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Genetic evaluation of production performance traits in Murrah buffaloes

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Abstract
The present study was conducted to evaluate the effect of non-genetic factors and estimate the genetic parameter of production performance traits {305 days or less milk yield (305MY), Peak yield (PY), Persistency (PR), Milk yield per day of lactation length (AMY), Milk yield per day of first calving interval (MCI) and Milk yield per day at age of second calving (MSC)} in Murrah buffaloes. The records pertaining to the first lactation of 396 buffaloes, the progeny of 82 sires; calved during the year 1995-2018 and maintained at Buffalo research centre, LUVAS, Hisar were analysed by using a mixed technique of Harvey model. The overall least-squares mean for 305MY, PY, PR, AMY, MCI and MSC were 2128.37±34.43 kg, 10.81±0.11 kg, 206.48 ±3.16, 6.95±0.08 kg/day, 4.80±0.09 kg/day and 1.22 ±0.02 kg/day, respectively. Period of calving had a significant effect on 305MY, PY, AMY, MCI and MSC. Linear regression of Age at first calving had a significant effect on PY, AMY and MSC. The heritability estimates 305MY, PY, PR, AMY, MCI and MSC were found to be 0.33±0.18, 0.33±0.18, 0.22 ±0.17, 0.26±0.18, 0.44±0.19 and 0.30±0.18 respectively. The observed genetic correlation and phenotypic correlation were positive among all traits, which varied from 0.13 ±0.52 (PR with AMY) to 0.94 ±0.02 (305MY with MSC) and 0.18 ±0.05 (PR with AMY) to 0.96 ±0.04 (305MY with MSC). The correlations of MCI and MSC with other traits are observed as high and positive, indicated that selection based on MCI and MSC simultaneously would improve other traits in Murrah buffaloes. The present study suggested that MCI and MSC may be the best trait to be taken into selection criteria for improvement of milk production in Murrah buffaloes.

Keywords: Murrah buffalo, production performance traits, non-genetic factors and genetic parameter

Introduction
Murrah is one of the best breed of buffaloes in the world by its milk-producing capacity with high potential for further genetic improvement. This breed is predominantly found in Haryana and adjoining states of Punjab, UP and Delhi. India with its 109.85 million heads of buffalo as reported in 20th livestock census 2019 has the largest buffalo population in the world. Owing to its potential, it has a shorter productive period in terms of milk and a longer unproductive life with more extended inter calving period and age at first calving. The situation gets more complicated when the environment becomes harsh and non-supportive for utilization of animal fullest capability in term of milk production. The economic value of animal depends upon the production and reproduction activity of the animal. However, many authors reported antagonistic genetic and phenotypic correlations between production and reproduction of the animal (Kumar *et al.* 2000, Dhaka *et al.* 2002 and Suresh *et al.* 2004) [12, 13, 22]. To gain a simultaneous improvement in productive and reproductive traits, it will be useful to utilise a practical measure that combines these traits that and new combined trait represents the overall efficiency of an animal. Evaluation of the genetic value of production performance traits requires knowledge of several genetic parameters so that suitable breeding schemes can be developed for the improvement of this species. The present study was planned to determine the influence of Period of calving, Season of calving and Age at first calving on several production performance traits of Murrah buffaloes maintained at an organised farm. The impact of any selection programme depends upon the degree of accuracy of selection and genetic correlation among production performance traits. It, therefore, becomes crucial to know the genetic and phenotypic association among these traits and the extent to which the genetic variation being in them for deciding appropriate selection and mating procedures.

Materials and Methods

The data from history and pedigree sheets on certain production performance traits obtained from 398 Murrah buffaloes born to 82 sires at Buffaloes Research Centre, Hisar for 24 years (1995-2018) were obtained. The data was recorded from the first lactation on all animals which were milked more than 150 days in the herd. Records on 305 days or less milk yield (305MY), Peak yield (PY), Persistency (PR), Milk yield per day of lactation length (AMY), Milk yield per day of first calving interval (MCI) and Milk yield per day at age of second calving (MSC) were analysed to estimate the effect of Period of calving, season of calving and regression of age at first calving by using a mixed model technique of Harvey (1990) [7]. The duration of twenty-four years was divided into six periods, viz. period 1 (1995-1998), period 2 (1999-2002), period 3 (2003-2006), period 4 (2007¬2010), period 5 (2011-2014) and period 6 (2015-2018). Every year was further divided into four seasons viz., summer (April-June); rainy (July-September); autumn (October-November) and winter (December-March). The mixed statistical model used to explain the biology of the various performance traits in the study was:

$$Y_{ijkl} = \mu \pm S_i \pm h_j + c_k + b_1(A_{ijkl} - \bar{A}) + b_2(A_{ijkl} - \bar{A})^2 + e_{ijkl}$$

