and effective management strategies. Most of the animals were maintaining a constant production during mid lactations after attainment of peak production in early lactation, pointed towards the targeted selection approaches.

Period of calving significantly influenced milk yields at TD5, TD35, TD65, TD95, and TD125, TD275 and TD305, while effects on TD155, TD185, TD215, and TD245 were non-significant. Corresponding effect of period of calving on early and mid-lactation test day milk yields were reported by several researchers (Chakraborty et al. 2010; Sangwan et al. 2016; Patil et al. 2016 and Singh et al. 2019) on mid-lactation test days. However, Kumar et al. (2012), Galsar et al. (2016), and Parmar et al. (2018) found no significant effects for TD5 or TD9 in Murrah and Mehsana buffaloes, respectively. The study found non-significant effects of period of calving on TD155, TD185, TD215, and TD245, although a notable significant ($p<0.05$) effect was obtained on TD275. The findings were in line with results of Singh et al. (2016), Sharma et al. (2017) and Rana et al. (2021) while Bhat et al. (2023) had the contrasting outcomes in Surti and Murrah buffaloes. The mean values of test day milk yields on specific test days across the studied periods in kg from TD5 to TD305 varied from 3.95±0.22 to 4.56±0.22, 9.46±0.36 to 11.11±0.30, 9.36±0.36 to 11.21±0.36, 9.82±0.38 to 10.93±0.38, 9.08±0.36 to 10.01±0.36, 9.41±0.52 to 9.51±0.48, 8.04±0.38 to 8.56±0.38, 7.39±0.40 to 7.97±0.40, 6.86±0.40 to 6.89±0.30, 5.03±0.36 to 5.96±0.35

and 4.45±0.30 to 5.34±0.20, respectively. Milk yield values were most notable from TD5 to TD125, TD275, and TD305 with the third period showing the highest values indicating a significant improvement in herd production.

Present study revealed that the season of calving had significant effects on various test days (TD5, TD35, TD65, TD95, TD125, TD155, TD185, TD215, and TD275). However, no significant effects were observed on TD245 and TD275, contrasting with Kokate et al. (2013), who reported significant effects for these test days. Patil et al. (2016), and Singh et al. (2016) similarly noted significant seasonal effects on test days. Likewise, significant effects of early lactation were supported by Kokate et al. (2013) and Sangwan et al. (2016), whereas Chakraborty et al. (2010) reported no significant seasonal impact on any of the test day milk yield. Considering other buffalo breeds, Galsar et al. (2016) and Bhat et al. (2023) noticed variable seasonal effects in Mehsana and Surti buffaloes, whereas Parmar et al. (2018) reported non-significant effect of season of calving in Mehsana buffaloes. Winter calvers performed well as compared to other seasons in milk yield across most test days, except TD245 and TD305. The highest yields observed (in kg) were 4.35±0.19 (TD5), 10.73±0.32 (TD35), 11.09±0.32 (TD65), 11.03±0.35 (TD95), 10.45±0.33 (TD125), 10.30±0.48 (TD155), 8.93±0.35 (TD185), 7.96±0.37 (TD215), and 5.90±0.30 (TD275). Murrah buffaloes are susceptible to heat stress, exhibiting optimal performance during cooler periods of the year. This study corroborates that trend, highlighting the significant decline in early and mid-lactation yields during warmer months. Strategic interventions, such as the selective use of elite animals and the implementation of effective management practices, have further enhanced these outcomes.

This study demonstrated a significant effect of parity ($p<0.01$) on test day milk yields, notably for TD5, TD35, TD65, TD95, TD125, TD155, TD185, and TD215 while non-significant effects were reported on TD245, TD275, and TD305. These results aligned with findings by Penchev et al. (2011) and Kumar et al. (2021) in Murrah buffaloes, Galsar et al. (2016) in Mehsana buffaloes and Tailor and Singh (2011) in Surti buffaloes on early and late test day milk yields (TDMY). The highest test day milk yields were observed in the third parity for TD35 (10.90±0.32 kg), TD65 (11.24±0.32 kg), TD95 (11.23±0.35 kg), TD125 (10.46±0.33 kg), and TD185 (9.05±0.36 kg); in the sixth parity for TD5 (4.70±0.30 kg); in the fifth parity for TD155 (10.42±0.57 kg); and in the fourth parity for TD215 (8.20±0.40 kg). Milk yields were optimal up to the third and fourth lactations, suggesting buffaloes were most productive through the fourth parity, after which yields decline. These findings highlight that parity significantly influences milk production in early to mid-lactation, with a lesser effect in later stages. Most peak records (TD35 to TD125) in the third parity indicate increasing yield capacity with physiological maturity.

