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A Comparison of Different Methods of Sire Evaluation for Production and Reproduction Traits of Murrah Graded Buffaloes

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Abstract:
First lactation monthly test day records of 2329 buffaloes sired by 79 sires distributed in 47 villages under field progeny testing programme in Anand milk shed were used to evaluate sires for age at first calving (AFC), first lactation predicted milk yield (FLY305) and milk fat percent (fat%) traits. The objective of the study was to estimate the sire breeding value and to compare various methods of sire evaluation viz. simple daughter's average (D) , contemporary comparison (CC), least squares (LS), best linear unbiased prediction (BLUP) and average information restricted maximum likelihood (AIREML) in terms of accuracy and efficiency. Heritability estimates by Least Square –Analysis of Variance (LS-ANOVA) method were 0.252 ± 0.044, 0.065 ± 0.032and 0.073 ± 0.035, respectively for AFC, FMY305 and Fat%. The genetic correlation of AFC with FLY305 and Fat% were -0.782 ± 0.192 and -0.451, respectively while the same between FLY305 and fat percent was 1.044 ± 0.39. The phenotypic correlations of FLY305 with Fat % and AFC were -0.042 and 0.109, respectively while same between Fat % and AFC was -0.099. For AFC, the AIREML had the lowest error variance than LS and BLUP, thus was the most efficient method. For FMY305 and Fat%, the BLUP was found to have lowest error variance and therefore, was the most efficient method. The relative accuracies in terms of rank correlations of D, CC, LS and BLUP methods with most efficient AIREML method were 0.35, 0.90, 0.37 and 0.97, respectively for AFC. For FLY305, the value of rank correlations of D, CC, LS and AIREML with most efficient BLUP method were 0.71, 0.71, 0.72 and 0.98, respectively. The values of rank correlations of D, CC, LS and AIREML with most efficient BLUP method were 0.89, 0.89, 0.95 and 0.99, respectively and these estimates of rank correlation were highly significant (P < 0.01).

Keywords: *AIREML, BLUP, DMU, Graded Murrah, Sire evaluation*

1. Introduction

In India, buffalo production plays an important role in the economies of the farmers and the country. India possesses 56 % population of whole world's buffalo population (Das *et al.* 2008). However, production per animal is comparatively low. So, to increase and to meet the rising demand for milk and milk products in India, the genetic improvement through grading up and selective breeding including progeny testing programme of the indigenous buffalo is the key. In India, large numbers of progeny testing programme in indigenous breed is being implemented but most of studies pertaining to progeny testing programme on buffalo in India are on institutional herds (Geetha *et al.* 2007) and rarely based on field recorded herd (Patel *et. al.* 2006). Grading up of Surti buffalo with Murrah breed was initiated in 1988 by AMUL Research and Development Association (ARDA), Amul, Anand and so, it is the largest population of Graded Murrah in India found in Anand and nearby districts. The present research work was planned to estimate the breeding values of sires by different methods for first lactation predicted milk yield (LMY305), milk fat% and age at first calving (AFC) and to compare the efficiency and accuracy of various sire evaluation methods in Murrah graded buffaloes.

2. Material and Methods

The first lactation monthly test day records of 2522 Murrah graded buffaloes scattered over 50 different villages of AMUL milk shed and progenies of 104 sires born under field progeny testing programme during 1998 to 2007 were collected from AMUL Research and Development Association (ARDA), AMUL, Anand and utilized for the present study. The buffaloes under study were milked twice a day at almost equal interval by hand milking. Milk recording was started from sixth day onwards after calving and all the buffaloes registered under field progeny testing programme were bred by frozen semen doses of test bulls. In the criteria of abnormal records, the lactations with five or less test day records were considered short and therefore eliminated from the study. For the increasing the accuracy of sire evaluation methods the sires with less than 10 daughters' records were eliminated from the study. At least 3 records in each Herd-Year-Season group were only considered for the study. Therefore, 2329 lactations records of daughters of 79 sires distributed in 47 villages were available for analysis for FLY305 and AFC traits and 2134 records on fat %were also available for the study. Thus, a total of around 8 percent records were discarded. The lactation milk yield from test day records was calculated using following formula.

$$305\ day\ yield(liter) = \frac{(R_1+R_2+R_3+\cdots\cdots+R_n)}{n} \times 305$$ (Anonymus, 2009)

Where, R = morning and evening milk yield in liter, n = No. of test day records

The data were grouped into different classes based on village clusters (herds), periods (years) of birth and calving, seasons and age at first calving. The total of 47 villages were clustered into six groups based on village average milk yield with an assumption that the variation in the village milk production average is due to the management practices and resources available within the village receiving random sires.

