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Comparison of animal model with other conventional methods of sire evaluation for milk production in Karan Fries cattle

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ABSTRACT

First lactation milk production records of (1122) Karan Fries cattle sired by 112 bulls were analyzed to estimate breeding values of sires using animal model (DFREML), best linear unbiased prediction (BLUP) and least squares methods (LSM) of sire evaluation. The average breeding value of sires was almost similar and ranged from 2942.67 kg (BLUP) to 2947.79 kg (DFREML). The lowest error variance and highest coefficient of determination in DFREML method revealed that this method of sire evaluation was most efficient and accurate. The coefficient of variation in DFREML method was closest to the CV (%) of unadjusted data, indicating highest stability of DFREML over other two methods of sire evaluation. The heritability estimate of milk yield by DFREML was higher than the estimates of BLUP and LSM. The rank and simple correlations among all three methods of sire evaluation were high and statistically highly significant, indicating that there was higher degree of similarity (about 90–97%) in ranking of sires by different methods.

Key words: Animal model, BLUP, Breeding Value, Karan Fries, Sire Evaluation

Selection of the superior sires with maximum accuracy is of utmost importance for any breed improvement programme, as semen of sires is easily and rapidly disseminated in various herds under progeny testing programme. When the accuracy of sire evaluation is higher, the expected genetic gain will also be higher. Robertson and Randle (1954) opined that as much as 61% of genetic gain in dairy cattle resulted from selection of sires through two paths, i.e. bulls to breed cows and bulls to breed bulls. Hence, accurate selection of bulls used in artificial insemination (AI) programme is of prime importance for long-term genetic progress in the population. In India, mostly sires are evaluated on the basis of first lactation 305-day or less milk yield of their daughters with a rationale behind it to minimize generation interval. At the National Dairy Research Institute (NDRI), Karnal, the high yielding Karan Fries (KF) breed was synthesized by crossing local dairy breed Tharparkar with three exotic breeds, viz Holstein-Friesian, Brown Swiss and Jersey. Finally, the level of exotic inheritance was stabilized to 62.5% using half-bred bulls of high breeding values (Gurnani *et al.* 1986).

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With advancement in computing power, many procedures have been proposed for evaluating sires based on the records of their progeny. In recent past, Henderson's (1975) mixed model or the Best Linear Unbiased Prediction (BLUP) procedure have been widely used as standard method of sire evaluation in many countries. However, Henderson (1976) opined that analysis of variance and covariance may give biased components of variance from selected population by BLUP method. Hence, the sire evaluation using advanced statistical techniques based on restricted maximum likelihood (REML) algorithms, i.e. derivative free restricted maximum likelihood (DFREML) as described by Meyer (1989), would be expected to enhance the accuracy of selection of bulls. However, DFREML in Indian breeds has been used scarcely (Jain and Sadana 2000, Banik and Gandhi 2006, Kumar 2007, Mukherjee *et al.* 2007). Hence in this paper, an attempt was made to compare the effectiveness of DFREML with other conventional methods of sire evaluation for milk production in KF cattle.

MATERIALS AND METHODS

In the present investigation, 1122 first lactation records of Karan Fries cows, progeny of 112 bulls (with 5 or more daughters), spread over 32 years (1972 to 2003) at NDRI, Karnal, were used to evaluate sires. The summary of data structure obtained using DFREML is presented in Table 1. The sires were evaluated on the basis of first lactation 305

Table 1. Summary of data structure

Animal data	First lactation 305 days or less milk yield
Number of animals with records	1 122
Number of base animals	446
Number of animals with unknown sire	261
Number of animals with unknown dam	429
Number of sires with progeny records	90
Number of dams with progeny records	435
Number of grand-sires with progeny records	60
Number of grand-dams with progeny records	171
Mean (kg)	2 947.79
Standard deviation	933.21
Coefficient of variation (%)	30.10

days or less milk yield using 3 methods of sire evaluation, viz. least squares method (Harvey 1990), best linear unbiased prediction (Henderson 1975) and DFREML version 3.0–ß (Mayer 1998). The seasons and periods of calving were used as fixed effects and age at first calving was used as a linear covariable. Sires in all three methods and dams along with sires in DFREML were considered as random effects. 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/simple product moment correlations. The sire evaluation method with lowest error variance was considered as the most efficient and appropriate. The most accurate method showed the highest coefficient of determination (R^2–value). The coefficient of variation of first lactation 305 days or less milk yield from different models of sire evaluation was estimated for judging the stability of sire evaluation methods. The nearer the CV (%) of adjusted data to CV (%) of unadjusted data of first lactation 305 days or less milk yield, the more stable was the method. After estimation of breeding value of sires the sires were given rank as per their genetic merit. Spearman's rank correlations (Steel and Torrie 1960) and product moment correlations between breeding values of sires derived by various methods were also used to judge the effectiveness of different methods.