Heritability estimates for test day milk yields (TDMY) varied across lactation, ranging from 0.10±0.09 (TD305) to 0.46±0.12 (TD95 and TD215) in the present study. These findings indicate a moderate to high genetic influence during mid-lactation, with diminishing genetic influence in later stages, similar to trends seen in previous studies. In accordance to the current study, Geetha et al. (2007) and Tonhati et al. (2008) reported heritability in range between 0.33 to 0.58 and 0.12 to 0.30, respectively. Borquis et al. (2010), Muñoz et al. (2011) in Colombian dairy buffaloes, Madad et al. (2013) in Iranian buffaloes reported medium heritability estimates for test day milk yieds, however, Sangwan et al. (2016) in Murrah buffaloes observed maximum heritability for TD5 as 0.40. Lower heritability estimates in later lactation (TD275 and TD305) were in correspondence with the results of Patil et al. (2016) as they reported heritability estimates as 0.05 for TD10. Contrary to the present study, Parmar et al. (2018) reported contrasting heritability values in early and late lactation, with higher estimates of 0.85 (TD1) and 0.52 (TD8) in Mehsana and Murrah buffaloes, respectively. The results pointed towards the role of genetic control in early and mid- lactations while this controls shift to environmental aspects in late lactation.

Genetic correlations between 305-day milk yield (305DMY) and test day milk yields ranged from 0.11±0.04 (TD5) to 0.99±0.12 (TD65), with phenotypic correlations following a similar trend varying from 0.11±0.03 (TD5) to 0.70±0.25 (TD215). The strong genetic and phenotypic correlations at 305DMY/TD65 (0.99±0.12) and 305DMY/TD215 (0.70±0.25) highlight a close link between milk yield at these stages and overall lactation production, while the low correlation among 305DMY/TD5 (0.11±0.04) suggests early-stage yields were less predictive of total lactation yield. In support of this study, Sahoo et al. (2016), Parmar et al. (2018) and Galsar et al. (2016) also reported highly significant genetic and phenotypic correlations ranging from 0.08 to 0.99 among test day yields and 305DMY. Singh et al. (2016) and Kumar et al. (2016) reported genetic correlations ranged from 0.10 to 0.99 and 0.51 to 0.99 along with phenotypic correlations ranging from 0.23 to 0.79 and 0.32 to 0.48, respectively among monthly test-day milk yields and with 305-day milk yield in Murrah buffaloes.Genetic correlations among test days ranged from 0.01±0.01 (TD5/TD275) to 0.98±0.25 (TD35/TD155), showing increased correlation strength as lactation progresses, particularly between TD125/TD215 (0.94±0.12) and TD95/TD185 (0.81±0.14). The phenotypic correlation ranged from non-significant i.e. -0.006±0.01 (TD5/TD275) to highly significant i.e. 0.67±0.32 (TD65/TD95). TD5 had minimum phenotypic correlation with all other test day milk yield values while TD35 and beyond test day milk yield values were highly correlated with each other ranging from 0.17±0.08 (TD35/TD275) to 0.67±0.32 (TD35/95), showcasing a highly significant correlation at $p<0.01$. Indistinguishable correlation values were obtained by Borquis et al. (2010) in Brazilian Murrah buffaloes (0.16 to 0.70) and Chakraborty et al. (2010) reported genetic correlation varying from 0.10 to 0.99 between test day milk yields. Zadeh (2016), Patil et al. (2016), Tamboli et al. (2021), Kumar et al. (2022) and Ranjan et al.

(2023) reported significant variation across lactations, supporting the importance of targeting mid-stages yields for selection. These results of the study indicated that while early test days show weaker correlations, mid-lactation test days (TD125 to TD215) exhibit stronger and more consistent correlations, enhancing their utility in predicting total yield.

Conclusion

The heritability estimates were low to moderate for the test day milk yields, however their genetic and phenotypic correlations were high and significant, pointing towards the reliable predictive potential. The results revealed a progressive strengthening of correlations as lactation progresses, with TD215 showing the strongest correlation, highlighting the importance of mid-lactation periods (up to TD215) in predicting total milk production in Murrah buffaloes.

Data availability

Data will be made available upon reasonable request from first author.

