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Genetic parameters of 305 days and monthly test-day milk yields in Murrah buffaloes

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ABSTRACT

The present investigation was carried out using first lactation 9,071 monthly test-day milk yield records of 965 Murrah buffaloes that calved from 1977 to 2012 sired by 98 bulls maintained at ICAR-National Dairy Research Institute, Karnal. Mixed model analysis was carried out by least-squares maximum likelihood programme to study the effects of genetic and non-genetic factors on first lactation 305-day milk yield and monthly test-day (TD) milk yield records of Murrah buffaloes. The highest monthly test-day milk yield was observed in TD_3 (7.64 kg) and lowest in TD_{10} (4.46 kg). The average first lactation 305 days or less milk yield (FL305DMY) was 1806.45±16.99 kg. The effect of season of calving, period of calving and age at first calving was highly significant on FL305DMY and on most of the monthly test-day milk yields. The heritability estimate for FL305DMY was 0.18±0.08 and for monthly test-day milk yields it ranged from 0.09 (TD_6) to 0.18 (TD_3). The genetic and phenotypic correlations among monthly test-day milk yields and with 305 days milk yield were highly significant. The present investigation revealed that the non-genetic factors such as season of calving in general and year of calving in particular, might be considered when performing an evaluation of Murrah buffaloes based on monthly test-day milk yield records. High genetic and phenotypic correlation among monthly test-day milk yields and with first lactation 305 days milk yield suggested that these test-day yields could be used as the selection criteria, leading to a reduction in generation interval.

Key words: 305 days milk yield, Buffaloes, Genetic estimates, Monthly test-day milk yields, Murrah

Murrah buffalo is an important breed of India with superior genetic potential for milk production. Buffalo population in India is 108.7 million (Livestock Census 2012), which accounts for more than half of world's buffalo population. The contribution of buffaloes to total milk production of India (127.9 million tonnes) is about 65.3 million tonnes, i.e. 51.09% (BAHS 2013), and is hence considered as India's milking machine. Hitherto, the sires have been evaluated for milk yield on the basis of first lactation 305 days or less milk yield (FL305DMY) of their daughters at various organized farms. To find out an alternative to daily milk recording to get the data of FL305DMY, some studies were undertaken on test-day milk yields in buffaloes (Singh and Rana 2008, Chakraborty *et al*. 2010, Singh and Tailor 2013). The genetic parameters like heritability, genetic and phenotypic correlation are required for developing optimum breeding strategies for genetic improvement of buffaloes. For this, use of test-day data would offer a practical solution. Information on estimates of genetic parameters of monthly test-day milk yield records of Murrah buffaloes are lacking , therefore, the present investigation was undertaken to know the genetic parameters of 305 days and monthly test-day milk yields (MTDMY).

MATERIALS AND METHODS

The data set for the present investigation comprised 9,071 monthly test-day milk yield records of 965 Murrah buffaloes that calved from 1977 to 2012 sired by 98 bulls. The data on monthly test-day milk yields and first lactation 305 days or less milk yield were collected from history cum-pedigree sheets and daily milk yield recording registers maintained at Dairy Cattle Breeding Division, ICAR-National Dairy Research Institute, Karnal. Milk yield recorded on 15th day of calving was taken as first monthly test-day milk yield (TD_1). Next 9 test-day milk yield records were taken at 30 days interval from first test-day (TD_2 – TD_{10}). The first lactation 305 days or less milk yield was also used in the present study. Only those records of Murrah buffaloes were considered that had produced milk for at least 100 days and minimum of 500 kg. Culling in the

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middle of lactation, abortion, still-birth or any other pathological causes, which affected the lactation yield were considered as abnormalities and were excluded from the study. The records of progenies of only those sires were included which had minimum 5 or more daughters. The outliers beyond two-standard deviation on both the tail of the distribution were expelled from the data. Seasons were considered to be one of the main factors of the environment that affects the performance of buffaloes. Each year was divided into 4 seasons, viz. winter, December – March; summer, April – June; rainy, July – September; and autumn, October – November. The data spread over 36 years (1977–2012) were classified into 12 periods of 3 consecutive years and age at first calving groups (10 groups).

