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Effect of genetic and non-genetic factors on milk yield and milk composition traits in Murrah buffaloes

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ABSTRACT

The objective of the present study was to investigate the effect of genetic and non-genetic factors and to estimate genetic parameters of first lactation 305 days milk yield (FLMY305), 305 days fat yield (LFY), 305 days solid not fat yield (LSNFY), 305 days total solid yield (LTSY), 305 days fat percentage (FAT%), 305 days solid not fat percentage (SNF%) and 305 days total solid percentage (TS%) in Murrah buffaloes. The data of 315 Murrah buffaloes calved from 1993 to 2013 and sired by 47 bulls maintained in an organized farm at ICAR-National Dairy Research Institute, Karnal was analyzed to study the effect of genetic and non-genetic factors. Least squares analysis was done to estimate the effect of genetic and non-genetic factors on FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS%. Heritability estimates were obtained by using paternal half-sib correlation method. The heritability estimates for FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% traits were found to be 0.30, 0.29, 0.30, 0.30, 0.05, 0.02 and 0.06, respectively. Very high and positive genetic and phenotypic correlations of FLMY305 with milk constituents' yield traits implied that selection based on FLMY305 would result in correlated response in milk constituents yield traits and therefore need not to be considered separately for their improvement.

Key words: Genetic factors, Milk constituent traits, Murrah buffaloes, Non-genetic factors.

INTRODUCTION

Buffalo is considered as the major dairy animal and backbone of Indian dairy industry. India ranks first in milk production, accounting for 18.5 % of world production, achieving an annual output of 146.3 million tonnes with per capita availability of 322 g /day (NDDB, 2014-15). Buffaloes with a population of 108.7 million, the largest in the world, contribute 53% (67.68 million tonnes) of the total milk produced in the country, which is valued for its quality being twice as rich in fat and other milk constituents as compared to the cow milk. Murrah is one of the superior breeds of Indian buffaloes with a population of 20.49 million (BAHS, 2012), which constitutes about 19.45% of the total buffalo population of the country.

Milk yield is the single most important economic trait determining economic returns from the dairy animals. Buffalo milk plays an important and vital role in providing nutritive food to families both in rural and urban areas. On an average cow milk is composed of 88% water, 3.2% protein, 3.4% fat, 4.7% lactose, 0.66% mineral and 61 kcal energy. On the other hand, buffalo milk composed of less water (84%), more protein (3.7%) and fats (6.9%), moreover higher lactose (5.2%), minerals (0.70%) and energy (97 kcal). Buffalo milk seems thicker than cow's milk because it generally contains more than 16 percent total solids compared with 12-14 percent for cow's milk. In addition, buffalo milk fat content is usually 50-60 percent higher than that of cow's milk. Now a day, milk pricing system is also based on the percentage of fat in milk, therefore, higher milk fat yield fetches better economic returns. Murrah is the most important buffalo breed with superior genetic potential for milk fat yield production.

The present investigation was undertaken with the objective to study the effect of various genetic and non-genetic factors and to estimate genetic parameters of FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% traits in Murrah buffaloes.

MATERIALS AND METHODS

The data of 315 Murrah buffaloes calved from 1993 to 2013 and sired by 47 bulls maintained in an organized farm at ICAR-National Dairy Research Institute, Karnal were analyzed to study the effect of genetic and non-genetic factors on various lactation traits. Data were collected from the history-cum-pedigree sheets and monthly record of milk yield and fat percentage register. The traits considered were FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS%. Culling in the middle of lactation, abortion, still-birth or any other pathological causes affecting the lactation yield were

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considered as abnormalities and thus, such records were not taken for the study. Normal lactation was considered as the period of milk production by buffalo for at least 100 days and has given minimum 500 kg of milk. To ensure the normal distribution, the outliers were removed, and data within the range of Mean ± 3 Standard Deviation were only considered for the present study.

