Sire Evaluation Using Animal Model and Conventional Methods in Murrah Buffaloes

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ABSTRACT : First lactation records of 683 Murrah buffaloes maintained at National Dairy Research Institute, Karnal, were used for comparing the sire evaluation for age at first calving, first lactation 305-day or less milk yield and first service period. The sires were evaluated using Simple daughters average, Contemporary comparison, Least-squares and BLUP methods. The BLUP evaluations were obtained under single-, two- and three-trait individual animal models. The results revealed that for taking a decision regarding the method of sire evaluation to be used for selecting sires with high breeding values, criteria of the rank correlation could be misleading and comparison of the selected sires is likely to give a veritable picture. The Best Linear Unbiased Prediction method under multi-trait animal model incorporating first lactation milk yield with first service period as a covariable and age at first calving in the model was found to be more efficient and accurate for sire selection in Murrah buffaloes. ***(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 9 : 1196-1200)***

Key Words : Animal Model, Multi-Trait, Murrah Buffaloes, Sire Evaluation

INTRODUCTION

A number of methods for bull evaluation in cattle and buffaloes have been studied under Indian conditions; the most common of these are: simple daughters average, contemporary comparison, least-squares and BLUP using a sire model. None of these methods is sufficient by way of utilizing all the available information (from all the relationships among animals). However, the contemporary comparison method, in addition to adjusting for environmental factors, in some cases also accounts for the performance of dams of the daughters. These days, however, with the advancement in the computer and computing technologies, use of BLUP method using an individual animal model has become very common in advanced countries owing to its various advantages including sufficiency i.e. utilization of all the available relationships among animals. The method, however, has not been studied under Indian conditions so far. The present study was, therefore, undertaken to compare the efficiency and accuracy of sire evaluation using the conventional methods and the recent BLUP method under an individual animal model. For this purpose, various single and multiple trait models were examined under BLUP method.

MATERIALS AND METHODS

First lactation records of 683 Murrah buffaloes, progeny of 84 sires, maintained at National Dairy Research Institute, Karnal were used. The records pertained to the year of birth from 1967 to 1991 and year of calving from 1971 to 1994. Cows culled in the middle of lactation, abortion and other pathological causes which affected the lactation were considered abnormal. Hence, such records were excluded from the analysis. The records with less than 500 kg of milk production or less than 100 days of lactation length were also excluded. A total of 17% records were discarded on account of these restrictions.

As the year to year differences were expected to be small, the total duration from 1967 to 1994 was classified into five periods based on year of birth (67-70, 72-76, 77-83, 84-87 and 88-91) and year of calving (71-74, 75-80, 81-86, 87-90 and 91-94). Moreover, a year was divided into four seasons viz. winter (December-March), summer (April-June), rainy (July-September) and autumn (October-November) to account for within year environmental effects. The sires were evaluated for age at first calving (AFC), first lactation 305-day or less milk yield (F305MY) and first service period (FSP). For AFC, period and season of birth of the buffalo were considered, whereas for milk yield and FSP, period and season of calving were considered. A total of 84 sires were evaluated; but the number was reduced to 80 when FSP was taken as a co-variable to F305MY.

Following four methods of sire evaluation were used:

a) Simple daughter average (D) method (Edward, 1932)

$$I_i = D$$

where,

I_i: is the sire index for ith sire,

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D: is the daughters' average for first lactation traits of the sire.

b) Contemporary comparison (CC) method (Jain and Malhotra, 1971)

$$I_i = A + \frac{2n_ih^2}{4+(n_i-1)h^2}(D_i - C_D)$$

where,

I_i: is index of the ith sire,

A: is population mean,

n_i: is the number of daughters of the ith sire,

h^2: is the heritability of the trait

D_i: is the average of daughters of the ith sire

C_D: is the contemporaries' average

The daughters with same year of birth for AFC, and same year of calving for F305MY were considered as contemporaries. The LS heritability estimates used in this method were 0.304 and 0.203 for AFC and F305MY respectively. These estimates were obtained using the model which included period and season as fixed effects, and sire as random effect. This model was found to be the most appropriate (Jain and Sadana, 1998).

c) Least squares (LS) analysis method (Harvey, 1966)
Model:

$$y_{ij} = \mu + s_i + e_{ij}$$

where,

y_{ij}: is the observation on jth progeny of ith sire on data corrected for significant non-genetic factor(s) for a trait

μ: is overall mean for the corrected data,

s_i: is the effect of ith sire,

e_{ij}: is random error NID $(0,\sigma_e^2)$

For this model, the data adjusted for non-genetic effects were used. The adjustment factors used were as obtained by Jain and Sadana (1998) under the model referred above. The software programme used was LSMLMW of Harvey (1990).