Statistical analysis: Mixed model analysis of data was carried out by least-squares maximum likelihood method to study the effects of genetic and non-genetic factors on FL305DMY and MTDMY records of Murrah buffaloes. The following models were used:

For 305 days milk yield,

$$Y_{ijklm} = \mu + S_i + P_j + A_k + B_l + e_{ijklm}$$

For test day milk yield,

$$TDY_{ijklm} = \mu + S_i + P_j + A_k + B_l + e_{ijklm}$$

where, Y_{ijklm}, FL305DMY of the mth individual of lth sire in kth age group of jth period and ith season; TDY_{ijklm}, test-day milk yield of the mth individual of lth sire in kth age group of jth period and ith season; μ, population mean; S_i, fixed effect of ith season (i=1 to 4); P_j, fixed effect of jth period (j=1 to 12); A_k, fixed effect of kth age group (k=1to10); B_l, random effect of lth sire; e_{ijklm}, random error~NID $(0,\sigma^2 e)$. The statistical significance of various fixed effects in the least squares model was determined by 'F' test. For significant effects, the differences between pairs of levels of effects were tested by Duncan's multiple range test as modified by Kramer (1957).

Estimation of heritability: Paternal half sib correlation method (Becker 1975) was used to estimate the heritability of different characters and their genetic correlations. The sires with five or more than five progeny were included for the estimation of heritability. The data adjusted for significant effects of non-genetic factors were used for estimation of heritability. The model used to estimate the heritability was:

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

where, Y_{ij}, observation of the jth progeny of the ith sire; μ, overall mean; S_i, effect of ith sire; NID $(0, \sigma^2_s)$; e_{ij}, random error NID $(0, \sigma^2_e)$. The standard error of heritability was estimated as per Swiger *et al.* (1964).

Genetic and phenotypic correlations: The genetic and phenotypic correlations among different MTDMY and FL305DMY were calculated from the analysis of variance and covariance among sire groups (Becker1975). The standard error of phenotypic correlations was obtained according to Panse and Sukhatme (1967). The statistical significance of correlations was tested by 't' test (Snedecor and Cochran 1967).

Table 1. Means and SE of monthly test-day milk yields and FL305DMY

Milk yield traits	No. observations	Mean	SE
TD_1	965	6.26	0.07
TD_2	965	7.59	0.07
TD_3	965	7.64	0.07
TD_4	965	7.39	0.07
TD_5	958	7.07	0.06
TD_6	948	6.56	0.06
TD_7	932	6.11	0.06
TD_8	895	5.51	0.06
TD_9	811	4.94	0.07
TD_{10}	657	4.46	0.07
305DMY	965	1806.45	16.99

RESULTS AND DISCUSSION

The highest MTDMY was observed in TD_3 (7.64 kg) and lowest in TD_{10} (4.46 kg) (Table 1). Chakraborty *et al*. (2010) also observed that the MTDMY was maximum for TD_3 (8.11 kg) and minimum for TD_{10} (5.13 kg). In general, MTDMY increased till TD_3 and thereafter, a gradual decline was noticed till the end of lactation. The coefficient of variation for MTDMY ranged from 27.27% (TD_3) to 38.69% (TD_{10}). The average FL305DMY in the present study was 1806.45 kg with coefficient of variation 29.21%. This estimated value was near to the average values reported by Wakchaure *et al.* (2011) and Borquis *et al.* (2010), being 1,812.58 kg and 1,813.15 kg, respectively, in Murrah buffaloes. Banik and Tomar (2002) and Chakraborty *et al*. (2004) also reported similar FL305DMY of 1,794.8 and

Table 2. Mixed model ANOVA showing mean sum of squares for factors affecting monthly test-day milk yields and 305-day or less milk yield

