Indian Journal of Animal Sciences **86** (2): 177–179, February 2016/Article
https://doi.org/10.56093/ijans.v86i2.55803

Comparative assessment of sire evaluation by univariate and bivariate animal model for estimation of breeding values of first lactation traits in HF cross cattle

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Received: 7 November 2014; Accepted: 6 July 2015

ABSTRACT

The aim of the present investigation was to study the superiority of bivariate over univariate sire evaluation. Data were collected on 1,988 first parity Karan Fries cows, spread over 31 years. The (co) variance components estimated by using average information restricted maximum likelihood (AIREML) were fitted into univariate and bivariate animal models for prediction of breeding values. Low heritability estimates were obtained for fertility traits ranging from 0.02 (FDPR) to 0.19 (AFC) indicating lesser role of additive gene action in fertility of dairy cattle. Comparative analysis revealed that the breeding values estimated using bivariate animal model had lower error variance and greater range in comparison to univariate animal models. The mean sire breeding values for production traits estimated by bivariate analysis ranged from 3055.50 to 3063.15 kg and were higher compared to the mean sire breeding values estimated by univariate animal model. The inclusion of fertility traits along with production traits improved the differentiating ability of bivariate animal model with respect to the production performance.

Key words: AIREML, Animal model, Bivariate, Univariate

In most of the genetic improvement programmes in the country, selection was focussed on production traits; whereas, fertility performance of the animal was not given the due emphasis. Therefore, there is a need to consider fertility traits in addition to production traits during selection. Selection considering fertility along with production performance was advocated under Indian conditions due to small number of daughters per sire; as such selection will improve the accuracy and efficiency of sire evaluation (Sahana and Gurnani 1999). Therefore, including fertility along with production traits in sire evaluation would enable genetic improvement in production potential along with improvement in fertility traits.

The Karan Fries (KF) crossbred dairy cattle was developed by crossing Holstein Friesian (H), Brown Swiss (B) and Jersey (J) bulls with Tharparkar cows, under a crossbreeding project at NDRI, Karnal in 1971. The level of Holstein inheritance was fixed around 62.5% (Gurnani *et al*. 1986). Sire evaluation for the progeny testing programme of the Karan Fries is done by contemporary comparison method, a univariate sire evaluation method that considers the first lactation milk production performance only (Singh and Gurnani 2004). The present investigation aims at studying the efficiency of bivariate over univariate sire evaluation. Comparative analysis was carried out using different combinations of 2 trait models in first-parity cows, considering production along with fertility traits.

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MATERIALS AND METHODS

Present study was carried out on Karan Fries cows maintained at National Dairy Research Institute (NDRI), Karnal, Haryana. Data on first lactation fertility and production performance of 1988 Karan Fries cows sired by 186 bulls, spread over a period of 31 years (1982 to 2012), were utilized for the study. The indicator traits for fertility performance of the Karan Fries cows considered were age at first calving (AFC), first service period (FSP), first calving interval (FCI), first lactation daughter pregnancy rate (FDPR) and the production traits considered for analysis were first lactation 305 day milk yield (F305) and first lactation total milk yield (FTMY). FDPR was calculated by referring to VanRanden *et al.* (2004).

Breeding values of the sires for production and fertility traits were estimated by both univariate and bivariate animal models. The (co)variance components were estimated by the average information maximum likelihood method

(AIREML) algorithm in WOMBAT genetic analysis tool (Meyer 2007). The animal model used for univariate was $Y_{klmno} = \mu + SC_k + PC_l + AFCG_m + a_o + e_{klmno;}$ where, Y_{klmno}, observation; μ, overall mean; SC_k, fixed effect of kth season of calving; PC_l, fixed effect of lth period of calving; $AFCG_m$, fixed effect of mth AFC group; a_o, random effect of o^{th} animal; and e_{klmno}, random error, NID (0, σ^2_e). Bivariate animal model used is denoted as follows;

$$\begin{vmatrix} y_1 \\ y_2 \end{vmatrix} = \begin{vmatrix} X_1 & 0 \\ 0 & X_2 \end{vmatrix} \begin{vmatrix} b_1 \\ b_2 \end{vmatrix} + \begin{vmatrix} Z_1 & 0 \\ 0 & Z_2 \end{vmatrix} \begin{vmatrix} a_1 \\ a_2 \end{vmatrix} + \begin{vmatrix} e_1 \\ e_2 \end{vmatrix}$$

Sires were ranked on the basis of breeding values estimated by both types of animal model. Efficiency of univariate and bivariate animal models was adjudged on the basis of Spearman's rank correlation between the rankings by univariate and bivariate animal model (Table 1) as well as by the standard deviation (SD) and error variance of estimated breeding values (Tables 2, 3).

Table 1. Spearman's Rank correlations (r_s) of univariate and bivariate animal model estimated breeding values (EBVs)

Traits in Bivariate model	Traits in Univariate model	Rank correlation
AFC & F305	AFC	0.98**
	F305MY	0.96**
FSP & F305	FSP	0.96**
	F305MY	0.98**
FCI & F305	FCI	0.75**
	F305MY	0.98**
FDPR & F305	FDPR	0.42**
	F305MY	0.97**
AFC & FTMY	AFC	0.46**
	FTMY	0.91**
FSP & FTMY	FSP	0.87**
	FTMY	0.97**
FCI & FTMY	FCI	0.71**
	FTMY	0.95**
FDPR & FTMY	FDPR	0.52**
	FTMY	0.96**

*, significant at P<0.05; **, highly significant at P<0.01.

