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Research Article

EFFICIENCY OF SIRE EVALUATION METHODS TO IMPROVE MILK YIELD OF MURRAH BUFFALOES

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ABSTRACT

The present investigation was conducted on records of 345 Murrah buffaloes from Buffalo Research Centre of this University distributed over 20 years (1993-2012) to compare progeny of 61 sires. Three sire evaluation procedures [ordinary least squares (OLS), regressed least squares (RLS) and best linear unbiased prediction (BLUP)] were used. These were based on estimated breeding value of production efficiency traits such as milk yield per day of first lactation length (MYLL), milk yield per day of first calving interval (MYFCI), milk yield per day of age at second calving (MYASC), milk yield per day of age at conception after first calving (MYAC), life time milk production (LMY4) and herd life milk yield (HLMY) in Murrah buffalo. The results indicated that sire number 60 had the highest merit computed by OLS, RLS and BLUP methods for MYLL. Product–moment correlations were comparatively higher than those of rank correlations barring a few exceptions. When comparison was made on the basis of coefficient of skewness, BLUP was found superior for MYLL, MYFCI, MYASC and MYAC. When comparison was made on the basis of coefficient of kurtosis, OLS was found better for MYLL, MYFCI, MYAC and HLMY. The OLS showed nearly perfect normal distribution for MYAC. When coefficient of determination was considered, OLS was found to be more accurate followed by RLS method for all the traits. RLS method was the most appropriate when coefficient of variation was considered.

Key words: Breeding values, correlations, Murrah, production efficiency

Genetic improvement for growth in Murrah buffaloes is of great importance in country like India, since buffalo contributes more than 50% of milk production in our country (BAHS, 2014). Buffalo produces 62.35 million tonnes milk out of total 121.85 million tonnes in India and Haryana contributes 5.24 million tonnes buffalo milk to it (DAHD-GOI, 2011). The aim of an animal breeder is to select the genetically superior bull for genetic improvement in the productive as well as reproductive performances of the herd. Therefore, suitable criterion of selection which gives best discrimination among sires should be formulated. To improve the efficiency and accuracy of sire evaluation programmes many sire indices have been developed by using the procedures of Ordinary Least-Squares (OLS), Regressed Least-Squares (RLS) and Best Linear Unbiased Prediction (BLUP). There are conflicting reports on comparative evaluation of various sire evaluation techniques in Murrah buffaloes (Pundir *et al*., 2004; Dhaka *et al*., 2004; Banik and Gandhi, 2006; Raja, 2010). Therefore, this study was undertaken to estimate breeding values for different production efficiency traits by different methods in Murrah buffalo.

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MATERIALS AND METHODS

The data on progeny of 61 bulls was collected from history cum pedigree sheets maintained at the Buffalo Research Centre, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, India**,** over a period of 20 years (1993 to 2012). Geographically, Hisar is situated in semi-arid region at 29° 10' N latitude, 75° 40' E longitude and 215.2 meters altitude and climatic condition is sub-tropical in nature. The production efficiency traits recorded were: milk yield per day of first lactation length (MYLL), milk yield per day of first calving interval (MYFCI), milk yield per day of age at second calving (MYASC), milk yield per day of age at conception after first calving (MYAC), life time milk production (LMY4) and herd life milk yield (HLMY). Bulls with minimum three progenies were considered for the present study.

Estimation of Breeding Value: Breeding value of sires for different production efficiency traits (MYLL, MYFCI, MYASC, MYAC, LMY4, HLMY) was computed separately by using different sire evaluation procedures: Ordinary Least Squares (OLS), Regressed Least Squares (RLS; Harvey, 1990) and Best Linear Unbiased Predictor

(BLUP; Henderson, 1973). The genetic and non genetic factors affecting the production efficiency traits and life time milk production traits were analyzed using the following mixed model for non-orthogonal data (Harvey, 1990).

$$Y_{ijkl} = \mu + s_i + h_j + c_k + b_1(X_{ijkl} - \bar{X}) + b_2(X_{ijkl} - \bar{X})^2 + e_{ijkl}$$

Where, Y_{ijkl}=lth record of individual of the ith sire calved in jth period and kth season; μ=overall population mean; s_i=random effect of ith sire; h_j=fixed effect of jth period of calving; C_k=fixed effect of kth season of calving; b_1 and b_2=linear and quadratic partial regression coefficients of age at first calving; X_{ijkl}=age at first calving; $\bar{X}$=mean of age at first calving; e_{ijkl}=error associated with each observation and assumed to be normally and independently distributed with mean zero and variance σ^2e.

