



Evaluation of Sahiwal sires using part lactation records for increasing the milk production

T V RAJA¹ and R S GANDHI²

National Dairy Research Institute, Karnal, Haryana 132 001 India

Received: 31 July 2014; Accepted: 11 September 2014

Key words: Breeding value, Cattle, DFREML method, Genetic evaluation, Part lactation milk records, Rank correlation, Sahiwal cattle

The accuracy of estimating the breeding value of an animal is the major factor that affects the genetic progress from selection. The success of a breeding programme depends on how early and how accurately young bulls can be evaluated at minimum possible cost. Mostly sires are evaluated on the basis of first lactation 305-day or less milk yield of their daughters. This results in increased generation interval, thereby reducing the annual rate of genetic progress and increasing the cost of sire evaluation. Furthermore, the sire proofs based only on complete lactation records of daughters can be biased due to elimination of daughters with incomplete or part records. Van Vleck and Henderson (1961) and Searle (1961) reported that the sire proofs based on part lactation are highly correlated with and are as repeatable as if based on complete lactation.

Many sire evaluation methods viz. contemporary comparison (CC), least squares (LS), simple regressed least squares (SRLS), and best linear unbiased prediction (BLUP) were suggested to estimate the breeding value of sires of indigenous breeds. Barring a few studies, sporadic efforts were made in the country to evaluate the sires using the recent and complex method namely derivative free restricted maximum likelihood (DFREML). In view of the above facts the present investigation was undertaken to estimate the breeding values of Sahiwal sires based on part lactation yields using derivative free restricted maximum likelihood method and to find out the relationship between estimates of breeding values based on first lactation part and 305-day or less milk yields.

The data on 586 Sahiwal cows born to 50 Sahiwal sires maintained at National Dairy Research Institute, Karnal over a period of 47 years (1961–2007) were used for the present study. The records of the animals with known pedigree and normal lactation were considered for this study. The records of animals with less than 300 kg of milk

production or less than 100 days of lactation length were also discarded. To ensure the normal distribution, the outliers were removed and data within the range of mean $\pm$ 2 SD were only considered for the study. Sires with less than five daughters were not included in the study. The individual and cumulative monthly part lactation records were generated from the daily milk yield.

The influence of various non-genetic factors on FL305DMY and different part lactation traits was studied by least squares analysis of variance for unequal non-orthogonal data using the technique described by Harvey (1966). The statistical model used for least squares analysis of variance for FL305DMY was

$$Y_{ijklm} = \mu + S_i + P_j + A_k + D_l + e_{ijklm}$$

where, Y_{ijklm} is trait under study, viz. first lactation 305-day or less milk yield, first lactation length, first dry period etc.; μ is overall mean; S_i is the effect of i^{th} season; P_j is the effect of j^{th} period; A_k is the effect of k^{th} age group; D_l is the effect of l^{th} days open and e_{ijklm} is the random error, assumed to be normally and independently distributed with mean zero and constant variance i.e. NID (0, σ_e^2)

For part lactation traits except days open all the above factors were considered. The genetic and phenotypic parameters, viz. heritability, genetic and phenotypic correlations between FL305DMY and different individual and cumulative monthly part lactation yields were estimated using the paternal half sib-correlation (intra-sire correlation among daughters) method as described by Becker (1975). Considering the high heritability estimates and genetic correlation with the FL305DMY, 2 part lactation traits, viz. individual third month and cumulative 90-day milk yield were used for evaluating Sahiwal sires along with FL305DMY.

The breeding values of sires for FL305DMY, individual third month and cumulative 90-day milk yield were estimated using the DFREML method as described by Meyer (1998) using the following animal model:

$$Y_{ijk} = Xb_i + Zu_j + e_{ijk}$$

where Y_{ijk} is the k^{th} observation of j^{th} random effect of i^{th} fixed effect; b_i is the vector of observation of fixed effects;

Present address: ¹Senior Scientist (venkatesanraja09@gmail.com), Central Institute for Research on Cattle, Grass Farm Road, Meerut. ²Assistant Director General (ravindersinghgandhi@gmail.com), Indian Council of Agricultural Research, New Delhi.

u_j is the vector of additive genetic effect (random effect/sire effect); X is the design matrix/ incidence matrix of fixed effect; Z is the design matrix/ incidence matrix of random effect and e_{ijk} is the vector of residual errors.

