



## Sire evaluation using REML and conventional methods for first lactation 300 day milk yield in Phule Triveni cattle

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### ABSTRACT

The present study was undertaken to estimate the breeding values of 55 Phule Triveni sires for first lactation 300 day or less milk yield (FL300DMY) by using four different sire evaluation methods/models viz. Least Squares (LS), Simple Regressed Least Squares (SRLS), Best Linear Unbiased Prediction-Sire model (BLUP-SM) and Restricted Maximum Likelihood Method (REML). The REML method produced lowest error variance for FL300DMY and it was considered to be the most efficient method. The BLUP-SM method was second efficient followed by SRLS and LS methods. The estimated breeding values of sires for FL300DMY under study showed large variation between estimated breeding values of sires which revealed more genetic variation in the herd.

**Key words:** First lactation 300 day milk yield, Phule Triveni, REML, Sire evaluation

The main aim of any breeding programme is to improve the profitability through production of superior animals which can transmit the economic characters to their progeny. Milk production and reproductive performance are the two major factors with respect to overall efficiency and profitability of the dairy animals. During selection, more emphasis is given to the sire than the dam as bull can be bred to a more number of cows, especially with the advent of reproductive biotechnology methods, and therefore greater selection intensity can be applied to the males, especially in those herds responsible for providing sires and dams to the next generation. In past, breeding programs in India have focused their goals on increasing milk production, therefore it is crucial to choose selection criteria easily measured genetically and favourably related with the selection objectives of the herds. The best linear unbiased prediction (BLUP) procedures have been widely used as a standard method of sire evaluation. However, Henderson (1984) opined that analysis of variance and covariance may give biased components of variance from selected population by BLUP method, whereas restricted maximum likelihood (REML) can give bias-free estimates. Hence, the sire evaluation using advanced statistical techniques based on restricted maximum likelihood (REML) using WOMBAT as described by Meyer (2007) would be

expected to enhance the accuracy of selection of bulls/sires. However, during the past, different methods like animal models, LS and SRLS in Indian cattle breeds have been used to evaluate sires of indigenous and crossbred cattle populations in India (Dash *et al.* 2016, Kumar *et al.* 2015, Divya *et al.* 2014, Mukherjee 2005, Gaur *et al.* 2001). Hence an attempt was made to compare the effectiveness of different methods of sire evaluation for milk production in synthetic crossbred strain of cattle.

### MATERIALS AND METHODS

The data were collected from the history sheets of Phule Triveni cows maintained at Research Cum Development Project (RCDP), Mahatma Phule Krishi Vidyapeeth, Rahuri, District Ahmadnagar (Maharashtra, India) located in the semiarid scarcity zone of Maharashtra. The geographical location of RCDP livestock farm is at an elevation of 559 meters above the mean sea level and approximately lies between 19°57' North latitude and 74°19' East latitude. The climate of the farm is subtropical in nature. The minimum temperature falls to 6°C in winter, whereas the maximum temperature goes up to 45°C in summer. The annual rainfall is about 700 to 800 mm, out of which most of the rainfall is received during months of July and August. The data for the present study were obtained from the first lactation performance records of 493 Phule Triveni synthetic daughters (50% HF + 25% J + 25% G) of 55 sires maintained at Research Cum Development Project (RCDP) of Mahatma Phule Krishi Vidyapeeth, Rahuri, District Ahmadnagar (Maharashtra) from 1976 to 2012. To ensure the normal distribution of records, the outliers were removed and data within the range of Mean±3 standard deviation

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was only considered for the study. Hence, after standardisation and normalisation, records of 493 Phule Triveni cows were retained for analysis. The data on sires having at least 3 daughters per sire were considered for estimation of breeding value of sire. The records of only those animals with known pedigree and normal lactation were considered, the abnormal and incomplete lactation records were excluded from the study. The lactation records of less than 150 days and <1000 kg first lactation milk yield were considered as abnormal and were not included in the analysis. The total duration of the present study was divided into 9 periods of 4 year each. Each year was divided into 3 seasons namely summer (February to May), rainy (June to September) and winter (October to January) based on climatic conditions of the region.