Source of Variation	Degrees of Freedom	TD_1	TD_2	TD_3	TD_4	TD_5	TD_6	TD_7	TD_8	TD_9	TD_{10}	305DMY
Sire	97	5.43**	4.43*	4.49**	4.19*	4.50**	4.29^{NS}	5.03**	5.69^{NS}	6.89*	7.01*	295691**
Period	11	23.17**	20.64**	12.54**	17.73**	12.00**	13.31**	9.08**	9.54**	8.76^{NS}	12.87**	980807**
Season	3	20.40**	45.87**	25.24**	4.40^{NS}	0.94^{NS}	12.84**	24.01**	19.05**	8.45^{NS}	10.99^{NS}	577227**
AFC	9	8.75**	10.23**	11.79**	7.48**	6.48*	5.17^{NS}	8.64**	8.13^{NS}	12.48**	9.48^{NS}	506439**
Error	844	3.89	3.43	3.15	3.12	3.29	3.51	3.71	4.56	5.38	5.47	205117

*P< 0.05; **P< 0.01; NS, nonsignificant.

Table 3. Least squares means along with their standard errors for non-genetic factors affecting monthly test-day milk yields

	TD_1	TD_2	TD_3	TD_4	TD_5	TD_6	TD_7	TD_8	TD_9	TD_{10}	305-DMY
Overall (965)	5.91±0.13	7.29±0.12	7.41±0.12	7.20±0.11	6.82±0.12	6.22±0.11	5.82±0.12	5.09±0.13	4.15±0.14	3.11±0.15	1758±31
seasons											
Winter (237)	6.04^{ab}±0.18	7.64 ^{a}±0.16	7.71 ^{a}±0.16	7.24±0.15	6.74±0.16	6.03^{b}±0.16	5.56^{bc}±0.17	4.87^{b}±0.18	4.14±0.20	3.21±0.20	1767^{ab}±41
Summer (225)	6.33 ^{a}±0.18	7.73 ^{a}±0.17	7.66^{a}±0.16	7.08±0.16	6.80±0.17	6.58^{a}±0.17	6.31^{a}±0.18	5.56^{a}±0.19	4.46±0.21	3.27±0.21	1835^{a}±43
Rainy (341)	5.69^{bc}±0.16	6.78 ^{b}±0.14	6.99 ^{b}±0.14	7.08±0.14	6.90±0.14	6.29^{ab}±0.14	5.91^{b}±0.15	5.08^{b}±0.16	4.04±0.18	3.01±0.18	1722^{b}±37
Autumn (162)	5.60 ^{c}±0.20	7.03 ^{b}±0.18	7.30^{b}±0.18	7.42±0.17	6.84±0.18	5.97^{b}±0.18	5.50^{c}±0.19	4.85^{b}±0.21	3.95±0.23	2.79±0.23	1709^{b}±46
Periods											
I Period (1977–79)	6.20^{cd}±0.47	6.93^{c}±0.44	7.56^{c}±0.42	6.63^{f}±0.42	6.43^{de}±0.43	6.13^{c}±0.44	5.60^{cd}±0.46	4.29^{d}±0.50	3.66±0.55	3.21^{cde}±0.55	1691^{cd}±108
II Period (1980–82)	6.04^{d}±0.45	7.39^{c}±0.42	7.63^{c}±0.41	7.38^{de}±0.40	7.21^{bc}±0.41	6.92^{b}±0.43	6.14^{bc}±0.44	5.15^{bc}±0.49	4.04±0.53	2.99^{def}±0.53	1808^{bc}±104
III Period (1983–85)	5.96^{d}±0.39	8.13^{b}±0.37	8.30^{ab}±0.35	7.65^{cd}±0.35	7.49^{bc}±0.36	6.89^{b}±0.37	6.01^{c}±0.38	5.16^{bc}±0.42	3.69±0.46	2.13^{g}±0.46	1830^{b}±91
IV Period (1986–88)	6.88^{ab}±0.37	8.77^{a}±0.35	8.68^{a}±0.34	8.67^{a}±0.33	8.10^{a}±0.34	7.05^{ab}±0.35	6.60^{ab}±0.36	5.71^{ab}±0.40	4.37±0.44	2.94^{def}±0.44	1980^{a}±86
V Period (1989–91)	7.01^{ab}±0.34	8.52^{ab}±0.31	8.71^{a}±0.30	8.64^{a}±0.30	8.08^{a}±0.31	7.61^{a}±0.31	6.93^{a}±0.33	5.69^{ab}±0.36	4.48±0.39	3.73^{abc}±0.40	2091^{a}±78
VI Period (1992–94)	7.00^{ab}±0.34	8.65^{ab}±0.32	8.35^{ab}±0.31	8.37^{ab}±0.30	7.59^{ab}±0.31	7.14^{ab}±0.32	6.72^{a}±0.33	6.33^{a}±0.36	5.36±0.40	4.24^{a}±0.40	2097^{a}±79
VII Period (1995–97)	7.44^{a}±0.37	8.51^{ab}±0.35	7.94^{bc}±0.34	8.02^{bc}±0.33	7.50^{b}±0.34	7.18^{ab}±0.35	6.77^{a}±0.36	5.96^{a}±0.40	5.11±0.44	4.11^{ab}±0.44	2046^{a}±87