Where, Y_{ijkl} = i^{th} record of individual pertaining to i^{th} sire calved in j^{th} Period and k^{th} season; μ = is the overall population mean; S_i = is the random effect of i^{th} sire; h_j = is the fixed Effect of j^{th} Period of calving; c_k = is the fixed effect of k^{th} season of calving; b_1&b_2 = are linear and quadratic partial regression coefficients of age at first calving on trait(s), respectively; A_{ijki} = is the age at first calving; $\bar{A}$ = is the mean for age at first calving; e_{ijkl} = is the random error associated with each observation and assumed to be normally and independently distributed with mean zero and variance σ^2 e

Considering the presence of non-orthogonality in the data, arising due to unequal subclasses frequencies, a computer program of Least-Square Maximum Likelihood "Harvey (1990) [7]" using Henderson's Method III (Henderson, 1973) [8] was utilised to evaluate the effect of different non-genetic factors on production performance traits and to estimate genetic and phenotypic parameters. The difference of means between subclasses of seasons, periods and age group were tested for significance using Duncan's Multiple Range Test (DMRT) as given by Kramer (1957) [11]. The standard error of phenotypic correlations was calculated by using the formula given by Snedecor and Cochran (1994) [21]. The significance of phenotypic correlations was tested by't' test as given by Snedecor and Cochran (1994) [21].

Results and Discussion

The overall least-squares mean for 305MY in the present study was 2128.37 ±34.43 kg. Chakraborty *et al.* (2010) [2], Thiruvenkadan (2011) [24], Gupta *et al.* (2012) [6], Singh and Barwal (2012) [20], Patil *et al.* (2012) [16], Sahoo *et al.* (2014) [19], Chaudhari (2015) [3], Chitra *et al* (2015), Panday *et al* (2016), Jakhar *et al* (2016) [9], Jamuna *et al* (2016) and Kumar *et al* (2016) [14] obtained lower value for the 305MY then present study while Pawar *et al.* (2012) [18] found higher value. The effect of the Period of calving was found to be significant (p<0.01) on 305MY. However, Sahoo *et al.* (2014) [19], Chitra *et al* (2015), Panday *et al* (2016), Jakhar *et al* (2016) [9], Jamuna *et al* (2016) found Significant effect of period of calving on 305MY. In this present investigation, the effect of season of calving on 305MY was non-significant. Similar non-significant effect of season of calving on 305MY was reported by Jakhar *et al* (2016) [9], Jamuna *et al* (2016) and Kumar *et al* (2016) [14]. However, Sahoo *et al.* (2014) [19], Panday *et al.* (2015) and Chitra *et al* (2016) [4] reported significant effect of season of calving on 305MY. The Effect of Linear and quadratic regression of age at first calving was non-significant on 305MY. Similar Effect of Period, season and age of calving on 305MY was reported by Patil, *et al.* (2012) [16].

The overall least-squares mean for PY was 10.81 ±0.11 kg/day in the present study which was similar to the findings of Patil *et al.* (2018) [17], Chakraborty *et al.* (2010) [2] in Murrah buffaloes. Kumar (2000) [12, 13], Kumar *et al* (2005) [15], Dev *et al.* (2015) [5], Thiruvenkadam (2011) [24], Thiruvenkadan *et al.* (2014) [25] and Chaudhari (2015) [3], found lower values while Tanpure *et al.* (2013) [23] reported higher values for PY in Murrah buffaloes. The effect of the Period of calving on PY was found to be significant (p<0.01). Thiruvenkadan (2011) [24] and Dev *et al.* (2015) [5] also reported significant Effect of Period of calving on PY in Murrah buffaloes; while Patil *et al.* (2018) [17] and Chakraborty *et al.* (2010) [2], found a non-significant effect of Period of calving on PY in Murrah buffaloes. The non-significant effect of season of calving on PY was obtained under the present study. Chakraborty *et al.* (2010) [2], Patil *et al.* (2018) [17] and Dev *et al.* (2015) [5] also reported non-significant of the season of calving on PY. However, Thriuvenkadan (2011) [24] found significant effect of season of calving on PY. The contents of Table 1 revealed that the effect of the linear regression of age at first calving was significant (p<0.05) on PY, while the quadratic regression was non- significant. While Dev *et al.* (2015) [5] and Chakraborty *et al.* (2010) [2], observed non-significant effect of both linear and quadratic regression on PY

