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Genetic evaluation of some first lactation traits in Murrah buffaloes

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ABSTRACT

A study was conducted for studying the inheritance pattern of some first lactation traits in Murrah buffaloes. Data on 577 Murrah buffaloes maintained at the farms - Firozpur, Ambala, Jallandhar, Jhansi, Lucknow, Bareilly, Agra and Pantnagar spread over 34 years was used. The traits considered were age at first calving (AFC), first calving interval (FCI), first lactation milk yield (FLMY), first lactation period (FLP), weight at first calving (FCI) and first service period (FSP). The heritability estimates (h^2±S.E) for AFC, FCI, FLMY, FLP, WFC and FSP traits were found to be 0.40±0.15, 0.14±0.10, 0.31±0.14, 0.23±0.12, 0.36±0.13 and 0.06±0.0, respectively. The genetic and phenotypic correlations revealed that selection for lower age at first calving and higher lactation milk yield can be used as a selection criterion for the genetic improvement in Murrah buffaloes.

Keywords: First lactation milk yield, Production traits, Reproduction traits

The dairy industry in India has its prime role in the socio-economic development of the rural mass. Presently, national, and international players are entering the dairy sector. The milk processing industry is expected to expand at CAGR of about 15% between the financial year 2018 to 2023. Buffaloes are the major contributor to the total share of milk production from different species. India possesses 17 registered breeds of buffaloes, which contribute significantly to the total milk production in India. Murrah has been a preferred breed of buffalo in different parts of the country.

Genetic improvement is an ongoing requirement for the breed and prime objective of an animal breeder is making genetic improvement in the next generation from the existing animal population of any breed. Based on the study of performance of the animals, heritability of different economic traits, and genetic and phenotypic correlations among these traits, the ways, and policies of selecting the better animals and better breeding strategies/plans could be formulated. Considering the above points in view, an investigation was planned for studying the inheritance pattern of some first lactation traits in the case of Murrah buffaloes utilizing the data maintained at different farms in India.

MATERIALS AND METHODS

The data on 577 Murrah buffaloes were used for studying the inheritance pattern of the traits viz. age at first calving (AFC), first calving interval (FCI), first lactation milk yield (FLMY), first lactation period (FLP), weight at first calving (FCI) and first service period (FSP). The daughters of 68 sires were located at seven military dairy farms and one Instructional Dairy farm, viz. Ferozepur, Ambala, Jalandhar, Jhansi, Lucknow, Bareilly, Agra and Pantnagar, and were distributed over 34 years (1960–1993). The data were divided into five periods of seven years each and three seasons, viz. rainy (July–October), winter (November–February), and summer season (March–June). The 300-day milk yield (FLMY) was obtained by regressing the first lactation yield on lactation period and age at first calving. The computed regression coefficient of lactation milk yield on lactation period and age at first calving was used for standardizing the yield on a 300-day basis according to the formula:

$$\text{300-day milk yield} = \text{Actual milk yield} - (b_1N + b_2M)$$

where b_1, regression of actual milk yield on lactation period; b_2, regression of actual milk yield on age at first calving = lactation period – 300 days, and M, age at first calving (months) – the average age at first calving (months).

The data were adjusted for the non-orthogonal nature of data for different factors like farm, period, and season. The Mixed Model Least-Squares and Maximum Likelihood Programme (LSMLMW) of Harvey (1990) was used for analyzing the data.

The model used for computing the least squares means utilizing the data on dams for first lactation traits was

$$Y_{ijkl} = \mu + Fi + P_j + S_k + e_{ijkl}$$

where Y_{ijkl}, observation of l^{th} individual belonging to k^{th} season, j^{th} period and i^{th} farm; μ, population mean; F_i, effect

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of ith farm (i = 1,2,…, 9 for dams); P_j, effect of jth period (j = 1,2,…, 6 for dams); S_k, effect of kth season (k=1, 2, 3), and e_{ijkl}, random error assumed to be normally distributed with mean zero and variance, σ^2_e, i.e. NID (0, σ^2_e).