Author contributions

S.S: Data acquisition, data analysis and drafting the manuscript, S.S.D: design of study and approved final version of article, P.R: design of study, data analysis and approved final version of article, M.K: Data analysis and approved final version of article

Funding

The author(s) reported there is no funding associated with the work featured in this article.

Competing interests

There is no conflict of interest among authors.

References

1) Alshdaifat, M.M., Al-Lataifeh, F., Al-Yacoub, A.N., Al-Barakeh, F., Al-Najjar, K. 2024. Multivariate of Physicochemical Properties of Daily Milk throughout Milking Seasons on Syrian Buffaloes (Bubalus Bubalis). Journal of Livestock Science 15: 46-52 doi.10.33259/JLivestSci.2024.46-52
2) Bhat, K.K., Sharma, P.C., Gour, M., Saini, S., Shrama, A., Meena, S.K. and Yadav, D.K. (2023). Estimation of the effect of non-genetic factors on test day milk yield in Surti buffalo. Journal of Experimental Zoology, 26(1), 1213.
3) Borquis, R.R.A., Bignardi, A.B., Seno, L.O., Camargo, G.M.F., Berrocal, M.H.M., Albuquerque, L.G., Palo, R.D. and Tonhati, H. (2010). Genetic parameters for milk yield analyzed by test-day models in Murrah buffaloes in Brazil. Italian Journal of Animal Sciences, 9, 179-182.
4) Chakraborty, D., Dhaka, S.S., Pander, B.L., Yadav, A.S. and Dandapat, A. (2010). Genetic studies on 305 days and test day milk yield records in Murrah buffaloes. Indian Journal of Animal Sciences, 80(8), 729-732.
5) DAHD (2023). DAHD (Department of Animal Husbandry and Dairying), Dairy Sector. Annual report.
6) El Faro, L., and Albuquerque, L. G. D. (2003). Estimation of genetic parameters for first lactation test-day records and total milk yield for Caracu cows. Revista Brasileira de Zootecnia, 32, 284-294.
7) GalsarNirali, S. (2016). Genetic and non-genetic factors affecting first lactation test-day milk yield in Mehsana buffaloes, Gujarat, India. International Journal of Agriculture Sciences, ISSN, 0975-3710.
8) Geetha, E., Chakravarty, A. K. and Kumar K. V. (2007). Estimation of genetic parameters using random regression test day model for first lactation milk yield in Murrah buffaloes. Indian Journal of Animal Sciences, 77, 889-901.
9) Harvey, W. R. (1990). User guide for LSMLMW and MIXMDL package. Mix model Least Squares and Maximum Likelihood Computer Programme. pc-2 version Mimeograph. Columbia, Ohio, USA.
10) Henderson, C. R. (1953). Estimation of variance and covariance components. Biometrics. 9, 226-252.
11) Kokate, L. S., Singh, A., Banu, R., Gandhi, R. S., Chakravarty, A. K., Gupta, A. K. and Sachdeva, G. K. (2013). Genetic and non genetic factors affecting monthly test day milk yield in Karan fries cattle. Indian Journal Animal Sciences, 83(4), 385-389.
12) Kumar, A., Gupta, J. P., Kaswan, S. and Lathwal, S.S. (2012). Non-genetic factorsinfluencing monthly test day milk yield records in Murrah buffaloes. Indian Journal of Field Veterinarians, 8(1), 41-43.
13) Kumar, A., Vohra, V., Verma, U. and Singh, U. (2022). Estimates of genetic parameters for production and reproduction traits in Murrah buffaloes (Riverine buffalo) in India. Buffalo Bulletin, 41(1), 135-141.
14) Kumar, M., Vohra, V., Ratwan, P., Valsalan, J., Patil, C. S., & Chakravarty, A. K. (2016). Estimates of genetic parameters for fat yield in Murrah buffaloes. Veterinary World, 9(3), 295.
15) Kumar, S., Gupta, I. D., Sharma, N., Deginal, R., Kumar, A., Chauhan, A. and Verma, A. (2021). Effect of season, parity and stage of lactation on productive performance of Sahiwal cattle. Indian Journal of Animal Research, 55(5), 597-602.
16) Madad, M., Ghavi Hossein-Zadeh, N., Shadparvar, A. A. and Kianzad, D. (2013). Random regression models to estimate genetic parameters for test-day milk yield and composition in Iranian buffaloes. Archives Animal Breeding, 56(1), 276-284.