Table 1: Analysis of variance for various production performance traits

Source of Variation	D.F.	Mean Squares					
		3005MY	PY	PR	AMY	MCI	MSC
Sire	81	230042.44	2.25	2001.90	1.32	1.48	0.10
Period	5	2077762.22**	40.56**	2518.19	21.30**	7.21**	0.66**
Season	3	235839.65	2.60	1654.57	0.43	1.52	0.084
Regressions							
AFC (Linear)	1	166979.81	9.33*	1755.29	5.37*	1.97	3.07*
AFC (Quad)	1	3009.37	0.37	351.95	0.079	0.15	0.14
Remainder	304	164350.71	1.61	1579.55	1.01	0.95	0.07
*P<0.05; **P<0.01							

Table 2: Least Squares Means with standard errors for various Production Performance traits

Effects		Obs	Least Sq. Means ± S.E.					
			305MY (kg)	**PY (kg)**	**PR**	**AMY (kg/day)**	**MCI (kg/day)**	**MSC (kg/day)**
Over All Means		396	2128.37 ±34.43	10.81 ±0.11	206.48 ±3.16	6.95 ±0.08	4.80 ±0.09	1.22 ±0.02
Period of Calving	1995-1998	33	1722.94^{c} ±130.47	9.68^{b} ±0.41	181.87 ±12.73	5.62^{b} ±0.32	3.95^{b} ±0.32	0.97^{b} ±0.09
	1999-2002	51	2060.25^{b} ±85.28	10.53^{b} ±0.27	214.22 ±8.28	6.48^{b} ±0.21	4.65^{b} ±0.21	1.20^{b} ±0.06
	2003-2006	79	1864.44^{bc} ±80.32	9.86^{b} ±0.25	201.42 ±7.78	6.25^{b} ±0.20	4.39^{b} ±0.20	1.08^{b} ±0.05
	2007-2010	83	1903.94^{bc} ±77.14	9.16^{b} ±0.24	216.02 ±7.47	6.27^{b} ±0.19	4.35^{b} ±0.19	1.09^{b} ±0.05
	2011-2014	82	2559.18^{a} ±85.34	12.29^{a} ±0.27	213.36 ±8.28	8.54^{a} ±0.21	5.60^{a} ±0.21	1.44^{a} ±0.06
	2015-2018	68	2659.47^{a} ±130.15	13.35^{a} ±0.41	211.96 ±12.70	8.54^{a} ±0.32	5.83^{a} ±0.31	1.54^{a} ±0.08
Season of Calving	Summer	109	2195.56 ±51.61	11.00 ±0.16	212.44 ±4.92	7.04 ±0.13	4.85 ±0.13	1.26 ±0.03
	Monsoon	134	2080.68 ±47.57	10.61 ±0.15	206.63 ±4.51	6.97 ±0.12	4.96 ±0.12	1.21 ±0.03
	Autumn	67	2087.70 ±61.49	10.73 ±0.19	199.66 ±5.91	6.84 ±0.15	4.75 ±0.15	1.18 ±0.04
	Winter	86	2149.54 ±56.90	10.90 ±0.18	207.17 ±5.45	6.94 ±0.14	4.62 ±0.14	1.22 ±0.04
RGRSN AFC Linear			0.15 ±0.15	0.0011 ±0.00047	-.015 ±.015	0.00085 ±0.00037	0.00052 ±0.00036	-0.00064 ±0.000097
RGRSN AFC Quad			-0.000052 ±0.00038	-0.00000058 ±0.0000012	.000018 ±.000037	-0.00000027 ±0.00000094	0.00000036 ±0.00000092	0.00000035 ±0.00000025

Mean with different superscripts differ significantly among themselves
DMRT as modified by Kramer (1957) [11] is used to find significant difference among various performance traits

The overall least-squares mean for persistency (PR) was 206.48 ±3.16 in the present study. Chakraborty *et al.* (2010) [2], also reported similar findings for PR least square means. The Effect of the Period of calving, the effect of season of calving and the effect of regression (linear and quadratic) of age at first calving was non-significant on PR in the present study. Findings of Chakraborty *et al.* (2010) [2] in Murrah buffaloes was similarly non-significant for effect of season and regression of age of first calving; while Chakraborty *et al.* (2010) [2] found a significant effect of Period of calving on PR.

