

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.802.239>

Comparative Efficiency of Sire Evaluation Procedures in Murrah Buffaloes

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ABSTRACT

The present investigation was conducted on records of 2959 buffaloes, progeny of 219 sires over a period of 24 years (1992-2015) maintained at Buffalo research centre (BRC), LUVAS, Hisar and Animal farm ICAR-CIRB, Hisar. Four sire evaluation procedures such as ordinary least squares (OLS), regressed least squares (RLS), Derivative free restricted estimated maximum likelihood (DFREML) and best linear unbiased prediction (BLUP) based on estimated breeding value of performance traits such as first lactation milk yield (FLY), first lactation peak yield (FPY), first lactation milk yield per day of first lactation length (MLL = FLY/FLL); first lactation milk yield per day of first calving interval (MCI = FLY/FCI) and first lactation milk yield per day of age at second calving (MSC = FLY/AFC+FCI) were compared. The results indicated that sire number 63 had the highest merit computed by OLS, RLS and sire number 27 had the highest merit for MCI computed by either of the four methods. In addition, sire number 63 had the highest merit for MSC computed by all the methods except OLS where it stood fourth in ranking. Product-moment correlations were comparatively lower than those of rank correlations barring a few exceptions. When comparison was made on the basis of coefficient of skewness, OLS was found superior for estimation of breeding value for FLY, MLL and MSC whereas RLS for FPY and BLUP for MCI. When comparison was made on the basis of coefficient of kurtosis, DFREML was better for FLY and FPY; OLS for MCI; and BLUP for MLL and MSC whereas RLS was found inferior when comparison was made on the basis of coefficient of kurtosis. When standard error of the estimate was considered, RLS was found to be more accurate in case of FLY, MLL, MCI and MSC. It is recommended to use BLUP where correct ratio of residual variance to sire variances is known.

Keywords

Breeding values, Correlations, Murrah, Phase traits, Satiability traits

Article Info

Accepted:

15 January 2019

Available Online:

10 February 2019

Introduction

Buffaloes have spread over almost all parts of country with varying population density, the majority (72%) being concentrated in North and Western states. The local defined breeds are stable as well; these can survive the varieties of feed/fodder/ shortage, extreme of temperature and /or prevalence of diseases. Preference for

buffaloes has continued to increase due to higher fat and SNF content of milk. India is fortunate in terms of largest buffalo population, buffalo germplasm diversity (13 recognized plus 17 distinct population groups) and the world renowned buffalo breeds: Murrah, Nili-Ravi, Banni, Jaffrabadi and Mehsana. Presently India possesses about 108.70 million buffaloes (BAHS, 2013). The aim of animal breeder is to select the

genetically superior bull to bring out genetic improvement in the productive as well as reproductive performance of the herd. Therefore, suitable selection criterion which gives best discrimination among sires should be formulated to evaluate sires on the basis of performance of their daughters considering both production and reproduction performance traits.

To improve the efficiency and accuracy of sire evaluation programmes many sire indices has been developed such as by using the procedures of Least-squares (LS), Regressed Least-Squares (RLS), Best Linear Unbiased Prediction (BLUP) and Derivative Free Restricted Maximum Likelihood Method (DFREML). The literature is dotted with conflicting reports (Pundir *et al.*, 2004; Dhaka *et al.*, 2004; Banik and Gandhi, 2006; Raja, 2010; Kamaldeep *et al.*, 2015) on comparative evaluation of various sire evaluation techniques in dairy animals. Therefore, an effort has been made to estimate breeding values for various performance traits by different procedures and comparison of these procedures to find out the most suitable for evaluation of Murrah sires.