The relationship between the estimated breeding values of part and FL305DMY was found by using the rank correlations as per Steel and Torrie (1960). Higher (near to unity) rank correlations amongst the sires from different traits revealed higher degree of similarity of ranking.

The heritability, genetic and phenotypic correlations between the 3 traits are presented in Table 1. The heritability estimate of FL305DMY was high (0.3554) and statistically highly significant ($P < 0.01$). The corresponding values for individual third and cumulative 90-day part lactation yields were 0.3046 and 0.2520, respectively. The genetic and phenotypic correlations between the part yields and FL305DMY were very high and statistically highly significant ($P < 0.01$).

Breeding value estimates for FL305DMY: The evaluation of Sahiwal sires for FL305DMY gave the average breeding value as 1,800.08 kg. Banik and Gandhi (2006) and Kumar (2007) reported lower estimates (1,503.99 and 1,523.7 kg, respectively) than the present estimate of breeding value in Sahiwal sires. Twenty seven (54.00%), out of 50 sires showed higher breeding values than the average breeding value. The highest breeding value was estimated as 2,359.92 kg, which was 31.10% higher than the average breeding value (Table 2). The lowest breeding value was 866.51 kg, which was 51.86% lesser than the average breeding value.

Table 1. Heritability, genetic and phenotypic correlation estimates of part lactation records with first lactation 305-day or less milk yield in Sahiwal cattle

Traits	Heritability	Correlations with FL305DMY	
		Genetic correlation	Phenotypic correlation
FL305DMY	0.3554** ±0.1295	-	-
3 rd month milk yield	0.3046** ±0.1217	0.9630** ±0.0195	0.8710** ±0.0204
Cumulative 90 days milk yield	0.2520* ±0.1139	0.9339** ±0.0358	0.8227** ±0.0236

** Significant at 1% level; * significant at 5% level.

The difference between these two extreme breeding values was highest (1,493.42 kg) indicating that this method discriminated amongst bulls to a greater extent. Six sires (12.00%) showed breeding value over and above 25% as compared to overall average; while 23 (46.00%), 17 (34.00%) and 12 (24.00%) Sahiwal sires were having 5, 10 and 15% higher breeding values than the overall average breeding value.

Breeding value estimates for individual third month milk yield: The average breeding value of Sahiwal sires evaluated by the derivative free restricted maximum likelihood method for individual third month milk yield was 228.37 kg (Table 2). The results revealed that 29 sires (58.00%) out of 50 sires had breeding values above the overall average, while 21 sires (42.00%) had breeding values below the overall average. The top ranked sire had the breeding value of 292.75 kg, which was 28.19% above the overall mean; while the lowest ranked sire had the breeding value of 139.09 kg, which was 39.09% below the overall average breeding value. The difference between the highest and lowest breeding values was estimated as 153.66 kg. In this method, out of 50 sires 3 sires had breeding values 25% above the overall average while, 23 (46.00%), 12 (24.00%), 7 (14.00%) and 4 (8.00%) sires had breeding values, which were 5, 10, 15 and 20% above the overall average breeding value, respectively.

Breeding value estimates for cumulative 90-day milk yield: The evaluation of breeding value of sires by this method gave the average breeding value as 678.27 kg (Table 2). Twenty-six (52.00%), out of 50 sires showed breeding values higher than the average breeding value. The highest breeding value was estimated as 877.95 kg, which was 29.44 % higher than the average breeding value. The lowest breeding value was 492.43 kg, which was 27.40 % lesser than the average breeding value. The difference between these 2 extreme breeding values was highest (385.52 kg). The results revealed that only 2 sires (4.00%) out of 50 sires showed breeding values over and above 25 % as compared to overall average; while 20 (40.00%), 12 (24.00%), 5 (10.00%) and 2 (4.00%) Sahiwal sires were having 5, 10, 15 and 20% higher breeding values than the overall average breeding value, respectively.