The overall least-squares mean for First lactation Average milk yield (AMY) was 6.95 ±0.08 kg/day. Nearly similar estimates for least square mean for AMY were also obtained by Patil *et al.* (2018) [17], Dev *et al.* (2015) [5], Singh & Barwal (2012) [20] and Chaudhari (2015) [3]; while Chakraborty *et al.* (2010) [2] and Thiruvenkadan *et al.* (2014) [25] reported lower values then present study. The effect of the Period of calving on AMY was found to be significant (p<0.01). The effect of season of calving on AMY was obtained Non-significant. Findings of the present study for effect of Period and season were found similar to findings of Patil *et al.* (2018) [17], Dev *et al.* (2015) [5] and Chakraborty *et al.* (2010) [2]. The effect of regression of age at first calving (Linear) was significant (p<0.05) on AMY, while the quadratic regression was non-significant. Similar effect of regression of age at first calving was reported by Chakraborty *et al.* (2010) [2]; while Dev *et al.* (2015) [5] reported a non-significant effect by linear and quadratic regression of age at first calving.

The overall least-squares mean for First lactation milk yield per day of first calving interval (MCI) was found as 4.80 ±0.09 kg/day. Chaudhari (2015) [3] also found nearly similar estimates for MCI. Lower estimates for least square mean for MCI were reported by Patil *et al.* (2018) [17] and Chakraborty *et al.* (2010) [2]. Significant effect (p<0.01) of the Period of calving on MCI was obtained under the present study. Effect of Period of calving was reported significant by Patil *et al.* (2018) [17] while non-singnificant by Chakraborty *et al.* (2010) [2]. The effect of season of calving on MCI was non-significant. Similar non-significant effect of season was reported by Patil *et al.* (2018) [17] and Chakraborty *et al.* (2010) [2]. The Effect of Linear and quadratic regression of age at first calving was non-significant MCI. The significant effect of linear regression of age at first calving was reported by Chakraborty *et al.* (2010) [2].

The overall least-squares mean for Milk yield per day of age at second calving (MSC) averaged as 1.22 ±0.02 kg/day. Lower values for MSC were reported by Patil *et al.* (2018) [17] and Chakraborty *et al.* (2010) [2]. A significant effect (p<0.01) of the Period of calving on MSC was obtained under the present study. Similar significant Effect of Period of calving was reported by Patil *et al.* (2018) [17] and Chakraborty *et al.* (2010) [2]. The effect of season of calving on MSC was non-significant. Similar non-significant effect was reported by Patil *et al.* (2018) [17] and Chakraborty *et al.* (2010) [2]. The effect of age at first calving (linear) was significant (p<0.05) on MSC, while the quadratic regression was non- significant. A similar effect of age at first calving was reported by Chakraborty *et al.* (2010) [2].

The performance of sixth-period calvers (2015-2018) was superior to the other five period calvers for all the traits under the present study except for PR where the second period (1999-2002) calvers showed better performance. All traits under study showed improvement in trend except for PR where no definite trend was observed in different periods of calving. Performance of animals calved during period six results indicated that they might have received better nutritional, managemental practices, environmental conditions and due to selection pressure over the years as compared to those during other periods.

The performance of summer calvers was superior to calvers of other three seasons for all the traits under present study except for MCI where monsoon calvers manifested one step ahead of the performance. However, performance for all of the traits did not differ significantly for different seasons under the present study. Better performance of summer calvers might be due to availability of lush green fodder after calving in the subsequent monsoon season.

Estimates of Linear Regression of Age at first calving on 305MY, PY, PR, AMY, MCI and MSC were found 0.15±0.15, 0.0011±0.00047, -0.015±.015, 0.00085±0.00037, 0.00052 ±0.00036, -0.00064 ±0.000097, Respectively. Values of positive regression coefficient indicated that with an increase of age at first calving by one day there would be a corresponding increase by 0.15 kg, 0.0011 kg and 0.00085 kg/day, 0.00052 kg/day in 305MY, PY, AMY and MCI, respectively; while negative values indicated that with an increase in one day of age at first calving there would be a decline of -0.015 and -0.00064 kg/day in PR and MSC, respectively.

Accurate estimates of heritability of various economic traits are essential in assessing the progress in different traits and for planning future selection and breeding programmes. The heritability estimates along with standard errors for different production performance traits viz., 305MY, PY, PR, AMY, MCI and MSC were found to be 0.33±0.18, 0.33±0.18, 0.22 ±0.17, 0.26±0.18, 0.44±0.19 and 0.30±0.18 respectively (Table 3). The heritability estimates for various production performance traits were found to be low to high ranging from 0.22 ±0.17 (PR) to 0.44±0.19 (MCI). Heritability estimate of MCI was high. The estimates of heritabilities for 305MY, PY, PR, AMY and MSC were moderate. Similar findings of moderate heritability in PY were supported by many workers Patil *et al.* (2018) [17] and Dev *et al.* (2015) [5]. Higher heritability of PY in Murrah buffaloes was reported by Parik and Narang (2014). Lower heritability of PY was reported by Chakraborty *et al.* (2010) [2] in Murrah buffaloes. Lower heritability of 305MY was reported by Jumuna *et al.* (2015). The low to moderate estimates of heritabilities obtained in the present study for production performance traits indicated that there is restricted scope for refinement in these traits by individual selection, further improvement in these traits will require information from other relatives and enhancement in managemental practices.