*Statistical analysis:* As the data in the present study were non-orthogonal in nature with unequal subclass numbers, they were subjected to least squares analysis of variance without interactions using different models to examine the effect of genetic as well as non-genetic factors on first lactation 300 day milk yield. The model was based on the assumption that different components fitting in the model were linear, independent and additive. While sire was treated as random effect, the other non-genetic factors (season, period and age group) were taken as fixed effect in the model. Breeding values of Phule Triveni sires for first lactation 300 day milk yield (FL300DMY) were estimated by least squares method, simple regressed least squares method (Harvey 1990), BLUP-Sire model (Model 8 in Least Squares) and REML using WOMBAT software (Meyer 2007). The model used for univariate animal model (REML) was

$Y_{klmno} = \mu + SC_k + PC_l + AFCG_m + a_n + e_{klmno}$ , where,  $Y_{klmno}$ , observation;  $\mu$ , overall mean;  $SC_k$ , fixed effect of  $k^{th}$  season of calving;  $PC_l$ , fixed effect of  $l^{th}$  period of calving;  $AFCG_m$ , fixed effect of  $m^{th}$  AFC group;  $a_n$ , random effect of  $n^{th}$  animal and  $e_{klmno}$ , random error, NID  $(0, \sigma_e^2)$ . After estimation of breeding value of sires, the sires were given rank as per their genetic merit. The effectiveness of different sire evaluation methods was judged by using various criteria like within sire variance or error variance, coefficient of determination ( $R^2$ ), coefficient of variation (%) and rank correlations. The sire evaluation method with lowest error variance was considered the most efficient and appropriate method. The most accurate method showed the highest coefficient of determination ( $R^2$  value). The spearman's rank correlations and product moment correlation between

breeding values of sires derived by various methods for first lactation 300 day milk yield were also used to judge the effectiveness of different methods.

### RESULTS AND DISCUSSION

The research data were adjusted for significant genetic and non-genetic factors. The overall least squares population mean for FL300DMY was  $2647 \pm 39$  kg. The average breeding value of sires (Table 1) from different sire evaluation methods ranged from 2,561 kg (SRLS) to 2,683 kg (LS).

The estimated overall average breeding value of sires by least squares method (LS) for first lactation 300 day milk yield (FL300DMY) was 2,683 kg, which was lower than Singh and Singh (2011) for triple crossbred cattle's (RD  $\times$  S  $\times$  J and HF  $\times$  R  $\times$  J). The highest breeding value observed for FL300DMY was 3,688 kg and lowest breeding value was 1,940 kg. The difference between highest and lowest breeding value was 1,748 kg. There were 18 (33%) sires whose breeding value observed above the average breeding value and 37 (67%) sires with breeding value below the average breeding value. By simplified regressed least squares method (SRLS), the average estimated breeding value for FL300DMY was 2,561 kg. The estimated breeding values ranged between 3,547 kg to 1,968 kg under SRLS for FL300DMY which had difference of 1,579 kg. There were 24 (44%) sires having breeding value more than the average breeding value and 31 (56%) sires had breeding value lower than the average breeding value.

The average breeding value for first lactation 300 day milk yield using BLUP-SM was estimated to be 2,624 kg while Kumar *et al.* (2015) and Singh and Singh (2011) reported higher estimates of estimated breeding values in Frieswal and Triple crossbred cattle than the present study. The estimated breeding values ranged from 3,184 kg to 2,245 kg with difference of 939 kg between highest and lowest estimated breeding value. Sires, 28 (51%) out of 55, had breeding value above the average breeding value, and 27 (49%) were having breeding value below the average breeding value. The estimated average breeding value of sires by REML for FL300DMY was 2,635 kg while Divya *et al.* (2014) and Dash *et al.* (2016) reported higher estimates of estimated breeding values in Karan Fries and HF crossbred. Through REML method, the highest and lowest estimated breeding value were 3,166 kg and 2,318 kg for FL300DMY with the difference of 848 kg between highest to lowest estimated breeding values. Out of 55 sires, 26

Table 1. Average breeding values (BV) estimates for FL300DMY by different methods

Sire evaluation method	Average BV	No of sires above average BV	Number of sires below average BV	Maximum BV	Minimum BV	Difference
LS	2683	18 (33)	37 (67)	3688 (73)	1940 (138)	1748
SRLS	2561	24 (44)	31 (56)	3547 (72)	1968 (130)	1579
BLUP	2624	28 (51)	27 (49)	3184 (82)	2245 (117)	939
REML	2635	26 (47)	29 (53)	3166 (83)	2318 (114)	848

(47%) sires had breeding value above the overall average breeding value and 29 (53%) sires had the breeding value below the average breeding value.