The efficiency, accuracy and stability of the DFREML method for various traits considered in the study were tested using the error variance, coefficient of determination and

Table 2. Average expected breeding value (EBV) for first lactation 305-day or less milk yield, individual third month milk yield and cumulative 90 days milk yield in Sahiwal sires

Traits	Average EBV	Number of sires		Maximum EBV	Minimum EBV
		above EBV average	below EBV average		
FL305DMY	1800.08	27 (54.00)	23 (46.00)	2359.92 (31.10)	866.51 (51.86)
3 rd month yield	228.37	29 (58.00)	21 (42.00)	292.75 (28.19)	139.09 (39.09)
90-day yield	678.27	26 (52.00)	24 (48.00)	877.95 (29.44)	492.43 (27.40)

Figures in the parentheses indicate per cent above and below the average breeding value.

Table 3. Error variance, coefficient of determination and coefficient of variation for first lactation 305-day or less milk yield, individual third month milk yield and cumulative 90 days milk yield in Sahiwal cattle

Traits	Error variance (Efficiency)	Coefficient of determination (%)	Coefficient of variation (CV %)
FL305DMY	160916.26 kg ²	66.53	35.25
3 rd Month yield	2394.25 kg ²	56.30	30.67
90-day yield	21860.41 kg ²	52.16	29.68

Table 4. Rank correlations among expected breeding values of sires estimated by DFREML method for first lactation 305-day or less milk yield, individual third month milk yield and cumulative 90 days milk yield in Sahiwal cattle

Duration of milk yield	First lactation 305-day or less milk yield	Individual third month milk yield	Cumulative 90 days milk yield
First lactation 305-day or less milk yield	1.0000	0.9164**	0.8732**
Individual third month milk yield		1.0000	0.9791**
Cumulative 90 days milk yield			1.0000

** Significant at 1% level.

coefficient of variation, respectively. The error variance obtained for different traits are presented in Table 3. Among the 3 traits, the model for FL305DMY showed highest accuracy (66.53%) followed by individual third month (56.30%) and cumulative 90 days milk yield (52.16%). The model and the one which gives CV (%) very near to the unadjusted data was considered as more stable. For FL305DMY the coefficient of variation was 35.25% which was very near to unadjusted data (37.25%). For individual third month milk yield the coefficient of variation of the model and unadjusted data were 30.67 and 32.77 % and the corresponding values for cumulative 90 days milk yield were 29.68 and 31.53 % respectively. The difference between the CV% of the model and the unadjusted data were almost similar indicating that the stability of all the 3 models was more or less same.

Relationship between estimated breeding values (EBVs) of sires from first lactation part and 305-day or less milk yield: In the present study, 50 sires were ranked according to their EBVs for first lactation 305-day or less milk yield, individual third month milk yield and cumulative 90 days milk yield.

The rank correlations were calculated for first lactation 305-day or less milk yield, individual third month milk yield and cumulative 90 days milk yield and the results are presented in Table 4. All the correlation estimates were very high and statistically highly significant ($P < 0.01$). The rank

correlation between first lactation 305-day or less milk yield and individual third month milk yield was 0.9164. The rank correlations between the first lactation 305-day or less milk yield with cumulative 90 days milk yield was 0.8732. The high and statistically highly significant ($P < 0.01$) correlations between the ranks of Sahiwal sires based on FL305DMY and the 2 part lactation records revealed that the evaluation of the Sahiwal sires for all the 3 traits by DFREML method resulted in almost similar ranking.

The ranks of top 10 Sahiwal sires evaluated on the basis of FL305DMY, individual third month milk yield and cumulative 90 days milk yield revealed that by all the three traits sire number 23 was ranked as first. The per cent of common sires among the top five sires ranked for FL305DMY and individual third month milk yield was 100 indicating that same five sires will be selected when the selection is based on either of these two traits. However, for selection based on cumulative 90 days milk yield, only four out of five sires will be selected in comparison to FL305DMY. The per cent of common sires among the top 10 sires evaluated on the basis of three traits showed a value of 60 for FL305DMY and individual third month yield was and for FL305DMY and cumulative 90 days milk yield the corresponding per cent was 70 revealing that the selection based on any of the 3 traits exhibited a higher degree of similarity (>60%) in the ranking of top 10 Sahiwal sires.