Due to year to year difference were expected to be small and hence the years were grouped in to periods on the basis of distribution of sires in a such a manner that there were minimum overlapping of sires over the period, the total duration of years from 1998 to 2007 were classified into five periods based on year of birth (1998-99, 2000-01, 2002-03, 2004-05 and 2006-07) and year of calving (2004-05,2006-07, 2008-09 and 2010-12). Moreover, on the basis of prevailing climatic condition, a year was divided into three season's viz. Winter (November-February), Summer (March-June) and Monsoon (July-October) to account for within year environmental effects. Buffaloes were assigned to 1 of 4 subclasses based on AFC in months (Age ≤ 45, 45 > age ≤ 60, 60 > age ≤ 75 and Age >75months). For AFC trait, period and season of birth of the daughters was considered, whereas for FMY305 and Fat%, period and season of calving were considered. In present study, the breeding values were estimated by different methods viz. simple daughter's average (D) method (Edward, 1932), Contemporary comparison (CC) method (Jain and Malhotra, 1971), Best Linear Unbiased Prediction (BLUP) method (Mrode and Thompson, 2005) and Average Information Restricted Maximum Likelihood (AIREML) Method (Thompson, *et al.* 2005).

1. Simple daughter average (D) Index $I = \overline{D}$(Edwards, 1932)

Where, I = index of sire's transmitting ability$\overline{D}$ = daughter's average

2. Contemporary comparison (CC) method $I = A + \left[\frac{2nh^2}{4+(n-1)h^2}\right](\overline{D}_i - C_{D_i})$

(Jain and Malhotra, 1971)

Where, A = Herd average, C_{D_i} = Average of contemporaries for the daughters of i[th] sire

$\overline{D}_i$ = Average of daughters of the i[th] sire, n = number of daughters of the sire,h^2 = heritability of the trait

The contemporaries of a cow are considered to be the daughters of the other sires performing at the same time period in the same herd group.

3. Least square (LS) analysis method

Under LS method, data adjusted for significant non-genetic factors were used for sire evaluation.

$y_{ij} = \mu + S_i + e_{ij}$ Where, y_{ij} = observation on j^{th} progeny of i^{th} sire on data corrected for significant non genetic factor(s) for a trait, μ = overall mean for corrected data, S_i = effect of i^{th} sire, e_{ij} = random error, assumed to be normally and independently distributed with mean zero and constant variance i.e. NID $(0,\sigma_e^2)$. The sire constant (S_i) obtained by LS technique was used in getting the sire index as estimated by following formula:

$$I = \left[\frac{2nh^2}{4+(n-1)h^2}\right]S_i \qquad \text{(Harvey, 1987)}$$

4. Best Linear Unbiased Prediction (BLUP) method

Under BLUP method, the sire effects were obtained by using single trait model. For this purpose the LS estimates of variance components from the corresponding model were used. The BLUP and AIREML evaluations were based on an animal model which utilized information from all the known relationships. The BLUP and AIREML evaluations were obtained under single trait animal model. AFC was taken as co-variable to the FMY305 and Fat%. The data were analysed using BLUPF90 DairyPAK, Version3 (Duangjinda *et al*, 2007).

$y = Xb + Za + e$ Where, y = observational matrix of traits, b = vector of fixed effects, a = vector of random effects, X and Z = design matrices for fixed and random effects respectively,

e = residual random effects vector. It is assumed that var $\begin{pmatrix} a \\ e \end{pmatrix} = \begin{pmatrix} A\sigma_a^2 & 0 \\ 0 & I\sigma_e^2 \end{pmatrix}$

Where, A = matrix of additive genetic relationships between individuals, I = identity matrix σ_a^2 and σ_e^2 are additive and residual genetic variances

5. Average Information Restricted Maximum Likelihood (AIREML) Method

The data were analyzed using DMU, a package analyzing multivariate mixed models (Madsen and Jensen, 2010). The same single trait models described in the method for BLUP were used for AIREML.

6. Effectiveness of various sire evaluation methods

The effectiveness of different sire evaluation methods were judged by various viz. within sire variance or error variance which give lowest error variance considered as to be the most efficient and most appropriate. Relative efficiency (RE) of method II with respect to method I (most efficient method) was calculated by the following equation:

$$RE\ (\%) = \frac{error\ variance\ of\ method\ I}{error\ variance\ of\ method\ II} \times 100$$

Another method Spearman's rank correlation is the correlation between breeding values of sires derived by various methods was used to judge the effectiveness of different methods. The rank correlation was estimated as per Steel and Torrie (1960).