RESULTS AND DISCUSSION

The overall least squares population mean for first lactation 305 days or less milk yield was 2 947.78±27.86 kg. The coefficient of variation for unadjusted records was 31.70%. The average breeding value of sires was almost similar and ranged from 2 942.67 kg (BLUP) to 2947.79 kg (DFREML). Using least squares method, the average breeding value (2 947.78 kg) of sires for first lactation 305 days or less milk yield was lesser than the estimate (3 180 kg) reported by Singh (2006) in same breed (Table 2). Fifty-four sires out of 112 sires (48.21%) had breeding value above average breeding value, whereas 58 sires (51.78%) were having breeding values below the average breeding value. The difference between the highest and lowest estimate of breeding value was 2 460.21 kg (Table 2). The highest breeding was 4 335.57 kg, being 47.07% higher than the average breeding value, while the lowest breeding value was 1 875.36 kg which was 36.38% lower than the average breeding value. Of the 112 Karan Fries bulls, only 7 sire (7.1%) had breeding value 20% above than the overall average breeding value, whereas 31 (27.67%) and 43 sires (38.39%) were having 10 and 5% higher breeding value than overall average breeding value (Table 3).

The average breeding value of Karan Fries sires for first lactation 305 days or less milk yield using best linear unbiased prediction was estimated as 2 942.67 kg, which was lesser than the estimate (3 185 kg) reported by Singh (2006). The breeding value ranged from 3 356.65 kg (14.06% above the average breeding value) to 2 538.01 kg (13.75% below the average breeding value). The range of breeding value was minimum (818.64 kg) because of the lowest CV (28.66%) of adjusted records of first lactation 305 days milk yield. Fifty-three sires out of 114 sires (47.32%) had breeding value above average breeding value, while 59 sires (52.68%) were having breeding value below the average breeding value (Table 2). Out of 112 sires, none of the sire had breeding value 20% above the average breeding value, whereas 8 (7.10%) and 19 sires (16.96%) had breeding value 10% and 5%, respectively, above the overall average breeding value (Table 3).

The DFREML method (animal model) of sire evaluation gave the estimate of average breeding value of 2 947.79 kg (Table 2) and the breeding value ranged from 3 634.75 kg (23.30% above the average breeding value) to 2 253.15 kg (23.56% below the average breeding value). Out of 112 sires, 58 sires (51.78%) had breeding value above the average

Table 2. Average breeding value (BV) estimates of sires for first lactation 305 days or less milk yield by different methods

Sire evaluation method	Average BV (kg)	Number of sires above average BV	Number of sires below average BV	Maximum BV (kg)	Minimum BV (kg)	Difference of BV (kg)
LSM	2 947.78	54(48.21)	58(51.79)	4 335.57 (47.07)	1 875.36 (36.38)	2 460.21
BLUP	2 942.67	53(47.32)	59(52.68)	3 356.65 (14.06)	2 538.01 (13.75)	818.64
DFREML	2 947.79	58(51.78)	54(48.22)	3 634.75 (23.30)	2 253.15 (23.56)	1 381.60

Figures in the parentheses indicate the percentage

Table 3. Number of sires with 20, 10 and 5% higher breeding value than the average breeding value from different methods

Sire evaluation method	20%	10%	5%
LSM	8 (7.1)	31 (27.67)	43 (38.39)
BLUP	0 (0)	8 (7.1)	19 (16.96)
DFREML	4 (3.5)	20 (17.85)	31 (27.67)

Figures in the parentheses indicate the percentage.

breeding value, whereas 54 sires (48.22%) were having breeding values below the average breeding value. Out of 112 sires, 4 (3.50%), 20 (17.85%) and 31 sires (27.68%) had breeding value 20%, 10% and 5%, respectively, above the overall average breeding value (Table 3).