VIII Period (1998–2000)	5.00^{e}±0.38	7.01^{c}±0.35	6.99^{d}±0.34	7.07^{ef}±0.34	6.89^{cd}±0.35	6.13^{c}±0.36	5.67^{c}±0.37	4.98^{c}±0.41	4.14±0.44	2.72^{efg}±0.45	1669^{d}±88
IX Period (2001–03)	4.76^{e}±0.45	6.01^{d}±0.42	6.16^{e}±0.41	5.97^{g}±0.40	5.72^{f}±0.42	4.70^{ef}±0.43	5.10^{de}±0.44	4.60^{cd}±0.49	4.02±0.53	2.65^{efg}±0.54	1439^{ef}±105
X Period (2004–06)	6.73^{bc}±0.49	7.30^{c}±0.45	6.85^{d}±0.44	6.79^{f}±0.43	6.06^{ef}±0.45	5.44^{d}±0.46	5.04^{de}±0.47	4.74^{cd}±0.52	3.30±0.57	2.31^{fg}±0.58	1656^{d}±112
XI Period (2007–09)	4.63^{e}±0.66	5.96^{d}±0.62	6.02^{e}±0.59	5.52^{g}±0.59	5.90^{ef}±0.61	5.14^{de}±0.63	4.71^{e}±0.64	4.19^{d}±0.71	3.61±0.78	2.77^{efg}±0.78	1485^{e}±153
XII Period (2009–12)	3.31^{f}±0.75	4.32^{e}±0.70	5.77^{e}±0.67	5.71^{g}±0.67	4.91^{g}±0.69	4.31^{f}±0.71	4.54^{e}±0.73	4.30^{d}±0.81	3.98±0.88	3.51^{bcd}±0.89	1307^{f}±173
Age at first calving groups (AFC)											
AFC I (d”1000 days)	5.66^{c}±0.54	6.73^{f}±0.51	7.21^{cd}±0.49	7.05^{bcde}±0.49	6.81^{bcd}±0.50	6.33±0.51	5.98^{b}±0.53	5.25±0.59	4.87^{a}±0.64	4.35±0.64	1804^{bc}±126
AFC II (1001–1090 days)	5.50^{c}±0.30	6.62^{f}±0.28	6.81^{d}±0.27	6.71^{e}±0.27	6.56^{cd}±0.27	5.85±0.28	5.37^{c}±0.29	4.57±0.32	3.76^{bd}±0.35	2.87±0.35	1615^{e}±70
AFC III (1091–1180 days)	5.52^{c}±0.20	6.79^{ef}±0.18	6.86^{d}±0.18	6.85^{de}±0.17	6.44^{d}±0.18	5.86±0.18	5.42^{c}±0.19	4.93±0.21	4.00^{bcd}±0.23	2.86±0.23	1651de±46
AFC IV (1181–1270 days)	5.56^{cd}±0.18	7.05^{def}±0.17	7.18^{cd}±0.16	6.99^{bcde}±0.16	6.68^{cd}±0.17	6.05±0.17	5.66^{bc}±0.18	5.17±0.19	4.42^{abc}±0.21	3.12±0.21	1745^{bcde}±43
AFC V (1271–1360 days)	5.96^{bc}±0.18	7.28^{cde}±0.16	7.33^{cd}±0.16	7.21^{bcde}±0.16	6.65^{cd}±0.16	5.98±0.16	5.44^{c}±0.17	4.59±0.19	3.72^{d}±0.20	2.70±0.21	1704^{cde}±42
AFC VI (1361–1450 days)	6.02^{bc}±0.19	7.40^{cd}±0.17	7.28^{cd}±0.17	6.98^{cde}±0.17	6.55^{cd}±0.17	5.89±0.17	5.33^{c}±0.18	4.88±0.20	3.85^{bcd}±0.22	2.89±0.22	1697^{cde}±45
AFC VII (1451–1540 days)	6.26^{ab}±0.21	7.59^{bc}±0.20	7.88^{ab}±0.19	7.49^{bc}±0.19	7.03^{bc}±0.19	6.36±0.20	6.03^{b}±0.21	5.30±0.22	4.43^{ab}±0.25	2.88±0.25	1816^{abc}±50
AFC VIII (1541–1630 days)	6.69^{a}±0.31	8.00^{ab}±0.29	8.25^{a}±0.28	7.98^{a}±0.28	7.24^{ab}±0.29	6.62±0.29	6.21^{ab}±0.30	5.48±0.34	4.71^{a}±0.37	3.72±0.37	1938^{a}±73
AFC IX (1631–1720 days)	5.92^{bc}±0.36	7.38^{cd}±0.33	7.48^{bc}±0.32	7.26^{bcd}±0.32	7.57^{a}±0.33	6.65±0.33	6.15^{ab}±0.35	5.61±0.38	4.69^{a}±0.42	3.58±0.42	1849^{ab}±83
AFC X (>1720 days)	6.04^{bc}±0.58	8.11^{a}±0.54	7.84^{ab}±0.52	7.50^{b}±0.52	6.70^{cd}±0.53	6.67±0.55	6.62^{a}±0.57	5.12±0.63	3.01^{e}±0.68	2.11±0.69	1762^{bcd}±134