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

Where, r = Rank correlation coefficient, n = Number of sires under evaluation, d_i = Difference of rank between paired items under two methods.

The significance of rank correlation was tested by t-test as given below:

$$t = r\sqrt{\frac{n-2}{1-{r_s}^2}}$$

3. Results and Discussion

The heritability estimates by paternal half-sib correlation method were obtained using model -2 of LSMLMW programme of Harvey PC version-2. The heritability estimate for AFC, FLY305 and Fat% were 0.252 ± 0.044, 0.065 ± 0.032 and 0.073±0.035, respectively. The least squares estimates of genetic correlations of FLY305 with Fat % and AFC were 1.044 ± 0.39 and -0.782 ± 0.192, respectively while same between Fat % and AFC was -0.451 ± 0.199. The phenotypic correlations of FLY305 with Fat % and AFC were 0.109 and -0.042, respectively while between Fat % and AFC was -0.099.

In the present study the phenotypic correlation coefficient between AFC and FLY305 was negative. This indicates that buffaloes with lower AFC would be expected to have higher milk production in the first lactation. The interest of the breeder would be to reduce AFC. This reduction is likely to be associated with genetic improvement in FLY305 as revealed by the negative genetic correlations. Therefore, the negative estimates of genetic correlation between AFC and FLY305 and AFC and Fat % are in the desirable direction. The estimate of heritability for AFC was reported as 0.214 by Raheja *et al.* (2000) in Murrah buffalo and 0.250 ± 0.207 by Shashidharan *et al.* (1999) in Surti buffalo. The heritability estimate for FLY305 was lower than those reported as 0.072 ± 0.114 by Gajbhiye and Tripathi (1991) and 0.083 ± 0.134 by Singh *et al.* (1998) in Murrah buffalo. Not much data available on Fat% trait pertaining to field population data.

3.1 Sire Evaluation

The population means estimated by the different methods were not the same, therefore, the sire effects were taken as deviation of the sires' breeding value from the population mean for simple daughter's average, contemporary comparison and BLUP methods. The population mean for AFC with 1763.32 days was used for deviation under simple daughter's average method, CC and BLUP methods and the least square mean with 1806.22 days was used for deviation under LS method. Under all the methods, about half of the sires(range: 45.57 % (LS)to 54.43 % (AIREML)) with negative sire effect were found to be superior and the other (range: 45.57 % (AIREML)to 54.43 % (LS))with positive sire effect were inferior to the population average. The range of sire effect for AFC were -367.41 to 615.01, -202.37 to 290.99, -453.56 to 574.54, -184.87 to 204.10 and -91.40 to 68.49 days under simple daughter average, CC, LS method, BLUP method and AIREML method, respectively and the breeding values of top ten sires are presented in Table 1.The present finding of sire effect of AFC with negative value indicated the breeding values of top ranking sire were 1395.91, 1560.95, 1578.45 and 1671.92 days for simple daughter average, CC, BLUP and AIREML which was fairly match with the breeding value for AFC as reported by Jain and Sadana (2000) for Murrah buffalo under Station Progeny Testing programme.

For FLY305 the estimated population mean of 1546.00 liter was used for deviation under simple daughter, CC and BLUP methods, and least square mean of 1530.60 liter under LS method. Under all the methods about half of the sires (range: 43.04 % to 53.16 %) were above and the other half (range: 46.83 % to 56.96 %) were below the population mean. The ranges of sire' effects for FLY305 were -198.38 to 158.73, -83.73 to 92. 28, -76.5 to 109.36, -21.58 to 28.10 and -6.24to 7.92 liter for simple daughter, CC, LS, BLUP and AIREML, respectively and the breeding value of top ten sires for FLY305 using different methods are presented in Table 2. The present finding of sire effect for FLY305 indicated the breeding values of top ranking sire were 1704.73, 1638.28, 1574.10 and 1553.92 liter for simple daughter average, CC, BLUP and AIREML, respectively, which was higher than reported by Ahmad *et.al.* (2009) and less than reported by Khan and Gaffar (2007) in Nili-Ravi buffalo under progeny testing programme.

