

Effect of sire and herd interaction on milk production in Sahiwal cattle

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ABSTRACT

First lactation records (903) of Sahiwal cows, sired by 46 sires of same breed maintained at 3 different farms were analyzed using sire model of best linear unbiased predictions (BLUP) and 2 different animal models based on derivative free restricted maximum likelihood (DFREML) algorithm. The animal model with sire $\times$ herd ($S \times H$) interaction as additional random effect was found to be the best in terms of efficiency and accuracy over other two models. The animal model with interaction explained 15.2% of total phenotypic variation of milk yield due to sire $\times$ herd interaction and the estimate of heritability for milk yield was highest (0.182). The herd specific breeding values of sires estimated from interaction model ranged from –441.60 kg to 401.39 kg. The genetic slippage was noticed in most of the sires due to differences in managemental practices followed at different farms. The Karnal herd had highest breeding worth whereas lowest breeding worth was for Lucknow herd. The pooled breeding value over herds showed a declining trend over periods.

Key words: Animal model, BLUP, Breeding value, Genetic slippage, Sahiwal, Sire $\times$ herd interaction

The genotype $\times$ environment interaction is the phenomenon that different environments do not equally affect performances of different genotypes (Falconer 1990). The analysis of variance techniques are not optimal for variance component estimation due to sire $\times$ herd ($S \times H$) interaction that can arise from heterogeneity of residuals and (or) additive genetic variance among herds (Dickerson, 1962); from use of small number of selected sires; from differential non random mating among herds or from preferential treatments of some paternal half sibs. During breeding value estimation, if $S \times H$ interaction is not taken into account the interaction might bias EBV and reduce effectiveness of selection, because sires might rank differently across different environments. Selection for improvement in specific environment of the seedstock herd is thus warranted only if the environment of seedstock herd is more similar to the customer environments of commercial herds where germplasm is to perform, a situation that in most cases seems unlikely. The “Associated Herd Progeny Testing in Sahiwal” a multilocal programme was started in 1979 to bring about genetic improvement in Sahiwal cattle. The purpose of this study was to evaluate impact of sire $\times$ herd interaction for milk production in Sahiwal cattle using sire model of BLUP and 2 different animal models of DFREML.

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MATERIALS AND METHODS

First lactation 305 days or less milk yield (FL305DMY) records of 903 Sahiwal cows, sired from 46 sires of same breed with 5 or more daughters, maintained at 3 different associated small herds namely National Dairy Research Institute (NDRI), Karnal, Government Livestock Farm (GLF), Chak Ganjaria, Lucknow and Government Cattle Breeding Farm (GCBF), Anjora, Durg over a period of 28 years (1979 to 2006) were analyzed after standardizing the records. Each of the sires had their daughters in at least two herds under the study. At 2 farms, namely GLF, Lucknow, and GCBF, Durg, the suckling was being practiced; whereas at NDRI farm weaning practice was followed which revealed about differences in managemental practices. The data structure is summarised in Table 1.

Data were analyzed using sire model of BLUP (Henderson 1973) and 2 different animal models of DFREML described by Grasser *et al.* (1986) and Meyer (1989, 1998). The sire model and first animal model included fixed effects of herd, season, period and age at first calving as linear co-variable along with sires as random effect. In second animal model sire $\times$ herd interaction effect was included as additional random effect along with all the effects of first model. The sire evaluation method with lowest error variance was adjudged as most efficient and appropriate. Accuracy of the effect of interaction was tested by comparing log likelihoods of the model that included the sire $\times$ herd interaction to those that included only sire effects

Table 1. Summary of data structure

Data	First lactation 305 days or less milk yield
Number of animals with records	903
Number of base animals	392
Number of animals with unknown sire	248
Number of animals with unknown dam	425
Number of sires with progeny records	46
Number of dams with progeny records	279
Number of grand-sires with progeny records	36
Number of grand-dams with progeny records	76
Mean (Kg)	1435.40
Standard deviation (Kg)	560.84
Coefficient of variation (%)	34.88

(Meyer 1987). The heritability estimated from different model was compared.