1,818.06 kg, respectively, while studying for same herd.

Effect of non-genetic factors: The effect of season of calving was highly significant (Pß0.01) on TD_1 to TD_3, TD_6, TD_7 and TD_8 and nonsignificant effect on TD_4, TD_5, TD_9 and TD_{10} (Table 2). The least squares mean along with their standard errors for seasons affecting MTDMY are presented in Table 3. The MTDMY were highest in summer followed by winter in TD_1 and TD_2. However, for TD_3 and TD_{10}, the highest milk yield was observed in winter followed by summer season, for TD_4 highest yield was observed in autumn followed by winter, for TD_5 the highest yield was obtained in rainy season, from TD_6 to TD_9, the highest milk yield was observed in summer. No definite trend for other seasons was observed for this trait. The effect of season of calving on FL305DMY was highly significant ($P \leq 0.01$) (Table 2). Wakchaure *et al.* (2011) and Chakraborty *et al.* (2004) in Murrah buffaloes and Ahmad *et al.* (2009) in Nili-Ravi buffaloes also observed significant effect of season of calving on FL305DMY. The least squares mean along with their standard errors for seasons affecting FL305DMY are presented in Table 3. The trait was highest (1,835.52 kg) in summer followed by winter (1,767.05 Kg), rainy (1,722.90 kg) and autumn (1,709.51 kg).

