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Univariate and multivariate animal models for evaluation of Sahiwal sires using derivative-free restricted maximum likelihood method

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SUMMARY

Data on 586 daughters of 50 Sahiwal sires maintained at National Dairy Research Institute, Karnal over a period of 47 years (1961–2007) were used to estimate the expected breeding values of sires by univariate and multivariate animal models using DFREML method. The first lactation 305-day or less milk yield (FL305DMY) was considered as the principal trait. For multi-trait evaluation, two sets of data were used. The first set consisted of first three individual monthly part lactation records along with FL305DMY and the second set was with the combination of different cumulative milk yields up to 90-days along with FL305DMY. The overall average expected breeding value for FL305DMY was estimated as 1800.08 kg. The error variance of single trait animal model was lower than multiple trait animal models and the relative efficiencies of multi trait DFREML for data set I and II were 77.08 and 65.52%, respectively. The rank correlation between the breeding values for first lactation 305-day or less milk yield of single trait DFREML and multi trait REML methods were very high (0.9580 and 0.9726 for data set I and II, respectively) and statistically highly significant (P<0.01) indicating that the evaluation of sires by both the models gave similar ranking to the extent of 96%. It was concluded that the single trait DFREML method was more efficient than the multi trait model for estimation of breeding value of Sahiwal sires for first lactation 305-day milk yield.

Key words: Animal model, DFREML method, Expected breeding value, Multivariate, Univariate, Part lactation records, Sahiwal cattle, Sire evaluation

The sire evaluation procedures have progressed a long way from the simple daughter average index to the recent animal model, from single trait to multiple trait analysis. The developments in computer hardware and software now allow estimation of genetic variances and covariances in large data sets under animal models (Meyer 1991, Boldman and Van Vleck 1991). Togashi *et al.* (2004) reported that multiple trait evaluation appears to be desirable because it takes into account the genetic and environmental variance and co-variance of all the traits evaluated and reduce the bias from selection and achieve a better accuracy of prediction as compared to single trait evaluation. Hence, the present investigation was undertaken to estimate the expected breeding values of sires by univariate and multivariate animal models using DFREML method and to compare their effectiveness in evaluation of Sahiwal sires.

MATERIALS AND METHODS

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. Single and multiple trait animal models were used for estimation of breeding value of Sahiwal sires by DFREML method using version 3.0-b as suggested by Meyer (1998). The first lactation 305-day or less milk yield (FL305DMY) was considered as the principal trait to compare the efficiency of univariate and multivariate animal models for evaluation of Sahiwal sires. In multi trait model, besides first lactation 305-day or less milk yield (FL305DMY), other part lactation yields having higher heritability estimates and strong genetic correlations with principal trait (FL305DMY) were considered. In the present study, for multi-trait sire evaluation of Sahiwal sires, 2 sets of data were used. The first set consisted of first 3 individual monthly part lactation records along with FL305DMY and the second set was with the combination of different cumulative milk yields up to 90-days along with FL305DMY.

The following animal model was considered:

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

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

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Table 1. Data structure

Data	Individual monthly yields (data set 1)				Cumulative milk yields (data set 2)		
	FL305 DMY	1st month MY	2nd month MY	3rd month MY	30 days MY	60 days MY	90 days MY
Number of animals with records	586	586	586	586	586	586	586
Number of base animals	50	50	50	50	50	50	50
Number of animals with unknown sires	0	0	0	0	0	0	0
Number of animals with unknown dams	586	586	586	586	586	586	586
Number of sires with progeny records	50	50	50	50	50	50	50
Number of dams with progeny records	0	0	0	0	0	0	0
No. of seasons of calving	4	4	4	4	4	4	4
No. of periods of calving	16	16	16	16	16	16	16
No. of age groups	10	10	10	10	10	10	10
No. of days open groups	12	-	-	-	-	-	-

Table 2. Heritability and genetic correlations between FL305DMY and other part lactation traits estimated by multivariate DFREML method

	Data set 1			
	FL305DMY	1st month MY	2nd month MY	3rd month MY
FL305DMY	**0.3672**	0.5228	0.6419	0.9857
1st Month MY	0.6351	**0.2002**	0.9853	0.6407
2nd Month MY	0.7604	0.8315	**0.3876**	0.7517
3rd Month MY	0.8489	0.7019	0.9066	**0.2411**
	Data set II			
	FL305DMY	30 days MY	60 days MY	90 days MY
FL305DMY	**0.3781**	0.7824	0.8581	0.9073
30 days MY	0.7155	**0.2511**	0.9850	0.9664
60 days MY	0.8069	0.9649	**0.3275**	0.9945
90 days MY	0.8606	0.9243	0.9872	**0.3539**

Values along the diagonal in bold scripts are heritability estimates, values above the diagonal elements are genetic correlations and below the diagonal elements are phenotypic correlations.

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

The effectiveness of univariate and multivariate animal models was judged by using with in sire variance or error variance and rank correlations. The most efficient method had the lowest error variance. Higher (near to unity) rank correlations amongst the sires from different models revealed higher degree of similarity of ranking from different models.

RESULTS AND DISCUSSION

The data structure for the traits considered in this study is presented in Table 1. The heritability estimates and genetic correlations of various traits are presented in Table 2. The heritability estimates for FL305DMY of data set I and II were 0.3672 and 0.3781 respectively. Among the individual monthly milk yields the second month had maximum heritability estimate of 0.3876; while the heritability estimate for cumulative part yields the 90 days milk yield was maximum (0.3539). In both the data sets the genetic correlation between FL305DMY and other part lactation traits increased as the lactation advanced. In general, the cumulative part yields had comparatively higher genetic correlations than the individual monthly yields. The phenotypic correlations between FL305DMY and other part lactation traits also showed trends similar to that of genetic correlations.