RESULTS AND DISCUSSIONS

The sire model of BLUP had lowest additive genetic variance of 4259.08 kg² and highest error variance of 232919.09 kg² than both animal models (Table 2). The heritability estimate observed by sire model was 0.028. Additive genetic variance using animal model without interaction was 36166.76 kg² which was 15.2% of total phenotypic variance (237457.58 kg²). Thus direct estimate of heritability was 0.152. The error variance (201290.82 kg²) explained 84.76% of total phenotypic variance in animal model without interaction. Inclusion of sire $\times$ herd interaction in second animal model improved the total as well as additive genetic variance to 250712.17 kg² and 46711.62 kg², respectively, as compared to sire model and animal model without interaction. The error variance in model with interaction reduced to 165755.29 kg² which was 66.11% of total phenotypic variance. The sire $\times$ herd interaction explained 15.2% of variation of milk production, which was higher than the estimate (2.3%) reported by Dimov *et al.*

Table 2. Estimation of variance components (kg²) and heritability for 305 days or milk yield using different models

	Sire model (BLUP)	Animal model (DFREML)	Animal model with interaction (DFREML)
σ_a^2	4259.08	36166.76	46711.62
$\sigma_{s \times H}^2$	-	-	38245.26
σ_e^2	232919.09	201290.82	165755.29
σ_p^2	434209.90	237457.58	250712.17
h_d^2	0.028	0.152	0.186
i^{2b}	-	-	0.152
Log L	-	-5979.99	-5959.72

σ_a^2 , direct additive genetic variance; $\sigma_{s \times H}^2$, interaction variance; σ_e^2 , random residual variance; σ_p^2 , total phenotypic variance; h_d^2 = direct heritability; i^{2b} , ratio of interaction variance: phenotypic variance; Log L, log likelihood.

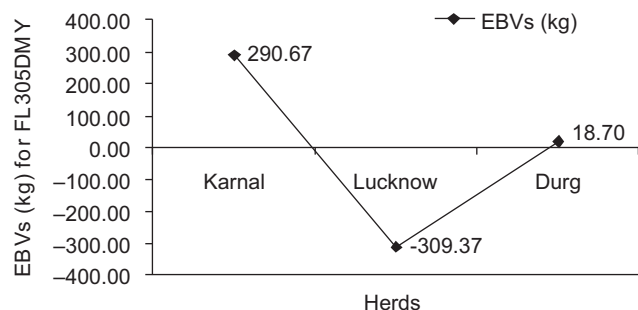


Fig 1. Estimated breeding values for FL305DMY across herds.

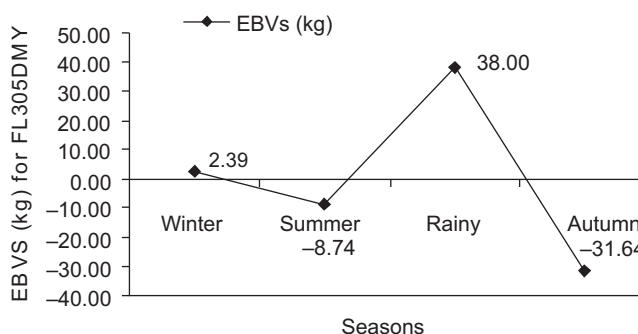


Fig 2. Estimated breeding values for FL305DMY across seasons.

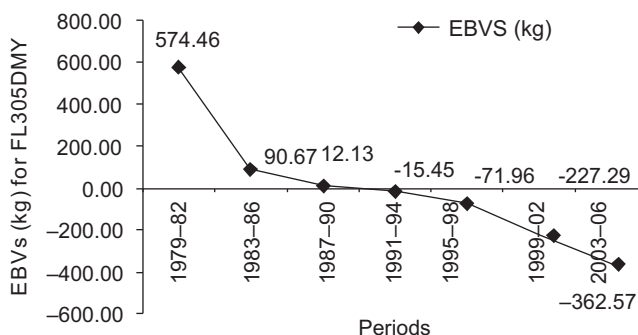


Fig 3. Estimated breeding values for FL305DMY across periods.

(1995) for first lactation milk production in Holstein cattle. Meyer (1987) reported estimates of sire $\times$ herd interaction were 2.1–4.3% for yield traits. Rorato *et al.* (1999) reported the lower averages (1.5% to 1.8%) for sire by herd interaction effects. The lowest error variance of sire $\times$ herd interaction model indicated its better efficiency than other 2 models. The higher log L value of interaction model revealed better accuracy of this model over model without interaction. The direct estimate of heritability also improved to 0.186 since the ratio of additive genetic variance to total phenotypic variance increased in interaction model.