17) Parmar, G. A., Gupta, J. P., Chaudhari, J. D., Prajapati, B. M., Panchasara, H. H., Chauhan, H. D., Ankuya, K. J. and Patel, P. A. (2018). Estimation of genetic and non-genetic factors for test-day milk yield in Mehsana buffaloes. Indian Journal of Dairy Science, 71(1), 67-71.
18) Patil, C. S., Chakravarty, A. K., Kumar, V., Das, R. and Vohra, V. (2016). Inheritance pattern of first lactation production traits in Murrah buffalo. Indian Journal of Dairy Science, 69(6), 693-697.
19) Penchev, P., Boichev, M., Ilieva, Y. and Peeva, T. Z. (2011). Effect of different factors on lactation curve in buffalo cows. Slovak Journal of Animal Science, 44(3), 103-110.
20) Rana, E., Gupta, A.K., Singh, A., Ruhil, A.P., Malhotra, R., Yousuf, S. and Ete, G. (2021). Prediction of First Lactation 305-day Milk Yield Based on Bimonthly Test Day Milk Yield Records in Murrah Buffaloes. Indian Journal of Animal Research, 55, 486-490.
21) Ranjan, A., Jain, A., Verma, A., Sinha, R., Joshi, P., Gowane, G. R. and Alex, R. (2023). Optimization of test day for milk yield recording and sire evaluation in Murrah buffaloes. Journal of Animal Breeding and Genetics, 140(4), 400-412.
22) Sahoo, S. K., Singh, A., Gupta, A. K., Chakravarty, A. K., Ambhore, G. S. and Dash, S. K. (2015). Comparative evaluation of different lactation curve functions for prediction of bi-monthly test day milk yields in Murrah Buffaloes. Animal Science, 9(3), 89-94.
23) Sahoo, S. K., Singh, A., Gupta, A. K., Chakravarty, A. K., Singh, M. and Ambhore, G. S. (2014). Estimation of genetic parameters of weekly test-day milk yields and first lactation 305-day milk yield in Murrah buffaloes. Veterinary World, 7(12),1094-1098.
24) Sangwan, S. K., Dhaka, S. S., Yadav, A. S and Singh, S. K. (2016). Genetic evaluation of Murrah sires using test day milk records. Haryana veterinarian, 55(1), 56-58.
25) Santos, D. J. A., Peixoto, M. G. C. D., Borquis, R. R. A., Verneque, R. S., Panetto, J. C. C., and Tonhati, H. (2013). Genetic parameters for test-day milk yield, 305-day milk yield, and lactation length in Guzerat cows. Livestock Science, 152(2-3), 114-119.
26) Schaeffer, L. R., Jamrozik, J., Kistemaker, G. J., and Van Doormaal, J. (2000). Experience with a test-day model. Journal of Dairy Science, 83(5), 1135-1144.
27) Sharma, S. P., Bhandari, P., Bhattarai, N., Kolachhapati, M. R. and Sapkota, S. (2017). Effect of Non-Genetic Factors on Lactational Efficiency of Indigenous Buffaloes at Different Stage of Parity in Western Hills of Nepal. International Journal of Research, 4(17), 491-497.
28) Singh, M., Singh, A., Gupta, A. K., Dash, S. K., Shivahre, P. R., Sahoo, S. K. and Ambhore, G. S. (2016). Genetic parameters of 305 days and monthly test-day milk yields in Murrah buffaloes. Indian Journal of Animal Sciences, 86(1), 55-60.
29) Singh, N. K., Sing, R., Gupta, A., Fahim, A., Dar, A. H and Kumar, A. (2019). Non-genetic factors affecting monthly test day milk yields in Murrah buffaloes. Buffalo Bulletin, 38, 4.
30) Tamboli, P., Bharadwaj, A., Chaurasiya, A., Bangar, Y. C. and Jerome, A. (2021). Genetic parameters for first lactation and lifetime traits of Nili-Ravi buffaloes. Frontiers in Veterinary Science, 8, 557468.
31) Tonhati, H., Munoz, M. F. C., Oliveira, J. A., Faro, L. E., Lima, A. L. F. and Albuquerque, L. G. (2008). Test-day milk yield as a selection criterion for dairy buffaloes. Genetics and Molecular Biology, 31(3),674-679.
32) Zadeh, N. G. H. (2016). Estimates of genetic parameters and genetic trends for production and reproduction traits in Iranian buffaloes (Bubalus bubalis). Animal Production Sciences, 57(2), 216-222.