Materials and Methods

The data for present investigation was collected from history cum pedigree sheets maintained at Buffalo Research Centre (BRC), Lala Lajpat Rai University of Veterinary and Animal Sciences and Central Institute for Research on Murrah Buffaloes (CIRB) Hisar over a period of 24 years from 1992 to 2015. Assuming that there is not much variation in adjacent years, entire period of twenty four years will be divided into 6 periods 1992-1995 (period 1); 1996-1999 (period 2); 2000-2003 (period 3); 2004-2007 (period 4); 2008-2011 (period 5); 2012-2015 (period 6). Each year will be divided into four seasons; summer, rainy, autumn and winter. The performance traits considered were: first lactation milk yield (FLY); first lactation peak yield (FPY); first lactation milk yield per day of first lactation length (MLL = FLY/FLL); first lactation milk yield per day of first calving interval (MCI = FLY/FCI) and first lactation milk yield per day of age at second calving (MSC = FLY/AFC+FCI). Breeding value of sires for different performance traits (FLY,

FPY, MLL, MCI and MSC) were computed separately by using different sire evaluation procedures: DFREML (derivative free restricted estimated maximum likelihood), Ordinary Least Squares (OLS), Regressed Least Squares (RLS) and Best Linear Unbiased Predictor (BLUP). In order to overcome non-orthogonality of the data, least Squares and maximum likelihood computer programme of Harvey (1987) using Henderson method III (1953) was used to estimate the effect of various tangible factors on different performance traits under study. The following mathematical model was deduced to explain the underlying biology of the traits included in the study:

Where

$$Y_{ijkl} = \mu + s_i + h_j + c_k + b_1(X_{ijkl} - \bar{X}) + b_2(X_{ijkl} - \bar{X})^2 + e_{ijkl} \quad (1)$$

Where

Y_{ijkl} = l^{th} observation on the progeny of the i^{th} sire in j^{th} period and k^{th} season of calving

μ = overall population mean

s_i = random effect of i^{th} sire

h_j = fixed effect of j^{th} period of calving

c_k = fixed effect of k^{th} season of calving

b_1 & b_2 = partial regression coefficient of age at first calving, linear and quadratic, respectively on the traits

X_{ijkl} = age at first calving comparing to Y_{ijkl} observations

\bar{X} = mean for age at first calving

e_{ijkl} = random error associated with each and every observation assumed to be normally and independently distributed with mean zero and variance σ_e^2 NID (0, σ_e^2).

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 criteria used to judge accuracy of different sire evaluation procedures were the coefficient of skewness, the coefficient of kurtosis and standard error of an estimate. The coefficient of skewness close to zero and coefficient of kurtosis close to 3 was considered as estimate perfect indicating that the population follows a normal distribution, whereas low standard error of the estimates was an indicator of the better accuracy of method.

Results and Discussion

The breeding values of sires were computed using the Simple Daughter Average (DFREML), Ordinary Least Square (OLS), Regressed Least Square (RLS) and Best Linear Unbiased Prediction (BLUP) procedures for different production efficiency traits. The above mentioned procedures were compared to assess accuracy utilizing standard error of the estimates, the coefficient of skewers and kurtosis. The estimated breeding values by DFREML, OLS, RLS and BLUP ranged from 1237.8 to 1973.82, -329.64 to 325.0, -120.29 to 119.63 and -150.33 to 169.01 for FLY; 6.38 to 10.33, -1.63 to 2.33, -0.89 to 1.03 and -0.64 to 1.04 for FPY; 4.24 to 6.72, -0.95 to 0.84, -0.38 to 0.56 and -0.38 to 0.61 for MLL; 2.59 to 4.09, -0.51 to 0.7, -0.21 to 0.23 and -0.26 to 0.32 for MCI and 0.92 to 1.55, -0.22 to 0.24, -0.08 to 0.1 and -0.14 to 0.19 for MSC (Table 1 and 2).

The results for FLY presented in (Table 1) revealed that sire number 63 had the highest merit computed by DFREML (1937.82) and RLS (119.63) while the same sire ranked fifth by OLS (239.39) and third by BLUP (145.39) method. Five sires out of top ten shared their ranks being in top ten positions irrespective of methods employed for computation of breeding value of sires. The perusal of Table