The data were analyzed to study the effect of genetic and non-genetic factors (period, month group and service period) on the considered traits. The data were classified into different periods and month groups. Each year was divided into 3 month groups on the basis of rainfall, temperature and humidity over the years – month group1 (April - July); month group 2 (August-November); and month group 3 (December-March). The data spread over 20 years (1993-2013) were classified into 9 periods. Fat percentage was determined by Lacto Star apparatus (German equipment produced by Funke Gerber). For calibration of Lacto Star apparatus, fat percentage of milk was tested by Gerber method (1977).

Statistical methods: The data were analyzed using a mixed model least-squares analysis for fitting constants (Harvey, 1990) to overcome the difficulty of disproportionate sub class number and non-orthogonality of data. The following models were used for different traits:

For FLMY305, LFY, LSNFY and LTSY:

$$Y_{ijkn} = \mu + S_i + P_j + M_k + b(SP_{ijk} - SP) + e_{ijkl}$$

For Fat%, SNF% and TS%:

$$Y_{ijkl} = \mu + S_i + P_j + M_k + e_{ijkl}$$

Where, Y_{ijkl} is l^{th} observation under k^{th} month-group, j^{th} period and i^{th} sire; ì is overall mean; S_i : effect of i^{th} sire; P_j : effect of j^{th} period; M_k : effect of k^{th} month group; $b(SP_{ijk} - SP)$: Service period as covariate; e_{ijkl} : Random error ~ NID (0, σ^2_e)

Estimation of heritability: Paternal half-sib correlation method (Becker, 1975) was used to estimate the heritability of different traits and their genetic correlations. The sires having three or more number of progenies were included for the estimation of heritability. The data adjusted for significant effects of non-genetic factors was utilized for estimation of heritability. The standard error of heritability was estimated as per Swiger *et al*. (1964).

Genetic and phenotypic correlations: The genetic and phenotypic correlations among FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% traits were calculated from the analysis of variance and covariance among sire groups as given by Becker (1975).

RESULTS AND DISCUSSION

The least squares means along with their standard errors for different traits are presented in Table 1. The overall least squares means for FLMY305 was 1977.9±36.2 kg. Similar findings were reported by Singh *et al.* (1990) and Dass *et al.* (2000) in Murrah buffaloes. On contrary, lower estimates ranging from 1600 to 1860 kg were reported by Dass and Sharma (1994), Kuralkar (1997), Chakraborty *et al.* (2010) and Singh *et al.* (2011) whereas Jain (2009) and Kumar *et al.* (2015) reported higher values of FLMY305 in Murrah buffaloes. Period and month-group of calving had significant effect on FLMY305. The significant effect of month-group of calving was in agreement with the results obtained by Lathwal (2000) and Sahoo (2014) in Murrah buffaloes. The significant differences in milk yield among animals calved in different periods may be attributed to differences in management, selection of sires and different environmental conditions. Several workers (Sahoo, 2014; Ratwan *et al*., 2015; Ratwan *et al*., 2016 and Kumar *et al*., 2016) also reported significant effect of period of calving on different lactation traits in buffaloes as well as cattle.

The overall least squares means of LFY was found to be 151.17±2.76 kg in our study. On contrary, Sarkar (2002) found lower and Kumar *et al*. (2016) reported higher estimates of LFY in Murrah buffaloes. The overall least squares means of Fat % was 7.89±0.02 % in the present study. The results obtained were in agreement with the findings of Sarkar (2002) and Verma (2012). However, several workers (Sharma *et al.,* 1980; Pandey *et al.,* 1986 and Bhonsle, 2003) found slightly lower estimates as compared to present study.

The overall least squares means of LSNFY was found to be 185.06±3.37 kg. Sarkar (2002) reported lower estimates but Kumar *et al.* (2015) found higher estimates as compared to our findings in Murrah buffaloes. The overall least squares means for SNF% was estimated as 9.65±0.07 %. The results obtained in this study were comparable with other findings (Ghosh and Anantkrshnan, 1964; Sarkar, 2002 and Verma, 2012). The estimates were slightly higher than those reported by Sharma *et al.* (1980) and Dubey *et al.* (1997) and slightly lower than those reported by Hatwar (1986).

Table 1: Overall least-squares mean of FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% traits in Murrah buffaloes.