The results of the present study revealed that the part lactation traits, viz. individual third month milk yield and cumulative 90 days milk yield had higher degree of relationship with the first lactation 305-day or less milk yield. Similar to the present findings, Jain *et al.* (1991) reported that the selection of sires for complete lactation yield may be done based on third month milk yield of the daughters in Holstein-Friesian cattle. However, considering the rank correlations between the part and complete lactation yields Gaur and Raheja (1996) recommended the second, sixth-and-seventh month milk yields and cumulative 150 days milk yield for genetic evaluation of sires for improving the total lactation yield in Sahiwal cattle. Singh (2006) concluded that the 150 to 180 day cumulative partial milk yield could be effectively used for sire evaluation in Karan Fires cattle. Bansal (2009) recommended that the peak yield and 120 days (4 months) milk yield may be used to select sires with good reliability rather than to wait for 300 days or total lactation milk yield.

Based on the results of the present study it was concluded that the Sahiwal sires may be evaluated on the basis of individual third month and/ cumulative 90 days milk yield using the DFREML method for increasing the milk production.

SUMMARY

Data on 586 daughters of 50 Sahiwal sires maintained at the Institute, over a period of 47 years (1961–2007) were used for the present study. The Sahiwal sires were evaluated on the basis of the breeding values for 3 traits, viz. FL305DMY, individual third month milk yield and

cumulative 90 days milk yield using derivative free restricted maximum likelihood method and the relationship between the expected breeding values were estimated using the rank correlation. The heritability estimates of FL305DMY and individual third month milk yields were highly significant. The genetic and phenotypic correlations between FL305DMY and part lactation yields were highly significant. The study on the relationship of estimated breeding values among the 3 different traits, viz. first lactation 305-day or less milk yield, individual third month milk yield and cumulative 90 days milk yield revealed a higher degree of rank correlations. The per cent of common sires among the FL305DMY and individual third month yield was 60 and for FL305DMY and cumulative 90 days milk yield the corresponding per cent was 70 revealing that the selection based on any of the 3 traits exhibited a higher degree of similarity (>60%) in the ranking of top 10 Sahiwal sires. It was concluded that the Sahiwal sires may be evaluated on the basis of individual third month and/ cumulative 90 days milk yield for selecting the sires for increasing the FL305DMY using the DFREML method.

REFERENCES

- Banik S and Gandhi R S. 2006. Animal model versus conventional methods of sire evaluation in Sahiwal cattle. *Asian-Australasian Journal of Animal Sciences* **19**:1225–28.
- Bansal S K. 2009. 'Evaluation of Sahiwal sires on the basis of early production performance of their daughters.' M.V.Sc. Thesis, DUVASU, Mathura, India.
- Becker W A. 1975. *Manual of Quantitative Genetics*. 3rd edn. Pub. Program in Genetics, Washington State University, Washington, USA.
- Gaur G K and Raheja K L. 1996. Genetic evaluation of Sahiwal sires based on milk yield of their daughters at earliest stage of lactation. *Indian Journal of Veterinary Research* **5** (2): 7–13.
- Harvey W R. 1966. *Least squares analysis of data with unequal sub-class numbers*. Agricultural Research Services, United States Department of Agriculture, USA.
- Jain A K, Parmar O S and Gill G S. 1991. Efficiency of part lactation milk yield records in progeny testing of Holstein-Friesian bulls. *Indian Journal of Dairy Science* **44**:479–84.
- Kumar A. 2007. 'Genetic analysis of stayability in Sahiwal cattle.' Ph.D. Thesis, NDRI, (Deemed University), Karnal, India.
- Meyer K. 1998. DFREML, Version 3.0-b. User notes. Site: <http://agbu.une.edu.au/~kmeyer/dfreml.html>.
- Searle S R. 1961. Part lactations. III. Progeny testing with part records. *Journal of Dairy Science* **44**:921–27.
- Singh S. 2006. 'Genetic evaluation of Karan Fries sires on the basis of part lactation milk yields.' M.Sc. Thesis, NDRI, Deemed University, Karnal, India.
- Steel R G D and Torrie J H. 1960. *Principles and procedures of statistics with special reference to the biological sciences*. McGraw Hill Book Company Inc, New York, 550.
- Van vleek L D and Henderson C R. 1961. Use of part lactation records in sire evaluation. *Journal of Dairy Science* **44**: 1511–18.