Sire and residual variance and covariance components were estimated by Henderson (1973). In this method, the sum of squares associated with various lines of analysis of variance (ANOVA) tables are equated to their expectations and resulting equations are solved for the unknown variance-covariance components. The estimates of variance and covariance from the use of the method are unbiased and translation invariant. The estimation of variance and covariance components were utilized for computing the genetic and phenotypic correlations among different economic traits as well as for estimating the heritability for different traits as follows:

$$\text{Heritability } (h^2) = \frac{\frac{1}{NR1} \times \sigma^2_s}{\frac{(1-NW)}{NR1} \times \hat{\sigma}^2_s + \hat{\sigma}^2_e}$$

where $\hat{\sigma}^2_e$, error variance component; $\hat{\sigma}^2_s$, sire component of variance. NR1, decimal percentage of additive genetic variance in $\hat{\sigma}^2_s$ and NW, decimal percentage of additive genetic variance in $\hat{\sigma}^2_w$. NR1 is between variance component and is equal to 0.25 and NW is within variance component and is equal to 0.75.

Estimation of genetic and phenotypic correlations: The genetic correlation among first lactation traits have been computed using sire components of variance and covariance (Becker 1964) as per the following:

$$r_{g(hh)} = \frac{Cov_{s(hh)}}{\sqrt{\left[\hat{\sigma}^2_{s(h)} . \hat{\sigma}^2_{e(h)}\right]}}$$

The phenotypic correlation coefficient between first lactation traits in the present work has been computed by using sire and error components of variance and covariance as follows, where, cov_s, is sire or family covariance; h, refers to h^2 traits and h' refers to another trait, respectively.

$$r_p(hh') = \frac{\hat{\sigma}^2_e(hh') + \left[\left(\frac{(1-NW)}{NR1}\right)\hat{\sigma}^2_s(hh')\right]}{\sqrt{\left\{\hat{\sigma}^2_e(h) + \left[\frac{(1-NW)}{NR1}\right]\hat{\sigma}^2_s(h)\right\}\{\ \}\left\{\hat{\sigma}^2_e(h') + \left[\frac{(1-NW)}{NR1}\right]\hat{\sigma}^2_s(h')\right\}}}$$

The $\hat{\sigma}^2_s$, is among variance or covariance components, and $\hat{\sigma}^2_e$, is within variance or covariance components. The standard error of heritability has been calculated by the relation as suggested by Swiger *et al.* (1964).

$$S.E.(h^2) = 4\sqrt{\frac{2(N-1)(1-t)^2(1+(k-1)t)^2}{k2(N-s)(s-1)}}$$

Where N, total number of observations; s, number of sires; t, intra class correlation between paternal half-sib $= \frac{\sigma^2_s}{\sigma^2_s + \sigma^2_w}$, and k, average number of progenies per sire.

Table 1. Heritability estimates along with standard errors of first lactation traits

Trait	h^2±S.E.
Age at first calving	0.40±0.15
First calving interval	0.14±0.10
First lactation milk yield	0.31±0.14
First lactation period	0.23±0.12
Weight at first calving	0.36±0.13
First service period	0.06±0.09

The standard errors of genetic correlation coefficients were estimated according to the formula suggested by Robertson (1959).

$$(S.E.).r_g(hh') = \frac{1-r_g^2(hh')}{\sqrt{2}}\sqrt{\frac{(S.E.).h^2_{(h)}.(S.E.).h^2_{(h')}}{h^2_{(h)}.h^2_{(h')}}}$$

where $(S.E.).r_{g(hh')}$, standard error of genetic correlation of the subscripted characters; $(S.E).h^2_{(h)}$, and $(S.E).h^2_{(h')}$, standard errors of h^2 of the subscripted characters; and $h^2_{(h)}$ and $h^2_{(h')}$, heritability of subscripted characters.

The standard errors of the phenotypic correlation coefficient have been determined as per the method described by Panse and Sukhatme (1967), is given below.

$$(S.E.).r_p(hh') = \frac{\sqrt{\left[1-r_p^2(hh')\right]}}{\sqrt{(N-2)}}$$

where $r_{p(hh')}$, phenotypic correlation between h and h′ traits based on the sire, and N, total number of observations. The significance of the phenotypic correlation is tested from the table of Snedecor and Cochran (1967) at (N-2) degrees of freedom.