Table 3: Heritabilities, genetic and phenotypic correlations among various performance traits

Traits	305MY	PMY	PR	AMY	MCI	MSC
305MY	0.33 ±0.18	0.77 ±0.04	0.77 ±0.22	0.78 ±0.03	0.79 ±0.03	0.94 ±0.02
PMY	0.79 ±0.18	0.33 ±0.18	0.16 ±0.48	0.71 ±0.04	0.69 ±0.04	0.76 ±0.04
PR	0.79 ±0.02	0.18 ±0.05	0.22 ±0.17	0.13 ±0.52	0.48 ±0.33	0.74 ±0.21
AMY	0.76 ±0.19	0.74 ±0.21	0.33 ±0.04	0.26 ±0.18	0.78 ±0.03	0.69 ±0.04
MCI	0.76 ±0.15	0.68 ±0.21	0.51 ±0.04	0.73 ±0.18	0.44 ±0.19	0.82 ±0.03
MSC	0.96 ±0.04	0.71 ±0.23	0.80 ±0.02	0.68 ±0.25	0.81 ±0.10	0.30 ±0.18

Figures above diagonal are estimates of genetic correlations; figures along the diagonal are estimates of heritability; figures below the diagonal are estimates of phenotypic correlations.

Genetic and phenotypic correlations of 305MY with other production performance traits were ranging from 0.76±0.19 (AMY) to 0.96±0.04 (MSC) and 0.77±0.03 (PY) to 0.94±0.02 (MSC). High genetic correlations of 305MY with PY, PR, AMY, MCI and MSC depicted that selection based on 305MY would result in improvement in all other traits in desirable direction through positive correlated response.

PY had low to high genetic correlations with production performance traits ranging from 0.18±0.05 (PR) to 0.96±0.04 (MSC). Genetic correlation of PY with AMY and MCI was found 0.74±0.21 and 0.76±0.15, respectively. PY had low to moderate phenotypic correlations with production performance traits ranging from 0.16±0.48 (PR) to 0.76±0.04 (MSC). Phenotypic correlation of PY with AMY and MCI was found 0.71±0.04 and 0.69±0.04, respectively. Estimates of similar magnitude for genetic and phenotypic correlation between PY and AMY were reported by Singh and Barwal (2012) [20], Chakraborty *et al.* (2010) [2] and Dev *et al.* (2015) [5]. Similar genetic correlation between PY with PR, MCI and MSC were reported by Chakraborty *et al.* (2010) [2]. However, Chakraborty *et al.* (2010) [2] reported negative phenotypic correlation between PY and PR. Patil *et al.* (2018) [17] reported lower estimates of genetic and phenotypic correlation then present study.

Genetic correlations of PR with production performance traits were found to be 0.33±0.04 (AMY), 0.51±0.04 (MCI) and 0.80±0.02 (MSC). While values for phenotypic correlation of PR with production traits were observed to be 0.13±0.52 (AMY), 0.48±0.33 (MCI) and 0.74±0.21 (MSC). Similar genetic and phenotypic correlation between PR and AMY were Chakraborty *et al.* (2010) [2]. Similar phenotypic correlation between PR with MCI and MSC were reported by Chakraborty *et al.* (2010) [2]. However, Chakraborty *et al.* (2010) [2] reported lower genetic correlation between PR and MCI and MSC then present study.

Estimates of genetic correlations of AMY with MCI and MSC were observed to be 0.73±0.18 and 0.68±0.25 while phenotypic correlations of AMY with MCI and MSC were found as 0.78±0.03 and 0.69±0.04. Patil *et al.* (2018) [17] reported higher estimates for genetic and phenotypic correlations for AMY with MCI and MSC. Similar high values of the genetic correlation between MCI and AMY were reported by Chakraborty *et al.* (2010) [2]. Romos *et al.* (2013) reported moderate genetic and phenotypic correlation between AMY and MCI.

Genetic and phenotypic correlations of MCI with MSC were found to be 0.81±0.10 and 0.82±0.03, respectively. Genetic and phenotypic correlation reported by Patil *et al.* (2018) [17] were slightly higher while Chakraborty *et al.* (2010) [2] were slightly lower than present study.

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