In the present study, the estimated breeding values of sires for FL300DMY showed large variation between estimated breeding values of sires which revealed more genetic variation in herd. Large genetic variation was also observed between the estimated breeding values of sires by Dalal *et al.* (1999), Dubey *et al.* (2006) and Moges *et al.* (2009) in crossbred cattle and Kumar *et al.* (2008) in Karan Fries cattle. The estimated breeding value of sires estimated for FL300DMY by REML showed small genetic variation in comparison to LS, SRLS and BLUP-SM methods. Therefore, REML was considered as the most efficient method out of four methods of sire evaluation used in the present study.

An efficient method of sire evaluation should have minimum error variance. The sire evaluation method which gave the lowest error variance was considered to be most efficient. The error variances of various sire evaluation methods for FL300DMY are presented in Table 2. It was observed that REML method had lowest error variance for FL300DMY. The relative efficiency of LS, SRLS and BLUP-SM method was 80.57, 81.13 and 83.12%, respectively in relation to REML. The highest efficiency of REML may be ascribed to all kinds of relationships among animals over all the recorded generations accounted into animal model analysis which produced lowest error variance compared to other single-trait sire evaluation methods. The REML method showed the highest coefficient of determination (30%) as compared to other methods revealing that this method of sire evaluation was most accurate as compared to other methods (Table 2). BLUP-SM (25%) was the second best method. LS and SRLS

Table 2. Effectiveness of different sire evaluation methods for FL300DMY

Method	Error variance (kg <sup>2</sup> )	RE%	R <sup>2</sup> %
Single-trait models			
LS	331955	80.57	19
SRLS	329657	81.13	20
BLUP-SM	321777	83.12	25
REML	267473	100	30

Table 3. Rank correlations (below the diagonal) between different sire evaluation methods and number of common (above diagonal) sires out of 10 for FL300DMY

Method	LS	SRLS	ST-SM	ST-AM
LS	-	7	6	4
SRLS	0.98**	-	4	4
ST-SM	0.49**	0.49**	-	5
ST-AM	0.45**	0.49**	0.61**	-

\*\*Correlation were significantly different at 1% level of significance (P≤0.01).

Table 4. Sires of top 10 ranks on the basis of estimated breeding values of sires for FL300DMY by different methods

Rank	LSQ	SRLS	BLUP-SM	REML
1	21 (3688)	21 (3547)	21 (3184)	21 (3166)
2	25 (3616)	101 (3499)	04 (2951)	91 (3000)
3	101 (3551)	25 (3487)	91 (2887)	43 (2944)
4	02 (3264)	02 (3163)	25 (2874)	25 (2943)
5	102 (3110)	102 (3091)	44 (2873)	04 (2934)
6	17 (3046)	06 (3011)	02 (2814)	56 (2895)
7	06 (3029)	17 (2983)	05 (2805)	86 (2840)
8	05 (2973)	33 (2919)	29 (2795)	18 (2816)
9	29 (2952)	04 (2878)	47 (2785)	40 (2811)
10	04 (2923)	12 (2875)	34 (2758)	02 (2786)

method showed lower estimates of coefficient of determination (19 and 20%). The relative accuracy of a method was estimated in terms of its rank correlation with the most efficient method. Another criterion taken was the number of common sires from the top 10 ranking as compared the most efficient method. The rank correlation of various methods/models with the most efficient REML method and number of common sires from the top 10 ranking are presented in Table 3. For FL300DMY, BLUP-SM had the highest rank correlation of 0.61 with the most efficient REML method followed by SRLS (0.49) and LS (0.45). The ranking of sires obtained from single-trait animal model for FL300DMY trait is least similar to the ranking of sires obtained from other single-trait based sire evaluation methods (LS, SRLS and ST-SM) and more similar to the ranking of sires obtained from various multi-trait animal evaluation methods. Similar findings of rank correlations amongst EBVs by single-trait (LS, SRLS, ST-SM and ST-AM) methods were also reported by Singh (2013) in Karan Fries cattle. Although, the relative accuracy of REML 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 FL300DMY. Nevertheless, practically only about 10% of the sires are selected from a population. Therefore, when ten top ranking sires (18%) were selected under each method to find the number of common sires as compared to the most efficient method for FL300DMY, five sires were common under REML and BLUP-SM, four sires were common under other methods.