RESULTS AND DISCUSSION

The present investigation was undertaken by using data on 577 Murrah buffaloes. The heritability estimates for different traits are shown in Table 1 and correlations among different traits are shown in Table 2.

Heritability of first lactation traits: The heritability estimates along with their standard errors of age at first calving (AFC), first calving interval (FCI), first lactation milk yield (FLMY), first lactation period (FLP), weight at first calving (WFC) and first service period (FSP) are given in Table 2. The heritability values of FCI, FLP, and FSP traits were reported as 0.14±0.10, 0.23±0.12, and 0.06±0.09, respectively. These results agreed with the report of Singh (1995), Kumar (1998), Thevamanoharan *et al.* (2000), Tewari *et al.* (2020), Thevamanoharan *et al.* (2002), and Kour and Narang (2021).

The lower magnitude of heritability was also reported by Sachan *et al.* (2005) for FCI and FLP traits and Warade *et al.* (2005) for FCI and FSP traits. Khan *et al.* (1996), Yadav *et al.* (2002), and Warade *et al.* (2005) estimated a higher value of heritability for the FLP trait. The lower magnitude of heritability of the FLP trait indicated the low genetic variance and most of the variation in the phenotypic

Table 2. Genetic and phenotypic correlations among first lactation traits

Trait	AFC		FCI		FLMY		FLP		WFC	
	r_G	r_P	r_G	r_P	r_G	r_P	r_G	r_P	r_G	r_P
FCI	0.26± 0.29	–0.009± 0.04								
FLMY	–0.39± 0.15	–0.12± 0.04*	0.32± 0.33	0.27± 0.04**						
FLP	0.04± 0.23	–0.10± 0.04*	0.64± 0.22	0.42± 0.03**	0.39± 0.21	0.58± 0.03**				
WFC	–0.68± 0.22	0.16± 0.04*	0.31± 0.03	–0.03± 0.04	0.38± 0.20	0.08± 0.04	0.77± 0.10	–0.02± 0.04		
FSP	0.24± 0.41	–0.009± 0.04	1.02± 0.01	0.97± 0.003**	0.30± 0.42	0.31± 0.03**	0.76± 0.13	0.50± 0.03**	–0.31± 0.35	0.03± 0.04

*, P<0.05; **, P<0.01; AFC, Age at first calving; FCI, First calving interval; FLMY, First lactation milk yield; FLP, First lactation period; WFC, Weight at first calving, and FSP, First service period.

expression was due to the environmental variance. So, there is a scope for the improvement of the trait by providing a better environment and management conditions. The heritability estimates of FCI and FSP indicated the very low additive genetic variance for the traits which do not hold much promise for improving these traits through direct selection. The reduction in the first service period and desirable calving interval should be brought about through planned management. Proper attention must be given proper management of buffaloes, right from the date of calving and buffaloes should be managed to optimum level of feeding and be provided optimum health control measures.

The heritability estimates of AFC, FLMY, and WFC traits were reported as 0.40±0.15, 0.31±0.14, and 0.36±0.13. Raheja (1992), Dutt and Taneja (1994), Dass and Sadana (2000) and Dutt *et al.* (2001) for AFC and FLMY and Singh (1995) for WFC also reported similar estimates. However, the lower magnitude of heritability was reported by Khan *et al.* (1996) for AFC and FLMY, Kuralkar and Raheja (1997) for AFC and FLMY, Kumar (1998) for AFC and WFC, Jain and Sadana (2000) for AFC and FLMY, Thevamanoharan *et al.* (2000) for AFC and FLMY, Singh (2001) for AFC, FLMY, and WFC, and Thevamanoharan *et al.* (2002) for AFC and FLMY traits. Tein and Tripathi (1990) reported higher estimates of heritability for AFC and WFC traits.

The moderate value of heritability suggested that the buffaloes could be selected for these traits due to the presence of additive genetic variance. These traits may also be considered in combination with other important traits for better evaluation of animals in herds.