2 revealed that sire number 59 was found to be of lowest in merit by RLS (-120.29), second lowest by BLUP (-140.32) and third lowest by OLS (-222.2) and was unable to found place in bottom ten sires when breeding value was calculated by DFREML method. Four sires out of bottom ten share their ranks being in bottom ten when breeding value was calculated by either of four methods included in the study. The results for FPY depicted in (Table 1) indicated that sire number 27 had the highest merit computed by DFREML (10.33), OLS (2.33) and RLS (1.03) methods whereas the same sire ranked second by BLUP (0.79) procedure. Only two sires out of top ten shared their ranks by being in top ten when breeding value was calculated by either of four methods. Sire number 61 was found to be of the lowest merit when B.V. was estimated by RLS (-0.89) and BLUP (-0.64) method but third lowest by OLS (-1.5), however, the same sire was unable to find place in bottom ten sires when breeding value was calculated using DFREML method. Two sires (sire no 20 and 29) out of lowest ten shared their ranks by being in bottom ten irrespective of methods of computation of breeding value of sires. The contents of Table 1 for MLL revealed that sire number 64 has the highest merit computed by DFREML (6.72), RLS (0.56) and BLUP (0.61) methods and the same sire ranked second when B.V. was calculated by OLS (0.83) method. Five sires out of top ten shared their ranks by being in top ten positions irrespective of methods used for calculation of breeding value. Sire number 55 was found to be of lowest in merit by DFREML (4.24), OLS (-0.95) and BLUP (-0.38) methods but second lowest by RLS (-0.35) method. Only two sires out of lowest ten shared their ranks by being in bottom ten when breeding value was estimated by either of the four methods included in the study.

The perusal of Table 1 revealed that sire number 27 has the highest merit for MCI

computed by either of the four methods. Five sires out of top ten shared their ranks by being in top ten when breeding value was calculated by either of four methods included in the study. However, sire number 68 was found to be lowest in merit by OLS (-0.51), third lowest by BLUP (-0.23) and fourth lowest by RLS (-0.17) but was unable to find place in bottom ten sires by DFREML method. In addition to this, two sires out of bottom ten shared their ranks by being in bottom ten when breeding value was calculated by any of the four methods.

The critical review of Table 1 indicated that sire number 63 has the highest merit for MSC computed by all the methods except for OLS (0.21) where it stood fourth in ranking. Five sires out of top ten shared their ranks by being in top ten when breeding value was calculated by any of the four methods. The results of Table 2 further revealed that sire no 81 was found to be of lowest merit by RLS (-0.08), second lowest by OLS (-0.19) and BLUP (-0.11) but was unable to find slot in bottom ten sires by DFREML method. Also only two sires out of lowest ten shared their ranks by being in bottom ten irrespective of methods of calculation of breeding value.

Rank and Product- Moment correlations

The rank and product-moment correlations among merit of sires for production efficiency traits by various sire evaluation methods are presented in Table 3 and 4, respectively.

The rank correlations calculated through different methods were very high and it ranged from 0.488 to 0.990 for DFREML X BLUP and OLS X RLS for MLL (Table 3). All the product moment correlations between estimated sire merit calculated by different methods were also very high and ranged from 0.485(DFREML X BLUP) to 0.988(OLS X RLS) for MLL (Table 4).

Similar findings were also reported by various researchers; Gaur *et al.*, (2001), Dhaka *et al.*, (2004), Banik and Gandhi (2006), Bajetha (2006), Mukherjee *et al.*, (2007), Kumar *et al.*, (2008), Moges *et al.*, (2009) and Kamaldeep *et al.*, (2015). Rank and product moment correlations among sire merit calculated by various sire evaluation procedures for different performance traits revealed that product moment correlations were comparatively higher than those of rank correlations barring few exceptions.

Comparison of different sire evaluation methods

The accuracy of four methods used in the study for the estimated breeding value of sires was judged through the coefficient of skewness, coefficient of kurtosis and standard error of an estimate. The content of Table 5 revealed that on the basis of the standard error of the estimates, RLS method was found to be most efficient accurate in case of FLY (58.47), MLL (0.19), MCI (0.10) and MSC (0.04) whereas BLUP was adjudged as superior for FPY (0.37). When comparison was made on the basis of coefficient of skewness, OLS was found superior for estimation of breeding value for the traits like FLY (0.254), MLL (0.135) and MSC (0.376). Whereas RLS for FPY (0.065) and BLUP for MCI (0.123). When comparison was made on the basis of coefficient of kurtosis, DFREML was better for FLY (-0.003) and FPY (0.066); OLS for MCI (0.216); and BLUP for MLL (0.336) and MSC (1.355) whereas RLS was found inferior when comparison was made on the basis of coefficient of kurtosis. Harvey (1990) also pointed that BLUP was more accurate (1-7%) than RLS when the usual assumptions were met and even when moderate amount of heterogeneous error variance exist. Choice among methods also to a greater extent depends upon computational difficulty and relative accuracy.