Comparative Evaluation of Different Methods: Spearman rank correlation among ranks and simple product moment correlation coefficient among estimates of sire merit (Steel and Torrie, 1981) were used to judge the relative efficiency of different methods. The following criteria were used to judge accuracy of different sire evaluation procedures: the coefficient of skewness, the coefficient of kurtosis, standard error of an estimate, coefficient of variation and coefficient of determination. The coefficient of skewness and coefficient of variation close to zero and coefficient of kurtosis close to 3 was considered as estimate perfect indicating that the population followed a normal distribution, whereas low standard error of the estimate and high value for coefficient of determination were indicators of the better accuracy of method.

RESULTS AND DISCUSSION

The estimated breeding values by OLS, RLS and BLUP ranged from 4.9 to 9.28, 6.33 to 6.81 and 5.4 to 7.44 for MYLL, 2.66 to 7.56, 3.66 to 5.55 and 3.13 to 5.49 for MYFCI, 0.76 to 1.77, 1 to 1.21 and 0.86 to 1.31 for MYASC, 0.89 to 2.24, 1.17 to 1.5 and 0.99 to 1.58 for MYAC; 1828.53 to 8469.15, 4038.82 to 6220.16 and 4377.73 to 7231.68 for LMY4; 950.75 to 13834.17, 3756.07 to 8119.71 and 5083.08 to 8991.61 for HLMY, respectively (Tables 1 and 2).

The result for MYLL revealed that sire number 60 had the highest merit computed by OLS (9.28), RLS (6.81) and BLUP (7.44) method (Table 2). Eight sires (60, 26, 59, 61, 55, 25, 18 and 16) out of top ten shared their ranks by being in top ten irrespective of methods employed for computation of breeding value of sires (Table 2). Sire number 37 was found to be the lowest in merit by OLS (4.9), third lowest by RLS (6.34) and sixth lowest by BLUP (6.02) (Table 1). Only two sires (57, 37) out of bottom ten shared their ranks by being in bottom ten (Table 1).

The result for MYFCI revealed that sire number 59 had the highest merit computed by OLS (7.56), RLS (5.55) and BLUP (5.46) method (Table 2). Irrespective of breeding value estimation method, sire nos. 59, 60, 26, 61, 56 and 51 out of top ten shared their ranks (Table 2). Sire nos. 21, 28 and 37 shared their ranks by being in bottom ten (Table 1). Sire number 37 was found to be the lowest in merit by OLS (2.66), RLS (3.66) and seventh lowest by BLUP (3.75) (Table 1). The result for MYASC revealed that sire number 59 had the highest merit computed by OLS (1.77), RLS (1.21) and BLUP (1.31) method (Table 2). Five sires (2, 25, 59, 60 and 61) out of top ten share their ranks by being in top ten irrespective of methods employed for computation of breeding value of sires (Table 2). Sire number 37 was found to be the lowest in merit by OLS (0.76) and RLS (1), and fifth lowest by BLUP (0.94) (Table 1). Four sires (26, 53, 17 and 37) out of bottom ten shared their ranks by being in bottom ten (Table 1).

The result for MYAC revealed that sire number 26 had the highest merit computed by OLS (2.24), BLUP (1.58) and same sire ranked second when breeding value calculated by RLS (1.49) method (Table 2). Sires (26, 59, 60, 61 and 18) out of top ten shared their ranks by being in top ten irrespective of methods employed for computation of breeding value of sires (Table 2). Sire number 6 was found to be of lowest in merit by OLS (0.89), same sire ranked tenth lowest by RLS (1.2) and was unable to found place in bottom ten sires when breeding value was calculated by BLUP method (Table 1). Four sires (53, 23, 37 and 17) out of bottom ten shared their ranks by being in bottom ten by all three methods (Table 1).