The evaluation of Sahiwal sires for FL305DMY by univariate and two different multivariate animal models gave the average breeding value as 1800.08 kg (Table 3). Banik and Gandhi (2006) and Kumar (2007) reported lower estimates 1503.99 and 1523.7 kg, respectively than the present estimate of breeding value in Sahiwal sires.

The effectiveness of different animal models were compared by using within sire variance or error variance and the rank correlations among the breeding values. The within sire variance or error variance for first lactation 305-day or less milk yield by multi- trait DFREML was comparatively higher (208765.70 kg^2 and 245582.30 kg^2 for data set I and

Table 3. Average expected breeding values (EBV), error variance and relative efficiency estimated by univariate and multivariate animal models for first lactation 305-day or less milk yield in Sahiwal cattle

Model	Average EBV	No. of sires above average EBV	No. of sires below average EBV	Maximum EBV	Minimum EBV	Error variance (kg^2)	Relative efficiency* Univariate DFREML (%)	Rank correlations of FL305DMY
Univariate	1800.08	27 (54.00)	23 (46.00)	2359.92 (31.10)	866.51 (51.86)	160916.26	100.00	1.000
Multivariate								
Data set I	1800.08	28 (56.00)	22 (44.00)	2198.24 (22.12)	1126.82 (37.40)	208765.70	77.08	0.9580**
Data set II	1800.08	29 (58.00)	21 (42.00)	2256.29 (25.34)	1084.24 (39.77)	245582.30	65.52	0.9726**

** Significant at 1% level.

II, respectively) in comparison to single trait DFREML (160916.26 kg^2); therefore, it was concluded that efficiency of multi-trait DFREML was lower than the single trait model. These findings revealed that the single trait DFREML method was effective than the multi-trait DFREML method for estimating the breeding value of Sahiwal sires for this set of data. Similar to the present findings, Kumar (2007) also reported that the single trait DFREML method was more efficient than the multi trait DFREML method for evaluating the Sahiwal sires as the later method gave higher error variance. However, Banik (2004) reported that the efficiency of multi trait DFREML method was slightly higher than the single trait model for evaluating the Sahiwal sires for first lactation 305-day or less milk yield.

The rank correlations between different traits included in the multi trait DFREML method are presented in Table 4. All the estimates of rank correlations were very high and statistically highly significant (P<0.01). The estimates in first set of data from first to third month ranged from 0.7139 to 0.9923 indicating that ranking of sires using the breeding values estimated by multi trait DFREML method for first lactation 305-day or less milk yield and different part lactation milk yields gave similar results to the extent of 71 to 99%.

The first lactation 305-day or less milk yield was used in both the sets of data and the breeding values estimated gave nearly similar ranking as the rank correlation was estimated as 0.9697.

Comparing the estimated breeding value of first lactation 305-day or less milk yield from a single trait model with multiple trait model, it was observed that the breeding values and the ranks of sires did not differ significantly from both the models. The rank correlation between the breeding values of first lactation 305-day or less milk yield of single trait DFREML and multi trait REML methods were very high (0.9580 and 0.9726 for data set I and II, respectively) and statistically highly significant (P<0.01) indicating that the evaluation of sires by both the models gave similar ranking to the extent of 97%.

The results of the present study revealed that the breeding values for FL30DMY estimated by both the single trait and multiple trait DFREML methods gave higher degree of similar ranking of Sahiwal sires. Hence, it was concluded that both the models were equally effective in estimating breeding values of Sahiwal sires for milk yield. However, the error variance or within sire variance was comparatively lower in single trait DFREML than the multi trait DFREML

Table 4 Rank correlations among breeding values of sires estimated for first lactation 305-day or less milk yield and other part lactation traits by multivariate DFREML method in Sahiwal cattle

	Data set I				Data set II			
Traits	FL305DMY1	Month 1	Month 2	Month 3	FL30MY 2	30 days	60 days	90 days
FL305DMY1	**1.0000**	0.7139**	0.8079**	0.9923**	0.9697**	0.7251**	0.7838**	0.8488**
Month 1		**1.0000**	0.9866**	0.7690**	0.7751**	0.8580**	0.8721**	0.8675**
Month 2			**1.0000**	0.8531**	0.8544**	0.8781**	0.9021**	0.9107**
Month3				**1.0000**	0.9765**	0.7658**	0.8218**	0.8788**
FL305DMY 2					**1.0000**	0.8479**	0.8921**	0.9377**
30 days						**1.0000**	0.9915**	0.9734**
60 days							**1.0000**	0.9908**
90 days								**1.0000**

FL305DMY1, First lactation 305-day or less milk yield with individual monthly yields; month1, Individual first month yield; Month 2, Individual second month; Month3, individual third month yield; FL305DMY2, First lactation 305-day or less milk yield with cumulative milk yields 30 days cumulative thirty days milk yield; 60 days, cumulative sixty days milk yield; 90 days, cumulative ninety days milk yield; ** significant at 1% level.

method. Based on these results, it was concluded that the single trait DFREML method was more efficient than the multi trait model for estimation of breeding value of Sahiwal sires for this set of data.

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