(d) Best Linear Unbiased Predictor (BLUP) method (Henderson, 1973)
Model:

$$y = \mathbf{Xb} + \mathbf{Zu} + e$$

where,

y: is an observational matrix of traits (AFC and F305MY),

b: is a vector of fixed effects (periods, seasons and FSP as a co-variable),

u: is a vector of random effects (animal),

X and **Z**: are design matrices for fixed and random effect respectively

For this model the mixed model equations can be represented as:

$$\begin{bmatrix} X'R^{-1}X & X'R^{-1}Z \\ Z'R^{-1}X & Z'R^{-1}Z+G^{-1} \end{bmatrix} \begin{bmatrix} b \\ u \end{bmatrix} = \begin{bmatrix} X'R^{-1}y \\ Z'R^{-1}y \end{bmatrix}$$

By solving these mixed model equations, BLUP of breeding value of all the animals (including sires) were obtained under single and multiple trait models. For this purpose, the Restricted Maximum Likelihood estimates of (co) variance components from the corresponding models were used as obtained by Jain and Sadana (2000). The software programme used were DFREML of Meyer (1993) and PEST of Groeneveld (1990).

The population means estimated by the different methods were not the same, therefore, the 'sire effects' taken as deviation of the sires' breeding values from the population mean are presented and discussed for the purpose of sire evaluation and comparison under different methods/models.

The efficiency of sire evaluation was evaluated on the basis of (a) within sire variance or error variance, and (b) Spearman's rank correlation (Steel and Torrie, 1960) of breeding values worked out by different methods. The significance of rank correlation was tested by using the formula $t = r(n-2)/(1-r^2)$ with n-2 degrees of freedom.

RESULTS AND DISCUSSION

The sires were evaluated for AFC, F305MY and FSP. Since the heritability estimates of FSP were either near zero or non-estimable, therefore, the sire effects for this trait were also zero or near zero under all the methods except the simple daughter average method. As such, further discussion of sire evaluation for FSP was not required.

The estimated average AFC of 43.67 months was used for simple daughter average, CC and BLUP methods, and 44.33 months for LS method. Range of the sire effect and percent of the sires above and below the population average under each method are given in table 1. Under all the methods and models, except the two trait BLUP models with FSP as a covariable to the F305MY, about half of the sires (range: 48.8% to 58.3%) were superior and the other half (range: 41.7% to 51.2%) were inferior to the population average. Consideration of FSP as a

Table 1. Details of sire evaluation under different models

Method	Traits considered	Percent of sires with		Minimum sire effect			Maximum sire effect		
		-ve sire effect	+ve sire effect	value	% of mean	sire code	value	% of mean	sire code
Age at first calving (AFC)									
D	AFC	55.95	44.05	-9.00	-20.61	478	9.08	20.79	473
CC	AFC	53.57	46.43	-4.22	-9.66	456	3.96	9.07	473
Ls	AFC	52.38	47.62	-6.77	-15.28	478	7.59	17.13	473
BLUP1	AFC	58.33	41.67	-2.54	-5.82	456	3.33	7.63	1004
BLUP2	F305MY, AFC	50.00	50.00	-2.37	-5.43	456	3.50	8.02	1004
BLUP3	F305MY, AFC, FSP	48.81	51.19	-2.41	-5.52	456	3.55	8.12	1004
BLUP2-C	F305MY+covFSP, AFC	78.75	21.25	-2.70	-6.17	652	1.87	4.29	1004
First lactation 305-day or less milk yield (F305MY)									
D	F305MY	50.00	50.00	-719.47	-40.46	47	747.89	42.06	2321
CC	F305MY	50.00	50.00	-245.38	-13.80	480	293.78	16.52	2321
LS	F305MY	46.43	53.57	-563.25	-32.51	2709	495.78	28.62	1992
BLUP1	F305MY	79.76	20.24	-175.61	-9.88	2288	97.31	5.47	475
BLUP2	F305MY, AFC	79.19	23.81	-169.75	-9.55	2288	93.12	5.24	475
BLUP3	F305MY, AFC, FSP	83.33	16.67	-139.67	-7.86	2288	63.79	3.59	475
BLUP1-C	F305MY+covFSP	43.75	56.25	-112.04	-6.09	2288	106.53	5.79	475
BLUP2-C	F305MY+covFSP, AFC	46.25	53.75	-115.47	-6.28	2288	120.76	6.56	475