The result for LMY4 revealed that sire number 33 had the highest merit computed by OLS (8469.15), and same sire ranked third when breeding value was calculated by RLS (6186.5) and fourth by BLUP (6493.62) method (Table 2). Six sires (33, 32, 2, 25, 54 and 51) out of top ten share their ranks by being in top ten irrespective of methods employed for computation of breeding value of sires (Table 2). Sire number 6 was found to be of lowest in merit by OLS (1828.53), same sire ranked fourth lowest by RLS (4759.41) and third lowest when breeding value was calculated by BLUP (4377.73) method (Table 1). The result for HLMY revealed that sire number 32 had the highest merit computed by OLS (13834.71) and RLS (8119.71) and the same sire ranked second by BLUP (8824.6) method (Table 2). Sire number 6 was found to be of lowest in merit by OLS (950.75) and BLUP (3101.61) and this sire ranked fourth lowest by RLS (4852.02) method (Table 1).

Rank and Product Moment Correlations: The rank and product moment correlations among merit of sires for production efficiency traits by various sire evaluation methods have been presented in the Tables 3 and 4. The rank correlations calculated through different methods were very high and they ranged from 0.66 to 0.99 for RLS X BLUP and OLS X RLS for MYFCI and HLMY, respectively (Table 3). All the product moment correlations between estimated sire merit calculated by different methods were also very high and ranged from 0.74 to 0.99 for OLS X BLUP and OLS X RLS for MYAC and MYFCI, respectively (Table 4). Dalal *et al.* (1999), Gaur *et al.* (2001), Dubey *et al.* (2006), Dhaka *et al.* (2004), Banik and Gandhi (2006), Bajetha (2006), Mukherjee *et al.*(2007), Kumar *et al.* (2008) and Moges *et al.* (2009) also reported high rank and product moment correlation. Rank and product moment correlations calculated by different procedures for production efficiency traits revealed product moment correlations to be comparatively higher than those of rank correlations.

Comparison of Different Sire Evaluation Methods: The content of Table 5 revealed that on the basis of the standard error of the estimates, RLS method was found to be most accurate method for all the production efficiency traits under study followed by BLUP. Dhaka *et al.* (2002) also reported similar results in Hariana cattle. When comparison was made on the basis of coefficient of skewness, BLUP method was found superior for estimation of breeding values for the traits like MYLL, MYFCI, MYASC and MYAC, while OLS was appropriate for LMY4 and HLMY (Table 5). When comparison was made on the basis of coefficient of kurtosis, OLS procedure showed nearly perfect normal distribution for MYLL, MYFCI, MYAC and HLMY, while RLS showed normal distribution for MYASC and LMY4 (Table 5).

When coefficient of determination was considered, OLS was found to be more accurate followed by RLS

Table 1
Ranking of bottom five sires for various economic traits using different procedures