The effect of period of calving on all the MTDMY was highly significant ($P \leq 0.01$) (Table 2) except on TD_9. The present finding was in accordance with the reports of Kumar *et al.* (2012) in Murrah buffaloes. The least squares means along with their standard errors for the effect of periods on test-days are showed in Table 3. However, the MTDMY exhibited an increasing trend from period I till period IV for TD_2 to TD_5. The effect of period of calving on TD_6 to TD_8 showed no definite trend till period VI. The effect of period of calving on 305 days milk yield was highly significant ($P \leq 0.01$) (Table 2). Jamuna (2012), Pathodiya and Jain (2004) and Sarkar *et al.* (2006) also reported that the 305 days or less milk yield was significantly influenced by the period of calving in Murrah buffaloes. The least squares mean along with their standard errors for the effect of periods on the FL305DMY are presented in Table 3. FL305DMY exhibited an increasing trend from period I till period VI. However, from period VII till period XI, no definite trend was observed in FL305DMY.

The effect of age at first calving was highly significant ($P \leq 0.01$) on all MTDMY except TD_6, TD_8 and TD_{10} on which nonsignificant effect was observed (Table 2). The effect of age at first calving was however, observed to be significant ($P \leq 0.05$) on TD_5. Appannayar (1997) and Kokate *et al.* (2013) however, reported that the age at first calving had non-significant effect on MTDMY in Murrah buffaloes and Karan Fries cattle, respectively. The information on the effect of age at first calving groups on FL305DMY is presented in Table 3. The effect of age at first calving on FL305DMY was highly significant ($P \leq 0.01$) (Table 2). Zaman *et al.* (1990) in Swamp buffaloes also reported the effect of age at first calving groups on first lactation 305 days milk yield to be significant.

Genetic and phenotypic parameters: The heritability estimate of MTDMY was the lowest for TD_6 and highest for TD_3 (Table 4). Similar finding was reported by Hurtado-Lugo *et al.* (2009) for Murrah buffaloes in Colombia (0.01 to 0.20). In accordance with the present findings, Kumar *et al.* (2012) reported that the heritability estimate for MTDMY in Murrah buffaloes was maximum (0.20) for TD_3 and minimum (0.09) for TD_7. Higher estimates of heritability for this trait were reported by Madad *et al.* (2013), Tonhati *et al.* (2008), Breda *et al.* (2010) and Chakraborty *et al.* (2010) in Murrah buffaloes. The heritability for FL305DMY was 0.18±0.08. The heritability estimates close to present estimate were reported by Tonhati *et al.* (2008); while lower estimates of heritability for this trait were observed by Hurtado-Lugo *et al.* (2009). On the other hand, Barros *et al.* (2013), Malhado *et al.* (2013), Wakchaure (2011), Breda *et al.* (2010) and Chakraborty *et al.* (2010) reported comparatively higher estimates of heritability for FL305DMY.

The genetic and phenotypic correlations among monthly test-day milk yields and with 305 days milk yield were highly significant ($P \leq 0.01$) (Table 4). The estimates of

Table 4. Heritability, genetic and phenotypic correlations among monthly test-day milk yields and with 305-day or less milk yield