Table.1 Ranking of top ten sires for various performance traits using different procedures

Rank	Methods	FLY	FPY	MLL	MCI	MSC
1	DFREML	1937.82(63)	10.33(27)	6.72(64)	4.09(27)	1.55(63)
	OLS	325.01(27)	2.33(27)	0.84(37)	0.7(27)	0.24(27)
	RLS	119.63(63)	1.03(27)	0.56(64)	0.23(27)	0.1(63)
	BLUP	169.01(32)	1.04(63)	0.61(64)	0.32(27)	0.19(63)
2	DFREML	1957(58)	10.27(63)	6.58(66)	3.94(64)	1.49(80)
	OLS	310.45(32)	1.41(71)	0.83(64)	0.47(71)	0.22(80)
	RLS	114.62(27)	0.86(90)	0.4(37)	0.19(64)	0.09(85)
	BLUP	159.52(27)	0.79(27)	0.36(66)	0.23(64)	0.13(80)
3	DFREML	1955(27)	9.92(66)	6.44(27)	3.87(63)	1.47(27)
	OLS	263.22(71)	1.37(90)	0.73(27)	0.43(88)	0.22(32)
	RLS	110.75(71)	0.79(63)	0.3(27)	0.18(71)	0.08(27)
	BLUP	145.39(63)	0.77(32)	0.34(37)	0.23(71)	0.1(85)
4	DFREML	1889.38(71)	9.48(90)	6.33(28)	3.83(66)	1.46(67)
	OLS	248.81(80)	1.34(63)	0.68(86)	0.39(73)	0.21(63)
	RLS	106.33(85)	0.72(71)	0.29(85)	0.17(85)	0.07(80)
	BLUP	139.97(71)	0.61(38)	0.33(27)	0.2(63)	0.09(27)
5	DFREML	1887.6(67)	9.45(71)	6.21(63)	3.8(71)	1.42(71)
	OLS	239.39(63)	1.16(38)	0.63(66)	0.38(32)	0.17(71)
	RLS	102.92(92)	0.7(93)	0.28(86)	0.16(93)	0.07(71)
	BLUP	124.44(52)	0.56(53)	0.29(52)	0.2(32)	0.09(30)
6	DFREML	1839.8(32)	9.4(32)	6.15(74)	3.79(67)	1.41(85)
	OLS	196.4(85)	1.06(73)	0.53(41)	0.36(37)	0.17(85)
	RLS	96.94(32)	0.68(8)	0.28(66)	0.15(63)	0.07(92)
	BLUP	117.25(85)	0.51(66)	0.27(28)	0.18(52)	0.08(71)
7	DFREML	1800.24(36)	9.2(58)	6.1(85)	3.76(58)	1.39(74)
	OLS	189.32(88)	1.04(7)	0.51(88)	0.33(85)	0.15(88)
	RLS	87.75(80)	0.65(89)	0.24(63)	0.15(92)	0.06(32)
	BLUP	114.9(92)	0.5(92)	0.26(85)	0.17(85)	0.06(32)
8	DFREML	1790.2(85)	9.14(7)	6.05(73)	3.75(73)	1.34(64)
	OLS	183.14(26)	1(89)	0.49(85)	0.32(64)	0.12(92)
	RLS	86.65(52)	0.62(85)	0.19(41)	0.14(37)	0.06(52)
	BLUP	101.53(58)	0.48(57)	0.25(63)	0.15(73)	0.06(26)
9	DFREML	1789.14(66)	9.14(89)	5.86(90)	3.67(62)	1.34(73)
	OLS	171.87(58)	0.99(83)	0.47(32)	0.32(63)	0.12(26)
	RLS	71.17(26)	0.56(38)	0.19(74)	0.13(73)	0.04(88)
	BLUP	99.41(26)	0.47(52)	0.24(41)	0.15(6)	0.06(64)
10	DFREML	1766.56(62)	9(73)	5.85(71)	3.64(74)	1.33(65)
	OLS	162.58(92)	0.98(85)	0.43(63)	0.25(92)	0.11(58)
	RLS	59.11(88)	0.51(83)	0.18(88)	0.12(88)	0.04(26)
	BLUP	91.72(80)	0.44(58)	0.24(32)	0.14(37)	0.06(65)

Figures within parenthesis are sire numbers.