Rank	Methods	Economic traits					
		MYLL	MYFCI	MYASC	MYAC	LMY4	HLMY
61	OLS	4.9 (37)	2.66 (37)	0.76 (37)	0.89 (6)	1828.53 (6)	950.75 (6)
	RLS	6.33 (38)	3.66 (37)	1 (37)	1.17 (17)	4032.82 (46)	3756.07 (46)
	BLUP	5.4 (57)	3.13 (1)	0.86 (1)	0.99 (1)	3512.12 (46)	3101.61 (6)
60	OLS	5.16 (57)	2.8 (28)	0.76 (6)	0.9 (17)	2056.29 (46)	1252.03 46
	RLS	6.34 (37)	3.68 (43)	1 (17)	1.18 (23)	4606 (43)	4522.62 (43)
	BLUP	5.55 (1)	3.5 (57)	0.9 (57)	1.05 (57)	4013.37 (43)	3216.35 (46)
59	OLS	5.42 (39)	2.86 (21)	0.78 (17)	0.93 (48)	2201.48 (48)	1380.64 (46)
	RLS	6.34 (43)	3.71 (28)	1 (50)	1.18 (50)	4736.64 (50)	4591.19 (50)
	BLUP	5.67 (33)	3.63 (33)	0.92 (33)	1.06 (33)	4377.73 (6)	3662.21 (48)
58	OLS	5.62 (36)	3.29 (43)	0.83 (48)	0.95 (23)	3439.68 (50)	2590.27 (50)
	RLS	6.36 (46)	3.73 (21)	1.01 (15)	1.19 (5)	4759.41 (6)	4852.02 (6)
	BLUP	5.76 (52)	3.68 (21)	0.94 (37)	1.09 (52)	4559.7 (39)	3675.21 (43)
57	OLS	5.65 (31)	3.38 (31)	0.83 (53)	0.95 (37)	3534.06 (43)	3011.68 (4)
	RLS	6.37 (57)	3.84 (31)	1.1 (53)	1.19 (15)	4831.32 (48)	4928.43 (48)
	BLUP	5.88 (44)	3.71 (11)	0.94 (52)	1.1 (23)	4574.57 (48)	3726.14 (39)
56	OLS	5.66 (28)	3.45 (48)	0.83 (9)	0.97 (53)	3708.68 (39)	3061.45 (43)
	RLS	6.37 (39)	3.87 (50)	1.01 (46)	1.2 (53)	4960.96 (39)	5078.03 (39)
	BLUP	6.02 (37)	3.73 (52)	0.95 (23)	1.12 (5)	4574.57 (10)	5083.08 (50)
55	OLS	5.66 (3)	3.45 (39)	0.84 (23)	0.97 (9)	3726.07 (4)	3136.33 (39)
	RLS	6.38 (50)	3.88 (5)	1 (35)	1.2 (46)	5040.78 (4)	5190.53 (4)
	BLUP	6.13 (29)	3.75 (37)	0.95 (17)	1.14 (17)	4742.63 (23)	5083.46 (10)
54	OLS	5.72 (33)	3.46 (36)	0.85 (50)	1.01 (50)	4148.59 (9)	3684.92 (49)
	RLS	6.38 (45)	3.90 (39)	1.01 (23)	1.20 (37)	5068.47 (38)	5283.64 (38)
	BLUP	6.13 (12)	3.75 (5)	0.95 (15)	1.14 (15)	4756.13 (15)	5101.40 (38)
53	OLS	5.73 (50)	3.51 (50)	0.85 (13)	1.01(13)	4221.06 (49)	4256.19 (53)
	RLS	6.38 (31)	3.90 (36)	1.01 (5)	1.20 (35)	5194.13 (53)	5545.50 (49)
	BLUP	6.15 (53)	3.78 (44)	0.97 (5)	1.15 (37)	4786.82 (57)	5132.15 (15)
52	OLS	5.74 (5)	3.53 (54)	0.86 (28)	1.03 (28)	4360.90 (53)	4566.05 (38)
	RLS	6.42 (5)	3.92 (35)	1.02 (48)	1.20 (6)	5206.74 (9)	5578.59 (53)
	BLUP	6.15 (11)	3.83 (28)	0.98 (53)	1.17 (53)	4795.43 (55)	5177.87 (23)

MYLL=Milk yield per day of first lactation length; MYFCI=Milk yield per day of first calving interval; MYASC=Milk yield per day of age at second calving; MYAC=Milk yield per day of age at conception after first calving; LMY4=Life time milk production; HLMY=Herd life milk yield; OLS=Ordinary least squares; RLS=Regressed least squares; BLUP=Best linear unbiased prediction. Figures within parenthesis are sire code

Table 2
Ranking of top ten sires for various production efficiency traits using different procedures