AFC=age at first calving, CC=contemporary comparison, D=simple daughters' average, F305MY=first lactation 305-day or less milk yield, FSP=fist service period, LS=least-squares.

covariable to F305MY in the BLUP2-C model had differential effect of adjustment on AFC. The adjustment due to FSP in the records with higher AFC was observed to be more. Thus, the upper limit of sire effects for AFC was reduced from about 3.5 months in the other BLUP models to 1.87 months in BLUP2-C model whereas, the lower limit was almost unaffected. As a consequence, under BLUP2-C model, 78.75% of the sires had negative sire effects and only 21.25% were with positive sire effects.

The range of sire effects was maximum under simple daughter average, followed by LS, CC and BLUP1 methods in that order. The range under BLUP2 and BLUP3 models were similar to BLUP1 model. However, the upper limit of sire effects under BLUP2-C model was almost half of the other BLUP models.

It was observed that the top ranking sire was not the same under all the methods. However, it was same (Code No.456) under all the BLUP models except that under BLUP2-C. The bottom ranking sire was same (Code No.1004) under all the BLUP models.

For F305MY the estimated average of 1778.04 kg was used for simple daughter average, CC and BLUP (BLUP1, BLUP2 and BLUP3) methods; 1839.22 kg for BLUP1-C and BLUP2-C models, and 1732.44 kg for LS method. Under all the methods, except BLUP1, BLUP2, and BLUP3 models, about half of the sires (range : 50.0% to 56.3%) were above and the other half (range: 43.8% to 50.0%) were below the population mean. Under BLUP1, BLUP2 and BLUP3 models about 80% of the sires (range: 79.2% to 83.3%) had negative sire effects whereas about 20% (range: 16.7% to 23.8%) had positive sire effects. When FSP was taken as a covariable to F305MY, then about 45% of the sires (43.8% under BLUP1-C and 46.3% under BLUP2-C models) had negative sire effect and about 55% (56.3% under BLUP1-C and 53.8% under BLUP2-C models) had positive sire effect. This can be due to the fact that variation in F305MY caused by FSP was accounted for in BLUP1-C and BLUP2-C models where FSP was taken as a covariable. The negative sire effects were influenced more under these models.

For F305MY, the range of sire effects was maximum under simple daughter average, followed by LS, CC and BLUP1 methods. The range under BLUP2 model was similar to that under BLUP1 model, but was slightly lower under BLUP3 model. The sire effects under BLUP1-C and BLUP2-C models were shifted in the positive direction as compared to other BLUP models.

From these results, it can be surmised that both for AFC and F305MY, the range of sire effects was maximum under simple daughter average method because non-genetic variations were not accounted for under this method, followed by LS, CC and BLUP methods which accounted for more and more of the non-genetic variation in that order. Consideration of FSP as a covariable further helped in accounting for the variation in F305MY due to variation in FSP, This is supported by the reduction in the error variance which was, in general, the highest under simple daughter average, followed by LS, CC, and the minimum in BLUP models.

Efficiency of sire evaluation under single and multiple traits

The sire evaluation method or model which gave the lowest error variance or within sire variance was considered to be the most efficient. The error variance of various sire evaluation methods or models for AFC and F305MY is given in table 2.

The BLUP2-C method was taken as most efficient because it had lowest error variance both for AFC and F305MY. For AFC, the relative efficiency of all the single and multiple trait BLUP models was similar. The CC, simple daughter average and LS methods with the relative efficiency of 91.43, 86.90 and 86.09 percent respectively were also equally efficient in evaluating sires for AFC.