Table.2 Ranking of bottom ten sires for various performance traits using different procedures

Rank	Methods	FLY	FPY	MLL	MCI	MSC
62	DFREML	1237.8(54)	6.38(54)	4.24(55)	2.59(54)	0.92(54)
	OLS	-329.64(28)	-1.63(40)	-0.95(55)	-0.51(68)	-0.22(28)
	RLS	-120.29(59)	-0.89(61)	-0.38(61)	-0.21(11)	-0.08(81)
	BLUP	-150.33(81)	-0.64(61)	-0.38(55)	-0.26(81)	-0.14(61)
61	DFREML	1295(57)	6.83(29)	4.92(53)	2.7(55)	0.93(53)
	OLS	-232.73(68)	-1.54(20)	-0.68(61)	-0.44(55)	-0.19(81)
	RLS	-102.93(28)	-0.78(40)	-0.35(55)	-0.18(61)	-0.08(59)
	BLUP	-140.32(59)	-0.61(87)	-0.35(61)	-0.23(59)	-0.11(81)
60	DFREML	1297.83(18)	6.97(18)	4.7(54)	2.74(18)	0.93(18)
	OLS	-222.2(59)	-1.5(61)	-1.5(40)	-0.38(1)	-0.16(68)
	RLS	-97.6(81)	-0.78(45)	-0.78(40)	-0.18(59)	-0.06(28)
	BLUP	-131.3(28)	-0.51(1)	-0.51(72)	-0.23(68)	-0.11(94)
59	DFREML	1342.6(20)	7(26)	4.7(26)	2.78(26)	1.01(1)
	OLS	-220.6(20)	-1.24(67)	-0.61(1)	-0.38(61)	-0.15(1)
	RLS	-89(31)	-0.72(29)	-0.28(62)	-0.17(68)	-0.05(68)
	BLUP	-106.79(18)	-0.46(3)	-0.3(40)	-0.21(94)	-0.1(18)
58	DFREML	1364.86(4)	7(19)	4.72(30)	2.8(30)	1.02(57)
	OLS	-217.02(81)	-1.18(29)	-0.6(67)	-0.36(59)	-0.15(20)
	RLS	-82.08(68)	-0.66(10)	-0.28(31)	-0.14(81)	-0.05(1)
	BLUP	-96.34(68)	-0.44(40)	-0.3(62)	-0.2(61)	-0.09(59)
57	DFREML	1384.33(1)	7.14(20)	4.74(29)	2.81(53)	1.03(50)
	OLS	-197.75(1)	-1.16(28)	-0.55(62)	-0.33(81)	-0.15(59)
	RLS	-77.63(10)	-0.66(3)	-0.26(11)	-0.14(50)	-0.05(61)
	BLUP	-84.48(1)	-0.43(4)	-0.28(94)	-0.17(55)	-0.08(28)
56	DFREML	1386.8(3)	7.22(55)	4.76(40)	2.81(50)	1.04(29)
	OLS	-155.03(61)	-1.09(45)	-0.46(50)	-0.32(50)	-0.11(41)
	RLS	-77.47(61)	-0.65(4)	-0.25(1)	-0.14(8)	-0.04(20)
	BLUP	-76.22(2)	-0.42(62)	-0.23(67)	-0.17(2)	-0.06(68)
55	DFREML	1395.22(81)	7.28(30)	4.77(50)	2.89(57)	1.04(4)
	OLS	-145.05(18)	-1.05(54)	-0.45(72)	-0.27(40)	-0.11(78)
	RLS	-75.63(18)	-0.61(20)	-0.24(50)	-0.13(55)	-0.04(78)
	BLUP	-75.69(20)	-0.41(20)	-0.23(23)	-0.16(72)	-0.05(78)
54	DFREML	1427(53)	7.29(4)	4.78(23)	2.94(19)	1.06(61)
	OLS	-143.59(41)	-1.05(26)	-0.39(31)	-0.26(11)	-0.1(54)
	RLS	-69.74(1)	-0.55(62)	-0.22(67)	-0.13(94)	-0.04(18)
	BLUP	-75.47(61)	-0.34(45)	-0.22(81)	-0.15(18)	-0.05(89)
53	DFREML	1429.13(37)	7.33(1)	4.92(20)	2.95(40)	1.06(20)
	OLS	-139.08(54)	-1.02(62)	-0.34(20)	-0.2(94)	-0.1(61)
	RLS	-68.88(20)	-0.55(31)	-0.21(94)	-0.12(1)	-0.04(10)
	BLUP	-72.84(54)	-0.33(29)	-0.19(59)	-0.14(50)	-0.04(1)