Traits	Overall mean
FLMY305	1977.9±36.2 kg
LFY	151.2±2.7 kg
LSNFY	185.5±3.4 kg
LTSY	336.2±6.1 kg
FAT%	7.89±0.02 %
SNF%	9.65±0.01 %
TS%	17.54±0.03 %

FLMY305 (kg) = first lactation 305 milk yield; LFY (kg) = first lactation 305 fat yield; LSNFY (kg) = first lactation 305 solid not fat yield; LTSY (kg) = first lactation 305 total solid yield; FAT (%) = 305 fat percentage; SNF (%) = 305 solid not fat percentage; TS (%) = 305 total solid percentage.

Table 2: Least-squares analysis of variance (MS value) of FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% traits in Murrah buffaloes.

Source of variation	d.f.	FLMY305	LFY	LSNFY	LTSY	FAT%	SNF%	TS%
Sire	46	298144.1*	1741.57*	2592.91*	8533.91*	0.245	0.010	0.229
Period	8	591923.2**	3523.19**	5188.68**	17174.09**	0.701**	0.124**	1.160**
Month-gp	2	701981.9*	4439.33*	6344.67*	21343.95*	0.099	0.005	0.084
Reg. on SP	1	1369908.6**	8761.54**	12487.21**	42167.39**			
Residual	257	200577.3	1175.54	1742.51	5722.79	0.226	0.007	0.264

* Significant at p<0.05; ** Significant at p<0.01.
d.f. = degree of freedom; FLMY305 (kg) = first lactation 305 milk yield; LFY (kg) = first lactation 305 fat yield; LSNFY (kg) = first lactation 305 solid not fat yield; LTSY (kg) = first lactation 305 total solid yield; FAT (%) = 305 fat percentage; SNF (%) = 305 solid not fat percentage; TS (%) = 305 total solid percentage.

The overall least squares means of LTSY was found to be 336.23±6.12 kg in present study. The estimates obtained were slightly lower than the estimates as reported by Sarkar (2002). However, Kumar *et al.* (2015) found higher estimates for LTSY in Murrah buffaloes. The overall least squares means of TS% was 17.54±0.03 % and was comparable to the findings as reported by Sarkar (2002) and slightly higher than the values reported by Pandey *et al.* (1986) and Dubey *et al.* (1997).

Analysis of variance showed that effect of sire on lactation average milk constituents percentage was found to be non-significant but found to be significant for all milk constituents yield traits (p<0.05) as presented in Table 2. The effect of month-group of calving was non-significant for milk constituent traits but significant for yield traits (p<0.05). The non-significant effect of month-group of calving was in agreement with the findings of Sarkar (2002) but contrary to the findings of Pandey *et al.* (1986) and Dubey *et al.* (1997). The period of calving had significant effect on both milk constituents and their yield traits (p<0.01) whereas, Sarkar (2002) reported non-significant effect of period of calving on fat percentage. The effect of service period was found to be significant for FLMY305, LFY, LSNFY and LTSY.

Genetic and phenotypic parameters: Heritability, genetic correlations and phenotypic correlations for first lactation traits were estimated by paternal half-sib correlation method and are shown in Table 3 and 4. The heritability estimates were 0.30±0.18, 0.29±0.08, 0.30±0.18, 0.30±0.18, 0.05±0.15, 0.02±0.17 and 0.06±0.15 for FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS%, respectively. The heritability estimates for FLMY305, LFY, LSNFY, LTSY traits indicated that these traits could be improved through selection. The heritabilities for FAT%, SNF% and TS% were either very low or had high standard error. The high standard errors of heritability could be attributed to smaller number of observations spread over a number of years and less number of progenies per sire.

Table 3: Heritability estimates of FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% traits in Murrah buffaloes.

Traits	Heritability
FLMY305	0.30±0.18
LFY	0.29±0.08
LSNFY	0.30±0.18
LTSY	0.30±0.18
FAT%	0.05±0.15
SNF%	0.02±0.17
TS%	0.06±0.15

FLMY305 (kg) = first lactation 305 milk yield; LFY (kg) = first lactation 305 fat yield; LSNFY (kg) = first lactation 305 solid not fat yield; LTSY (kg) = first lactation 305 total solid yield; FAT (%) = 305 fat percentage; SNF (%) = 305 solid not fat percentage; TS (%) = 305 total solid percentage.