Correlation among first lactation traits: A phenotypic correlation is the correlation between records of two traits on the same animal and is usually estimated by the product-moment correlation statistic. The genetic correlation, on the other hand, is the correlation between an animal's genetic value for one trait and the same animal's genetic value for the other trait. The association at a genetic and phenotypic level among AFC, FCI, FLMY, FLP, WFC, and FSP traits are presented in Table 2.

The AFC trait was positively correlated with FCI, FLP, and FSP traits, whereas AFC was negatively correlated with FLMY and WFC traits at the genetic level. The positive magnitude of genetic correlation was also reported by Jain and Sadana (2000), Singh (2001) and Badran *et al.* (2005) between AFC and FCI, Kumar (1998) and Singh (2001) between AFC and FLP, and Jain and Sadana (2000), Saha and Sadana (2000) and Badran *et al.* (2005) between AFC and FSP traits. These results indicated that AFC can be used as a selection criterion for milk production.

The phenotypic correlation of the AFC trait with all the first lactation traits was negative except the trait WFC. However, the correlation of the AFC trait with FCI, FLP, and FSP traits was found to be non-significant. The correlations of AFC with FLMY, FLP, and WFC traits were found to be significant. Kornel and Patro (1988) also found non-significant phenotypic correlations of AFC with FCI, FLMY, and FLP traits. Dhama *et al.* (1991) reported a significant association of AFC with FCI, FLMY, and FLP traits at the phenotypic level. These results indicated that higher AFC would decrease FLMY and WFC because of not so good physiological maturity of the buffaloes at higher ages.

The genetic and phenotypic correlations among FCI, FLMY, FLP, and WFC traits were positive except phenotypic correlations between FCI and WFC, FLP and WFC, and genetic correlation between WFC and FSP traits. The values of phenotypic correlations between FCI and FLMY, FCI and FLP, FCI and FSP, FLP and FLMY, FSP and FLMY, and FLP and FSP were found positive and significant. The longer FCI was associated with higher FLP and FLMY. The report of Thevamanoharan *et al.* (2000) and Singh (2001) agreed with the present results. However, a negative magnitude of genetic correlation was reported by Kornel and Parto (1988) between FCI and FLP traits.

The buffalo with longer FSP might have taken longer FCI. This result is in close conformity with the report of Badran *et al.* (2005). The positive estimate between FLP and FLMY indicated that selection for buffalo having a higher FLMY would lead to longer FLP since both traits were affected by the set of genes. The observed relationship between FLP and FLMY in the present study is in close conformity with the reports of Kumar (1998), Thevamanoharan *et al.* (2000), and Roshanfekr (2005). The buffaloes that lactate higher FLMY took a longer time to conceive and then resulted in longer FSP. A similar finding was also given by Raheja (1992) and Kumar (1998). The buffaloes having high WFC had longer FCI at the genetic and phenotypic levels. Singh (2001) and Badran *et al.* (2005) also reported a similar association of WFC with FCI. The buffaloes with higher FCI lactated for longer FLP. The reports of Tein and Tripathi (1990) and Singh (1995) were following the present results. However, a negative magnitude of genetic correlation was reported by Kumar (1998) and Singh (2001) between WFC and FLP traits. The buffaloes with higher WFC have taken less time to conceive. Kumar (1998) and Badran *et al.* (2005) also found a negative genetic correlation of WFC with FSP traits. While, Singh (1995) found a positive correlation between these two traits.

Therefore, it is concluded that the heritability estimates along with their standard errors for age at first calving (AFC), first calving interval (FCI), first lactation milk yield (FLMY), first lactation period (FLP), weight at first calving (WFC) and first service (FSP) traits were found to be 0.40±0.15, 0.14±0.10, 0.31±0.14, 0.23±0.12, 0.36±0.13 and 0.06±0.09, respectively. The low estimates of heritability for FCI and FSP do not hold much promise for improving these traits through direct selection. The moderate value of heritability for AFC, FLMY, and WFC suggested that the buffaloes could be selected for these traits. The genetic and phenotypic correlations indicated that selection for lower age at first calving and higher lactation milk yield can be used as a selection criterion for the genetic improvement in the herd. The buffaloes having higher weight at first calving had longer first calving interval, lactated for a longer period, and conceived earlier.

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