Top 10 sires ranked on the basis of estimated breeding values of sires for FL300DMY by all the four methods, are depicted in Table 4. Top 10 sires ranked on the basis of estimated breeding values of FL300DMY revealed that sire no. 21 ranked first by all the four methods. There were changes in the rank of sires by different sire evaluation methods, except sire no 21. These results indicated that all sires would not rank same for FL300DMY trait. These results suggested that to improve the productivity of herd, major culling of males should be done on the basis of their daughter's first lactation 300 day milk yield. Dubey *et al.* (2006) also reported same trend on the basis of first lactation

traits in crossbred cattle. These results revealed that REML method showed small genetic variation in comparison to LS, SRLS and BLUP-SM. Because of its desirable properties, REML method may be considered to be more appropriate than other methods.

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#### REFERENCES

- Dalal D S, Rathi S S and Raheja K L. 1999. Relationship between sires estimated breeding values for first lactation and lifetime traits in Haryana cattle. *Indian Journal of Animal Sciences* **72**: 398–401.
- Dash S K, Gupta A K, Singh A, Shivahre P R, Panmei A and Singh M. 2016. Comparative assessment of sire evaluation by univariate and bivariate animal model for estimation of breeding values of first lactation traits in HF cross cattle. *Indian Journal of Animal Sciences* **86**: 176–79.
- Divya P, Singh A, Gandhi R S and Singh R K. 2014. Estimation of breeding values of first lactation 305-day milk yield from single and multi-trait animal models in Karan Fries cattle. *Indian Journal of Animal Sciences* **84**: 1085–89.
- Dubey P P, Singh C V and Prasad R B. 2006. Relationship between sire's estimated breeding values for first lactation and lifetime traits and ranking of sires in Sahiwal and its cross. *Indian Journal of Animal Sciences* **76**: 824–28.
- Gaur G K, Tripathi V N, Mukherjee S and Choudhary V K. 2001. Efficiency of sire evaluation procedures in Frieswal cattle. *Indian Journal of Veterinary Research* **10**: 1–6.
- Harvey W R. 1990. Guide for LSMLMW, PC-1 Version, mixed model least squares and maximum likelihood computer programme. Mimeograph, Ohio State University, USA.
- Henderson C R. 1984. Application of linear model in breeding. University of Guelph Press, Guelph, Canada.
- Kumar A, Gandhi R S, Singh A and Haile A. 2008. Comparison of animal model with conventional methods of sire evaluation for milk production in Karan Fries cattle. *Indian Journal of Animal Sciences* **78**: 1393–96.
- Kumar S, Alex R, Singh U, Kumar A and Das A K. 2015. Comparative performance evaluation of Frieswal bulls in organized farms and farmers' herd. *Indian Journal of Animal Sciences* **85**: 316–19.
- Meyer K. 2007. WOMBAT-A tool for mixed model analyses in quantitative genetics by REML. *Journal of Zhejiang University Science B* **8**: 815–21.
- Moges T G, Singh C V, Barwal R S, Kumar D and Singh C B. 2009. Evaluation of sires using different multi-trait sire evaluation methods in crossbred cattle. *Indian Journal of Dairy Sciences* **62**: 1–4.
- Mukherjee S. 2005. 'Genetic evaluation of Frieswal cattle.' Ph.D. Thesis, ICAR-National Dairy Research Institute, Karnal, India.
- Singh R K. 2013. 'Genetic evaluation of Karan Fries sires using multiple trait models.' Ph.D thesis submitted to NDRI, Karnal, Haryana.
- Singh V K and Singh C V. 2011. Sire evaluation using animal model and conventional methods for milk production in crossbred cattle. *Indian Journal of Animal Sciences* **81**: 77–79.