Figures within parenthesis are sire numbers

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

VARIABLE	DFREML X OLS	DFREML X RLS	DFREML X BLUP	OLS X RLS	OLS X BLUP	RLS X BLUP
FLY	0.655	0.599	0.670	0.943	0.918	0.877
FPY	0.778	0.800	0.712	0.936	0.685	0.726
MLL	0.551	0.548	0.488	0.990	0.870	0.861
MCI	0.527	0.500	0.523	0.966	0.862	0.868
MSC	0.572	0.536	0.514	0.978	0.818	0.835

Table.4 Product-moment correlation among estimated sire merits for different performance traits calculated by various sire evaluation methods

VARIABLE	DFREML X OLS	DFREML X RLS	DFREML X BLUP	OLS X RLS	OLS X BLUP	RLS X BLUP
FLY	0.654	0.636	0.671	0.980	0.942	0.941
FPY	0.835	0.801	0.710	0.964	0.740	0.723
MLL	0.547	0.543	0.485	0.988	0.861	0.852
MCI	0.533	0.493	0.520	0.979	0.862	0.846
MSC	0.509	0.504	0.494	0.976	0.791	0.813

Table.5 The standard error, coefficient of skewness and kurtosis for different performance traits calculated by various sire evaluation methods

VARIABLE	COEFFICIENT OF SKEWNESS				COEFFICIENT OF KURTOSIS				STANDARD ERROR			
	SDA	OLS	RLS	BLUP	SDA	OLS	RLS	BLUP	SDA	OLS	RLS	BLUP
FLY	0.371	0.254	0.282	0.331	0.003	0.029	0.441	0.397	165.24	139.20	58.47	75.64
FPY	0.328	0.122	0.065	0.670	0.066	0.887	1.180	0.034	0.83	0.91	0.50	0.37
MLL	0.409	0.135	0.386	0.429	0.288	0.260	0.139	0.336	0.50	0.39	0.19	0.19
MCI	0.503	0.387	0.214	0.123	0.346	0.216	0.277	0.341	0.34	0.24	0.10	0.13
MSC	0.554	0.376	0.526	0.422	0.314	0.122	0.057	1.355	0.14	0.10	0.04	0.06

RLS computations are more tedious than BLUP because of the size of the matrix that must be inverted to get to the inverse elements needed for computation of RLS estimates. Contrarily, OLS and BLUP are easy to compute since the least-squares and mixed model equations are well suited to the iterative solution and consequently inversions not required. Moreover, RLS is not a suitable method for evaluation sires as compared to

mixed model equation method (Henderson, 1978). On a theoretical basis, the BLUP is the best and has minimum prediction error variance provided that true variance of random effects is known. Therefore, it is suggested use BLUP procedure in a situation where correct ratio of residual variance to sire variances 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 situation where correct ratio of residual variance to sire variance is not known.

Acknowledgement

We thank to department of animal genetics and breeding, department of livestock production and management and icar-CIRB Hisar.

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How to cite this article:

Vikram Jakhar, A.S. Yadav and Dhaka, S.S. 2019. Comparative Efficiency of Sire Evaluation Procedures in Murrah Buffaloes. *Int.J.Curr.Microbiol.App.Sci.* 8(02): 2065-2072. doi: <https://doi.org/10.20546/ijcmas.2019.802.239>