Rank	Methods	Economic traits					
		MYLL	MYFCI	MYASC	MYAC	LMY4	HLMY
1	OLS	9.28 (60)	7.56 (59)	1.77 (59)	2.24 (26)	8469.15 (33)	13834.71 (32)
	RLS	6.81 (60)	5.55 (59)	1.21 (59)	1.5 (59)	6220.61 (51)	8119.71 (32)
	BLUP	7.44 (60)	5.49 (59)	1.31 (59)	1.58 (26)	7231.68 (2)	8991.61 (2)
2	OLS	8.87 (26)	7.1 (60)	1.77 (60)	2.15 (59)	8437.95 (32)	9947.61 (2)
	RLS	6.8 (59)	5.21 (60)	1.19 (60)	1.49 (26)	6194.74 (1)	7876.96 (41)
	BLUP	7.24 (26)	5.13 (60)	1.29 (60)	1.57 (59)	6597 (47)	8824.6 (32)
3	OLS	8.68 (59)	6.72 (26)	1.61 (61)	2.11 (60)	7808.01 (2)	9494.95 (33)
	RLS	6.77 (26)	5.08 (26)	1.14 (61)	1.46 (60)	6186.5 (33)	7397.33 (1)
	BLUP	7.21 (59)	4.95 (26)	1.19 (61)	1.52 (60)	6522.99 (54)	8351.66 (47)
4	OLS	8.49 (61)	6.29 (6)	1.45 (25)	1.89 (61)	7721.11 (25)	9167.9 (28)
	RLS	6.77 (55)	4.80 (61)	1.12 (24)	1.38 (61)	6033.78 (32)	7395.62 (51)
	BLUP	7.13 (55)	4.71 (51)	1.19 (51)	1.45 (18)	6493.62 (33)	7696.90 (28)
5	OLS	8.46 (55)	5.91 (25)	1.40 (24)	1.74 (25)	7667.11 (54)	8590.19 (51)
	RLS	6.69 (18)	4.76 (55)	1.11 (25)	1.36(51)	6026.80 (2)	7353.28 (2)
	BLUP	7.02 (51)	4.65 (61)	1.18 (2)	1.44 (51)	6320.92 (32)	7612.02 (8)
6	OLS	8.45 (25)	5.60 (55)	1.28 (34)	1.61(24)	7333.49 (60)	6027.93 (25)
	RLS	6.68 (25)	4.69 (25)	1.11 (25)	1.35 (11)	5992.76 (54)	7231.17 (8)
	BLUP	6.97 (18)	4.63 (18)	1.17 (18)	1.41 (2)	6224.92 (31)	7278.19 (33)
7	OLS	7.94 (24)	5.37 (24)	1.22 (2)	1.53 (58)	7282.72 (51)	8393.59 (8)
	RLS	6.68 (61)	4.61 (24)	1.11 (51)	1.35 (25)	5912.18 (60)	7212.13 (33)
	BLUP	6.96 (61)	4.61 (49)	1.15 (38)	1.40 (14)	6140.07 (51)	7260.07 (41)
8	OLS	7.65 (18)	5.02 (56)	1.22 (11)	1.50 (34)	6964.25 (1)	8336.53 (54)
	RLS	6.67 (16)	4.58 (51)	1.09 (2)	1.34 (24)	5895.57 (25)	7110.15 (28)
	BLUP	6.95 (25)	4.59 (42)	1.14 (14)	1.40 (58)	6019.90 (25)	7234.24 (7)
9	OLS	7.53 (16)	4.91 (49)	1.22 (44)	1.33 (18)	5882.73 (22)	8294.51 (1)
	RLS	6.67 (24)	4.44 (18)	1.09 (18)	1.49 (18)	6033.78 (5)	6850.91 (54)
	BLUP	6.93 (42)	4.53 (38)	1.13 (56)	1.39 (38)	6010.18 (22)	7177.36 (54)
10	OLS	7.47 (19)	4.90 (51)	1.22 (55)	1.49 (44)	6828.50 (34)	8131.81 (60)
	RLS	6.61 (51)	4.44 (56)	1.09 (34)	1.33 (55)	5814.25 (31)	6793.73 (47)
	BLUP	6.90 (16)	4.53 (56)	1.12 (25)	1.38 (61)	5994.28 (7)	7030.38 (1)

MYLL=Milk yield per day of first lactation length; MYFCI=Milk yield per day of first calving interval; MYASC=Milk yield per day of age at second calving; MYAC=Milk yield per day of age at conception after first calving; LMY4=Life time milk production; HLMY=Herd life milk yield; OLS=Ordinary least squares; RLS=Regressed least squares; BLUP=Best linear unbiased prediction. Figures within parenthesis are sire code