The mean and standard deviation for first lactation 305 days or less milk yield were 1435.40 kg and 560.84 kg, respectively (Table 1). The breeding values for first lactation 305 days or less milk yield were estimated across herds, season and periods using most efficient interaction model.

Table 3. Herd specific breeding values estimated using animal model with interaction for Sahiwal sires

Sire No.	Herd specific breeding values (kg)			Sire No.	Herd specific breeding values (kg)		
	Karnal	Lucknow	Durg		Karnal	Lucknow	Durg
1	-26.29	-34.69	-	563	127.08	-14.22	-
79	-94.30	-169.80	-60.61	606	-79.42	-	47.07
80	-	1.51	-7.41	611	-145.53	-4.77	79.17
87	135.11	-84.38	-97.53	633	113.62	75.55	-
147	-238.80	-23.24	-56.59	668	-266.29	217.03	-
150	-165.70	-30.08	68.32	771	222.16	-131.96	-
33	44.30	88.62	-	1033	187.16	-254.27	66.46
237	79.96	-12.55	-44.05	1056	260.03	-210.21	37.17
282	-1740	-31.71	-	1060	401.39	-162.91	-
327	70.55	-158.30	-	1069	13.01	14.39	24.20
329	189.41	-11.04	-	1084	-129.14	17.62	38.87
397	-216.70	-4.64	25.00	1090	119.59	32.53	110.59
400	189.91	-14.52	1.25	1208	-188.46	226.20	-
403	57.02	6.81	24.81	1220	-77.81	146.28	-
419	184.70	-10.23	-	1223	-159.50	66.92	-
442	-150.40	2.32	-	1260	-25.49	11.58	-
446	69.40	16.14	-	1274	-441.60	261.74	-
457	-140.10	15.54	-	1299	95.22	-	-47.85
494	79.77	-109.10	32.96	1328	75.01	78.33	-157.66
506	260.15	-38.12	-	1337	-143.73	124.02	-60.01
518	62.38	-53.57	-	1361	-198.54	148.24	26.00
526	69.77	-36.89	-	1376	114.67	-	-8.09
530	-127.20	49.90	-	1401	-32.26	-	-43.07

There were differences in breeding values of a sire estimated from first lactation performance (FL305DMY) evaluation of its daughters maintained at 3 different farms and thus each sire had a farm specific breeding value. The herd specific breeding values of sires estimated from interaction model ranged from -441.60 kg to 401.39 kg (Table 2). The genetic slippage with reduction of breeding worth of sires were frequently observed due to sire $\times$ herd interaction, if the daughters of the sires performed at some different farm than their sires farm. Simultaneously in many cases the breeding worth of sires improved when their daughter performed at some different farm than their respective sire farm, which once again may be ascribed due to sire $\times$ herd component of interaction. The Karnal herd had highest breeding worth of 290.67 kg whereas lowest breeding worth was for Lucknow herd (-309.37 kg) (Fig. 1). The better estimate of breeding value at Karnal herd as compared to Lucknow and Durg herds revealed good breeding, feeding and managerial practices followed at the Karnal farm. The rainy season had highest breeding value of 38.00 kg whereas autumn season had lowest breeding value of -31.64 kg (Fig. 2), which may be ascribed due to availability of better quality of green fodder in the ensuing autumn season and persistent milk production for longer duration whereas autumn calvers dried up earlier due to hot conditions of next coming summer during late stage of their lactation. The pooled breeding value over herds was highest (574.46) during period of 1979-82 whereas it

reduced over periods with lowest breeding value (-362.57 kg) for the period 2003-06 (Fig. 3).

The impact of sire $\times$ herd interaction is more important where it is difficult to maintain uniform managerial practices at different farms. The S $\times$ H interaction variance had a significant influence on partitioning of total phenotypic variance of milk yield. So it is necessary to incorporate the S $\times$ H interaction effect (a manifestation of genotype $\times$ environment interactions) during genetic evaluation of Sahiwal population for getting better and reliable estimate of genetic parameters. The sire model could not be as good as interaction model for an efficient genetic evaluation and discriminates among sires on the basis of their estimated breeding values for milk yield.

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