	TD_1	TD_2	TD_3	TD_4	TD_5	TD_6	TD_7	TD_8	TD_9	TD_{10}	305-DMY
TD_1	**0.16±0.08**	0.63±0.02	0.56±0.02	0.52±0.02	0.46±0.03	0.40±0.03	0.37±0.03	0.31±0.03	0.29±0.03	0.23±0.03	0.57±0.02
TD_2	0.93±0.18	**0.12±0.07**	0.72±0.02	0.65±0.02	0.57±0.02	0.49±0.02	0.46±0.03	0.40±0.03	0.37±0.03	0.28±0.03	0.67±0.02
TD_3	0.74±0.20	0.98±0.13	**0.18±0.08**	0.74±0.01	0.62±0.02	0.57±0.02	0.53±0.02	0.44±0.03	0.40±0.03	0.30±0.03	0.73±0.02
TD_4	0.58±0.26	0.99±0.18	0.95±0.11	**0.14±0.08**	0.72±0.02	0.65±0.02	0.61±0.02	0.53±0.02	0.49±0.02	0.38±0.03	0.78±0.01
TD_5	0.36±0.31	0.82±0.22	0.99±0.15	0.88±0.13	**0.15±0.08**	0.76±0.01	0.69±0.02	0.60±0.02	0.53±0.02	0.43±0.03	0.79±0.01
TD_6	0.27±0.41	0.68±0.34	0.85±0.24	0.49±0.34	0.90±0.15	**0.09±0.07**	0.79±0.01	0.69±0.02	0.6±0.02	0.48±0.02	0.82±0.01
TD_7	0.28±0.34	0.83±0.27	0.81±0.20	0.78±0.20	0.99±0.13	0.99±0.13	**0.15±0.08**	0.77±0.01	0.65±0.02	0.52±0.02	0.82±0.01
TD_8	0.67±0.35	0.23±0.45	0.17±0.41	0.10±0.47	0.61±0.28	0.68±0.29	0.99±0.12	**0.10±0.07**	0.77±0.01	0.62±0.02	0.79±0.01
TD_9	0.42±0.36	0.58±0.36	0.63±0.30	0.57±0.31	0.69±0.26	0.95±0.25	0.99±0.17	0.99±0.14	**0.12±0.07**	0.77±0.01	0.78±0.01
TD_{10}	0.19±0.40	0.70±0.38	0.79±0.32	0.88±0.31	0.99±0.28	0.99±0.35	0.99±0.25	0.99±0.26	0.99±0.15	**0.12±0.07**	0.68±0.02
305-DMY	0.40±0.28	0.93±0.15	0.97±0.10	0.97±0.11	0.99±0.08	0.96±0.11	0.99±0.07	0.63±0.22	0.82±0.14	0.99±0.15	**0.18±0.08**

Figures along the diagonal in bold scripts are the heritability estimates. The value above and below the diagonal are phenotypic and genetic correlations, respectively which are highly significant (P<0.01).

phenotypic correlations among all the monthly test-day milk yields ranged from 0.23 (TD_1 and TD_{10}) to 0.79 (TD_6 and TD_7). The magnitude of phenotypic correlations among MTDMY decreased with increasing time interval between test-day milk yields. Borquis *et al.* (2010) reported that the phenotypic correlations among MTDMY ranged from 0.16 (TD_1 and TD_9) to 0.70 (TD_2 and TD_3) in Brazilian Murrah buffaloes. However, Chakraborty *et al.* (2010) reported that the phenotypic correlations among MTDMY varied from -0.05 (TD_1 and TD_7) to 0.65 (TD_9 and TD_{10}) in Murrah buffaloes. The genetic correlation amongst various MTDMY ranged from 0.10 (TD_4 and TD_8) to 0.99 (TD_2 and TD_3). No definite trend for increase or decrease in genetic correlations among MTDMY was observed during different months. The estimates of phenotypic and genetic correlations of MTDMY with FL305DMY ranged from 0.57 to 0.82 and 0.40 to 0.99, respectively, and the estimates were generally higher in the mid segment of lactation.

The present investigation revealed that the non-genetic factors such as season of calving in general and year of calving of in particular, might be considered when performing an evaluation of Murrah buffaloes based on monthly test-day milk yield records. The differences in different monthly test-day milk yields over the periods and seasons may be attributed to the different culling levels on the basis of production and differences in feeding and management practices. The estimates of genetic and phenotypic correlation of monthly test-day milk yields and with first lactation 305 days milk yield was generally higher in the middle segment of lactation suggested that these test-day yields could be used as the selection criteria, leading to a reduction in generation interval.

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