Table 3
Spearman Rank correlations among estimated sire merits for different production efficiency traits calculated by various sire evaluation methods

Variables	Spearman Rank Correlation		
	OLS X RLS	OLS X BLUP	RLS X BLUP
MYLL	0.95	0.71	0.69
MYFCI	0.98	0.66	0.66
MYASC	0.97	0.70	0.70
MYAC	0.96	0.69	0.68
LMY4	0.99	0.78	0.78
HLMY	0.99	0.78	0.80

MYLL=Milk yield per day of first lactation length; MYFCI=Milk yield per day of first calving interval; MYASC=Milk yield per day of age at second calving; MYAC=Milk yield per day of age at conception after first calving; LMY4=Life time milk production; HLMY=Herd life milk yield; OLS=Ordinary least squares; RLS=Regressed least squares; BLUP=Best linear unbiased prediction

Table 4
Product–moment correlations among estimated sire merits for different production efficiency traits calculated by various sire evaluation methods

Variables	Product Moment Correlation		
	OLS X RLS	OLS X BLUP	RLS X BLUP
MYLL	0.96	0.79	0.76
MYFCI	0.99	0.75	0.75
MYASC	0.97	0.76	0.77
MYAC	0.98	0.74	0.75
LMY4	0.95	0.79	0.79
HLMY	0.96	0.80	0.82

MYLL=Milk yield per day of first lactation length; MYFCI=Milk yield per day of first calving interval; MYASC=Milk yield per day of age at second calving; MYAC=Milk yield per day of age at conception after first calving; LMY4=Life time milk production; HLMY=Herd life milk yield; OLS=Ordinary least squares; RLS=Regressed least squares; BLUP=Best linear unbiased prediction

method for all the traits whereas, RLS method was observed most appropriate when coefficient of variation was considered (Table 5). Kumar and Gandhi (2010) also supported the results pertinent to coefficient of determination. Harvey (1990) also pointed that BLUP was more accurate (1-7%) than RLS when the usual

Table 5
Moments of different production efficiency traits

Variables	Coefficient of skewness			Coefficient of kurtosis			Coefficient of determination			Coefficient of variation			Standard error		
	OLS	RLS	BLUP	OLS	RLS	BLUP	OLS	RLS	BLUP	OLS	RLS	BLUP	OLS	RLS	BLUP
MYLL	0.19	-0.53	1.29	2.46	1.68	1.65	0.477	0.274	0.070	34.64	12.10	14.40	273.99	95.61	119.57
MYFCI	0.98	0.78	-0.16	0.87	0.46	0.75	0.555	0.310	0.065	13.89	4.23	6.16	4.98	1.51	2.20
MYASC	0.33	0.40	-0.33	0.64	0.11	0.87	0.515	0.320	0.124	14.90	4.60	6.91	2.24	0.69	1.04
MYAC	1.14	0.84	0.27	1.13	0.17	0.30	0.535	0.337	0.138	22.83	6.09	10.07	47.78	12.73	21.01
LMY4	0.07	-0.26	0.83	0.12	1.06	1.30	0.202	0.123	0.053	28.55	6.05	13.16	43.85	9.31	20.11
HLMY	1.20	0.96	-0.10	1.07	0.49	0.78	0.226	0.140	0.054	14.44	1.80	6.06	0.12	0.01	0.05

MYLL=Milk yield per day of first lactation length; MYFCI=Milk yield per day of first calving interval; MYASC=Milk yield per day of age at second calving; MYAC=Milk yield per day of age at conception after first calving; LMY4=Life time milk production; HLMY=Herd life milk yield; OLS=Ordinary least squares; RLS=Regressed least squares; BLUP=Best linear unbiased prediction

assumptions were met and even when moderate amount of heterogenous error variance exit.

The BLUP is the best and has minimum prediction error variance provided that true variance of random effects is known. Therefore, it is suggested to use BLUP procedure in a situation where correct ratio of residual variance to sire variance is known. Trade-offs between what is computationally ideal and what is practically feasible, are a fact of life in animal breeding and hence, use of OLS is suggested in situations where correct ratio of residual variance to sire variance is not known.

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