For F305MY, the relative efficiency of BLUP1-C model was 97 percent. Next in the order of efficiency were the other BLUP models (BLUP1, BLUP2 and BLUP3) with the relative efficiency of more than 72 percent. The conventional methods of sire evaluation (CC, LS and D) had the relative efficiency of about 67 percent.

Relative accuracy of sire evaluation with respect to most efficient method

The relative accuracy of a method was estimated in terms of its rank correlation with the most efficient method. Another criteria taken was the number of common sires from the top 10 ranking as compared to the most efficient method. The rank correlation of various methods/models with the most efficient BLUP2-C model and the number of common sires from top 10 ranking are presented in table 2.

For AFC, the BLUP models and simple daughter average method had the rank correlation of 0.88 with the most efficient BLUP2-C model; the values for LS and the CC methods were 0.78 and 0.69 respectively. Similarly, for F305MY, BLUP1-C model had the highest rank correlation of 0.98 with the most efficient BLUP2-C model followed by the other BLUP models (BLUP1, BLUP2 and BLUP3) and then the other methods (simple daughter average, CC and LS methods). Although the relative accuracy of BLUP method was higher when compared with the other methods, the rank correlation estimates suggested that all the methods were statistically similar ($p<0.01$) in their accuracy for ranking sires for AFC as well as

Table 2. Relative efficiency and accuracy of sire evaluation as compared to the most efficient, BLUP2-C method

Method	Traits considered in the model	Error variance	Relative efficiency	Rank correlation*	No. of common sires**
Age at first calving (AFC)					
D	AFC	31.645	86.90	0.8826	6
CC	AFC	30.077	91.43	0.6911	5
LS	AFC	31.944	86.09	0.7751	4
BLUP1	AFC	27.537	99.87	0.8800	8
BLUP2	F305MY, AFC	27.527	99.90	0.8823	8
BLUP3	F305MY, AFC, FSP	27.501	100.00	0.8889	8
BLUP2-C	F305MY+covFSP, AFC	27.500	100.00	1.0000	10
First lactation 305-day or less milk yield (F305MY)					
D	F305MY	169694.580	66.55	0.3748	3
CC	F305MY	163634.550	69.01	0.5875	3
LS	F305MY	166835.450	67.69	0.6393	3
BLUP1	F305MY	152466.440	74.07	0.8127	4
BLUP2	F305MY, AFC	151929.500	74.33	0.8194	6
BLUP3	F305MY, AFC, FSP	156043.590	72.37	0.8776	6
BLUP1-C	F305MY+covFSP	115588.800	97.70	0.9832	8
BLUP2-C	F305MY+covFSP, AFC	112931.200	100.00	1.0000	10

AFC=age at first calving, CC=contemporary comparison, D=simple daughters' average, F305MY=first lactation 305-day or less milk yield, FSP=fist service period, LS=lest-squares.

* All the rank correlations were significant ($p<0.01$).

** The top ranking ten sires were taken under each method and the sires which were common with the most efficient method (BLUP2-C) are shown in this column.

for F305MY. Nevertheless, practically only about ten percent of the sires are selected from a population under progeny testing. Therefore, when ten top ranking sires (12%) were selected under each method to find the number of common sires as compared to the most efficient method then for AFC, eight sires were common under all the other BLUP models and 4 to 6 under the other methods. However, for F305MY, eight sires were common under BLUP1-C, 4 to 6 under other BLUP models and only three under the other conventional methods (simple daughter average, CC and LS). The results of this study revealed that the criteria of rank correlation could be misleading in deciding the method of sire evaluation to be used for selecting sires as all the methods were found equally efficient under this criterion. However, comparison of the number of selected sires gave a veritable picture because this criteria was based on what is actually followed in practice in most of the cases of sire selection. From the foregoing discussion, it could be concluded that the Best Linear Unbiased Prediction method under multi-trait animal model incorporating first lactation milk yield with first service period as a covariable and age at first calving in the model (BLUP2-C) was more efficient for sire selection in Murrah buffaloes than the other models.

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