The within sire variance or error variance was the lowest (557 870.15 kg^2) in DFREML method and therefore it was considered as the most efficient method out of all the 3 methods of sire evaluation (Table 4), whereas BLUP method had the highest within sire variance (713 956.74 kg^2) and so it was the least efficient method of sire evaluation. The relative efficiency of LSM and BLUP method was 78.20 and 78.13%, respectively, in comparison with most efficient DFREML method of sire evaluation (Table 4). Similar findings were reported by Sahana and Gurnani (1999) in crossbred cattle, Banik and Gandhi (2006) in Sahiwal cattle; Haile (2006) in crossbreds, Mukherjee *et al.* (2007) in Frieswal cattle and Kumar (2007) in Sahiwal cattle. The DFREML method of sire evaluation had the highest coefficient of determination (29.17%) as compared to LSM (26.86%) and BLUP (18.70%) methods revealing that animal model or DFREML was the most accurate method of sire evaluation (Table 4). Similar findings were reported by Banik and Gandhi (2006) in Sahiwal and Mukherjee (2005) in Frieswal cattle. The alteration of CV (%) with respect to unadjusted data CV (31.70%) was lowest (1.60%) in DFREML method followed by BLUP (3.04%) and LSM (3.05%) methods sire evaluation indicating that DFREML method of sire evaluation was the most stable method as compared to LSM and BLUP methods. On the contrary, Banik and Gandhi (2006) reported BLUP as the most stable

Table 4. Relative efficiency, coefficient of determination (R^2–Value), coefficient of variation and heritability estimates of different methods of sire evaluation

Method	Error variance (kg^2)	Relative Efficiency* (%)	R^2–value (%)	Coefficient of variation (%)**	h^2
LSM	713302.20	78.20	26.86	28.65	0.23
BLUP	713956.74	78.13	18.70	28.66	0.10
DFREML	557870.15	100	29.17	30.10	0.29

*Relative efficiency with respect to most efficient (DFREML) method.

** Coefficient of variation (%) for unadjusted record was 31.7%.

Table 5. Rank correlations (above diagonal) and product moment correlations (below diagonal) among different methods of sire evaluation

Sire evaluation method	LSM	BLUP	DFREML
LSM	1.00	0.956**	0.934**
BLUP	0.934**	1.00	0.973**
DFREML	0.909**	0.974**	1.00

** Significant at 1% level.

method of sire evaluation in Sahiwal cattle, while Gandhi and Gurnani (1991) reported BLUP as the least stable method of sire evaluation in Sahiwal cattle.

The rank and simple correlations among all the 3 methods of sire evaluation were high and statistically highly significant ($p<0.01$) suggesting that all the methods of sire evaluation were equally effective to discriminate amongst sires on the basis of first lactation 305 days or less milk yield (Table 5). The rank correlations of breeding value of sires ranged from 0.934 (LSM with DFREML) to 0.974 (BLUP with DFREML), whereas simple correlations among breeding value of sires estimated by different methods ranged from 0.909 (LSM with DFREML) to 0.974 (BLUP with DFREML). Similar to present findings, Sahana (1996), Gaur and Raheja (1996), Gaur *et al.* (2001), Banik and Gandhi (2006) and Mukherjee *et al.* (2007) reported high rank and simple correlations between DFREML, LSM and BLUP methods and suggested that these methods were more or less similar in ranking of dairy sires for first lactation 305 days or less milk yield. Out of top 10 sires evaluated by all 3 methods of sire evaluation, 6 sires were found to be common in all the methods of sire evaluation.

The heritability estimate of first lactation 305 days or less milk yield was estimated as 0.23, 0.10 and 0.29, respectively, using LSM, BLUP and DFREML methods of sire evaluation, respectively (Table 4).

In comparison of different methods of sire evaluation, DFREML method was found to be more efficient, accurate and stable with lowest error variance, highest R^2–value and lowest alteration of adjusted CV (%) to unadjusted records CV (%). The estimate of heritability from DFREML method were also improved over other 2 methods of sire evaluation. The rank correlation coefficients amongst breeding value of sires by different methods of sire evaluation showed a reasonably higher degree of agreement (> 90%) in the ranking of sires. The lowest range of breeding values using BLUP indicated that this method was least effective to discriminate amongst bulls as compared to animal model and least squares method.

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