Table 4: Estimates of genetic and phenotypic parameters of FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% traits in Murrah buffaloes.

Traits	FLMY305	FAT%	SNF%	TS%	LFY	LSNFY	LTSY
FLMY305	**0.30**	-0.28	-0.03	-0.27	0.97**	0.99**	0.99**
FAT%	-0.36	**0.05**	0.50**	0.96**	0.134**	-0.043	0.03
SNF%	0.014	0.25**	**0.02**	0.65**	0.065**	-0.005	0.02
TS%	-0.28	0.90**	0.65**	**0.06**	0.13**	-0.039	0.038
LFY	NE	-0.47	0.02**	-0.35	**0.29**	0.982**	0.995**
LSNFY	0.99	-0.34	0.06**	-0.24	NE	**0.30**	0.996**
LTSY	NE	-0.40	0.04**	-0.29	NE	NE	**0.30**

Diagonal values indicate heritability; Lower diagonal values indicate genetic correlation; Upper diagonal values indicate phenotypic correlation. * Significant at p<0.05; ** Significant at p<0.01.
FLMY305 (kg) = first lactation 305 milk yield; LFY (kg) = first lactation 305 fat yield; LSNFY (kg) = first lactation 305 solid not fat yield; LTSY (kg) = first lactation 305 total solid yield; FAT (%) = 305 fat percentage; SNF (%) = 305 solid not fat percentage; TS (%) = 305 total solid percentage.

Phenotypic correlation of FLMY305 with milk constituent yield traits *viz*. LFY, LSNFY, LTSY were 0.97±0.001, 0.99±0.0001 and 0.95±0.0003, respectively. This implies that selection for FLMY305 will be quite effective for improvement of LFY, LSNFY and LTSY. The genetic correlations of FLMY305 were low with milk constituent percentage traits and non estimable with milk constituent yield traits. The negative but non-significant genetic and phenotypic correlations of FLMY305 with milk constituent traits (FAT%, SNF% and TS %) revealed that selection for FLMY305 will have little effect on these traits. The reported estimates of phenotypic correlations among milk yield and milk constituents ranged from -0.54 (Ferrer *et al.,* 1966) to 0.379 (Sarkar, 2002) for first lactation milk yield with fat percentage and 0.027 (Sarkar, 2002) to 0.09 (Schneider *et al.,* 1948) for first lactation milk yield with SNF percentage. Sarkar (2002) reported positive and significant phenotypic correlation among milk yield and all yield traits (LFY, LSNFY and LTSY). The reported estimates of genetic correlation ranged from -0.19 (Aspilcueta-Borquis *et al.,* 2010) to -0.64 (Sarkar, 2002) and -0.80 (Sarkar, 2002) to 0.76 (Pal *et al.,* 1971) among milk yield and fat percentage in buffaloes.

CONCLUSION

In the present study, analysis of variance showed that the effect of sire was significant ($p<0.05$) on all milk constituent yield traits whereas for lactation average milk constituent percentage it was found to be non-significant. The effect of month-group of calving was significant for yield traits ($p<0.05$) but was non-significant for milk constituent traits. The period of calving had significant effect on both milk constituents and their yield traits ($p<0.01$) and the effect of service period was found to be significant for FLMY305, LFY, LSNFY and LTSY. The h^2 estimates of FLMY305, LFY, LSNFY, LTSY, FAT%, SNF% and TS% were 0.30, 0.29, 0.30, 0.30, 0.05, 0.02 and 0.06, respectively. Moderate heritability estimate of FLMY305 (0.30) along with its high phenotypic correlations with milk constituent yield traits suggests that selection for FLMY305 would be effective for improvement of milk constituent yield traits without affecting the milk constituent % traits. High phenotypic correlations among the milk constituent yield traits indicated that improvement in one trait would be associated with positive desirable improvement in other traits.

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