For Fat % the estimated average of 7.0399 was used for deviation under simple daughter, CC,AIREML and BLUP methods, and 7.008 under LS method. Under all the methods about half of the sires (range: 47.87 % to 53.62 %) were above and the other half (range: 46.38 % to 52.17%) were below the population mean. The ranges of sire' effects for Fat % were -0.455 to 0.327, -0.170 to 0.264, -0.159 to 0.266, -0.055 to 0.081and -0.048 to 0.070liter for simple daughter, CC, LS, BLUP and AIREML, respectively. The range of sire effect was maximum under Simple daughter, followed by CC, LS mean, BLUP and AIREML and the breeding values of top 10 sires for Fat% are presented in Table 3.

3.2 Efficiency of Sire Evaluation Methods

An efficient method of sire evaluation should have minimum error variance. The sire evaluation method/model which gave the lowest error variance was considered to be most efficient. The error variance of various sire evaluation methods for AFC, FLY305 and Fat % are presented in Table4.

3.3 Relative Accuracy of Sire Evaluation Methods with respect to most Efficient Method

The relative accuracy of a method with respect to the most efficient method as well as between other methods was estimated in terms of rank correlation coefficients. The rank correlations between different methods of sire evaluation for AFC, FLY305 and Fat% are presented in Table 5. The estimates of rank correlation were highly significant ($P < 0.01$). As such all these methods are expected to rank sires with similar accuracy as compared to the most efficient method. However, the magnitude of the rank correlation indicated that relative accuracy was higher for CC and BLUP methods followed by LS and D.

For FLY305 trait, the magnitude of rank correlations was highest with AIREML. The LS, D and CC showed comparatively equal rank correlations with BLUP. For Fat % trait, All the methods have high magnitude of rank correlations with BLUP method. The D and CC showed equal rank correlations with BLUP.

The results of the present study were comparable with those reported by Mukherjee *et al.* (2007), Banik and Gandhi (2006) with high rank correlation value among all methods and comparable fairly well with Singh and Singh (2011), Kumar and Gandhi (2010), Singh *et al.* (2010), Tailor *et al.* (2000) with high and positive correlation with Least Square as best method of sire evaluation.

According to rank correlation, the numbers of sires which are common among the different methods are presented in Table 5 (above diagonal). The maximum number of sires are common for BLUP and AIREML methods viz. 8, 10 and 10 sires for AFC, Fat% and FLY305, respectively indicating both BLUP and AIREML methods as most efficient and optional methods of sire evaluation for field progeny testing programme. The maximum numbers of common sire are for BLUP and AIREML might be due to similarity of model as compared to other methods viz. D, CC and LS where no regression coefficient applied. The AIREML was found to be the most efficient method for AFC trait while BLUP was found to be the most efficient method for FMY305 and Fat% traits but still need to be defined firmly.

4. Conclusion

In present study of comparison of different sire evaluation method for field progeny testing programme, for AFC trait AIREML method and for FMY305 and Fat% traits BLUP methods were found the best methods of sire evaluation with lower error variance and high accuracy.

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Tables:

Table 1:Tentop ranking sires for AFC estimated by different methods of sire evaluation

Sire	D		CC		LS		BLUP		AIREML	
	Rank	BV	Rank	BV	Rank	BV	Rank	BV	Rank	BV
330	1	-367.41	-	-	7	-348.89	-	-	-	-
310	2	-355.88	4	-175.61	3	-436.71	4	-119.71	7	-45.46
322	3	-351.62	-	-	-	-	-	-	-	-
328	4	-339.90	-	-	8	-341.88	-	-	-	-
331	5	-268.92	-	-	-	-	-	-	-	-
313	6	-262.91	8	-110.17	4	-394.38	-	-	-	-
285	7	-250.92	2	-199.62	2	-446.38	2	-180.84	3	-84.46
302	8	-250.28			5	-382.96	-	-	-	-
277	9	-248.74	1	-202.38	1	-453.56	1	-184.87	1	-91.41
297	10	-225.66	5	-170.47	6	-366.70	-	-	-	-
253	-	-	3	-188.10	-	-	3	-175.63	2	-90.62
238	-	-	6	-156.34	-	-	6	-111.82	8	-41.16
255	-	-	7	-154.08	-	-	7	-109.93	5	-48.76
217	-	-	9	-107.98	-	-	-	-	-	-
254	-	-	10	-94.68	-	-	-	-	-	-
272	-	-	-	-	9	-340.69	-	-	9	-38.33
318	-	-	-	-	10	-337.74	-	-	-	-
247	-	-	-	-	-	-	5	-119.30	4	-58.54
258	-	-	-	-	-	-	8	-101.30	6	-46.63
209	-	-	-	-	-	-	9	-99.27	-	-
191	-	-	-	-	-	-	10	-99.07	-	-
260	-	-	-	-	-	-	-	-	10	-36.52