Table 2. Error variance, standard deviation (SD) and mean of breeding values of production traits estimated by bivariate animal model of F305MY with fertility traits

Bivariate model	F305MY		
	Error variance (kg^2)	SD of sire breeding values (kg)	Mean sire breeding value (kg)
AFC & F305MY	429820.00	300.01	3055.50
FSP & F305MY	421315.00	281.84	3057.63
FCI & F305MY	423082.00	279.81	3056.87
FDPR & F305MY	423798.00	278.99	3063.15
Univariate Model (305MY)	447933.00	229.46	3025.84

Table 3. Error variance, standard deviation (SD) and mean of breeding values of production traits estimated by bivariate animal model of FTMY with fertility traits

Bivariate model	FTMY		
	Error variance (kg^2)	SD of sire breeding values (kg)	Mean sire breeding value (kg)
AFC & FTMY	1353690.00	305.92	3391.22
FSP & FTMY	1350430.00	272.01	3393.93
FCI & FTMY	1311260.00	315.30	3398.12
FDPR & FTMY	1323070.00	298.22	3394.20
Univariate model (FTMY)	1442020.00	182.80	3371.19

RESULTS AND DISCUSSION

Estimates of genetic parameters: The heritability estimates obtained for individual traits, viz. AFC, FSP, FCI, FDPR, F305, FTMY were 0.19±0.05, 0.12±0.06, 0.03±0.04, 0.02±0.05, 0.31±14, 0.14±0.04, respectively. The heritability estimates of fertility traits indicated that these traits were less affected by additive gene action; the estimates for production traits indicated higher role of additive gene action. The estimates obtained using AIREML were in agreement with those of Kadarmideen *et al.* (2003), Sun *et al.* (2010) and Divya *et al.* (2014).

Spearman's rank correlation estimates: Sires were ranked for both production and fertility traits, on the basis of EBVs, estimated by both univariate and bivariate animal models. Comparison of rankings was done on the basis of spearman's rank correlation estimate. The rank correlation estimates of production traits indicated very strong and highly significant correlation between the univariate and bivariate rankings indicating that EBVs of production traits estimated by bivariate animal model in which fertility trait was considered in addition to a production trait (F305MY or FTMY) were similar to those estimated by univariate animal model.

The rank correlation estimates for fertility traits such as AFC and FSP indicated lesser variation between univariate and bivariate rankings. However, for traits such as FCI and FDPR the estimates indicated greater variation of sire rankings on the basis of univariate and bivariate animal models. The fertility traits were also considered in combination with FTMY in bivariate animal model. The spearman's rank correlation estimates for AFC and FDPR indicated moderate correlation between univariate and bivariate rankings. Highly and significant rank correlation estimates were obtained for FSP and FCI. The rank correlation estimates varied greatly when fertility traits were considered in association with FTMY. In fertility traits univariate rankings of sire varied greatly in comparison to bivariate rankings which may be attributed to the lesser additive genetic nature of fertility traits as well as their negative association with production traits. The findings were in agreement with the results of multi-trait sire evaluation reported by Raheja *et al.* (2000), Sun *et al.* (2010) and Divya *et al.* (2014).

Standard deviation (SD) and error variance of EBVs

The breeding values estimated by bivariate animal model for F305MY or FTMY, with AFC, FSP, FCI and FDPR as fertility traits in the model had higher standard deviation (SD) in comparison to the breeding values estimated by univariate model. The error variance of estimated breeding values by bivariate animal model was lower than univariate animal model both in F305MY and FTMY.

The results indicated that bivariate model, in which production trait was analyzed with inclusion of fertility traits, had greater ability for differentiating superior and inferior sires with respect to F305MY or FTMY than univariate animal model. This may be attributed to the correlation between the production and fertility traits that was accounted for by the bivariate animal model.

Kadarmideen *et al.* (2003) recommended the bivariate genetic evaluation and selection of dairy cattle on the basis of both fertility and production performance. Similar observation was given by Mukherjee (2005) and Kumar (2007). Sun *et al.* (2010) reported models combining milk production traits, showed better stability and predictive ability than single-trait models for all the fertility traits. Divya *et al.* (2014) reported bivariate animal model to be superior to univariate animal model on the basis of standard deviation of EBVs for first lactation production fertility and production traits. Zink *et al.* (2012) used the bivariate animal model for estimation of genetic parameters using AIREML algorithm, the genetic parameters were further utilized in the computation of selection indices, which had higher accuracy when fertility traits were combined with production traits.

An overview of the results of sire evaluation for first lactation fertility and production traits indicated that the 2-trait models were superior in comparison to single trait animal models for estimation of breeding values. The heritability estimates obtained using AIREML indicated fertility traits in comparison to production traits were less affected by additive gene action. The inclusion of fertility traits along with production traits improved the differentiating ability of bivariate animal model with respect to the production performance as the bivariate model accounted for the correlation between the production and fertility traits. Therefore, fertility traits need to be given due importance in sire evaluation along with production performance.

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