Table 2 : Ten top ranking sires for FLY305 estimated by different methods of sire evaluation

Sire	D		CC		LS		BLUP		AIREML	
	Rank	BV	Rank	BV	Rank	BV	Rank	BV	Rank	BV
187	1	158.73	1	92.28	-	-	5	22.78	5	6.13
280	2	124.16	7	63.55	1	109.36	6	21.33	6	6.06
328	3	118.73	10	52.06	-	-	-	-	-	-
323	4	115.49	3	77.87	6	84.78	-	-	-	-
254	5	101.75	2	79.36	3	87.37	1	28.10	1	7.92
271	6	93.45	-	-	4	86.61	-	-	-	-
285	7	89.42	-	-	2	91.62	-	-	-	-
297	8	88.73	4	76.51	10	72.01	8	18.98	8	5.30
266	9	85.36	5	72.58	5	85.93	4	24.46	4	6.99
255	10	83.57	6	67.28	7	82.20	3	26.29	3	7.53
301	-	-	8	61.90	9	74.07	-	-	-	-
228	-	-	9	55.29	-	-	-	-	-	-
275	-	-	-	-	8	80.41	-	-	-	-
253	-	-	-	-	-	-	2	26.40	2	7.79
259	-	-	-	-	-	-	7	20.33	7	5.79
260	-	-	-	-	-	-	9	18.91	9	5.50
315	-	-	-	-	-	-	10	17.68	10	4.91

Table 3 : Ten top ranking sires for Fat % estimated by different methods of sire evaluation

Sire	D		CC		LS		BLUP		AIREML	
	Rank	BV	Rank	BV	Rank	BV	Rank	BV	Rank	BV
297	1	0.327	1	0.264	1	0.266	2	0.060	2	0.060
328	2	0.269	8	0.096	10	0.109	-	-	-	-
271	3	0.260	3	0.194	2	0.239	7	0.031	7	0.031
252	4	0.223	4	0.186	3	0.194	4	0.038	4	0.038
242	5	0.212	2	0.199	4	0.187	1	0.081	1	0.070
323	6	0.158	-	-	8	0.123	-	-	-	-
285	7	0.141	-	-	6	0.155	-	-	-	-
281	8	0.134	-	-	-	-	-	-	-	-
279	9	0.134	10	0.095	5	0.157	6	0.034	6	0.034
260	10	0.132	5	0.155	7	0.150	3	0.043	3	0.043
231	-	-	6	0.105			10	0.025	10	0.025
214	-	-	7	0.102	-	-	-	-	-	-
246	-	-	9	0.095	-	-	-	-	-	-
311	-	-	-	-	9	0.116	5	0.037	5	0.037
319	-	-	-	-	-	-	8	0.028	8	0.028
229	-	-	-	-	-	-	9	0.025	9	0.025

Table 4: Relative efficiency of different sire evaluation methods for different first lactation traits in Murrah graded buffalo

Trait	Method	Error Variance	Relative efficiency of methods
AFC	LS	126446.546	87.89
	BLUP	119448.950	93.04
	AIREML	111139.516	100.00
FLY305	LS	106933.977	79.93
	BLUP	85477.005	100.00
	AIREML	106933.977	79.93
Fat %	LS	0.431	90.61
	BLUP	0.390	100.00
	AIREML	0.438	89.04

Table 5. : Rank correlation (below the diagonal) between different methods and number of common (above diagonal) sires out of ten for AFC, Fat% and FLY305

AFC					
Method	**D**	**CC**	**LS**	**BLUP**	**AIREML**
D		5	8	3	3
CC	0.47**		5	6	6
LS	0.98**	0.49**		3	5
BLUP	0.36**	0.83**	0.25**		8
AIREML	0.35**	0.90**	0.37**	0.98**	
Fat %					
Method	D	CC	LS	BLUP	AIREML
D		7	9	6	6
CC	0.94**		7	7	7
LS	0.97**	0.96**		7	7
BLUP	0.89**	0.91**	0.95**		10
AIREML	0.89**	0.89**	0.91**	0.99**	
FLY305					
Method	D	CC	LS	BLUP	AIREML
D		8	8	6	6
CC	0.84**		7	6	6
LS	0.98**	0.84**		5	5
BLUP	0.71**	0.71**	0.72**		10
AIREML	0.70**	0.71**	0.71**	0.98**	

*** Correlations were significantly different at 1% of level (P < 0.01) from zero.*