Genetic and Phenotypic Evaluation of Milk and Fat Production Traits and Their Interrelationship in (Zebu×European) Crossbred Cattle Using Parent Group Mixed Model

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ABSTRACT : Data pertained to 335 crossbred cows comprising of 1/2 Friesian (F) + 1/2 Hariana (H), 1/2 F + 1/4 Jersey (J) + 1/4 H, 1/2 F + 1/4 Brown Swiss (BS) + 1/4 H, 1/2 F + 1/4 Red Dane (R) + 1/4 H, FR (I) and FRH (I) genetic groups extending over a period of 21 years (1970-1990) maintained at Animal Farm of CCS HAU, Hisar. The averages for first lactation milk yield was 2,486.24±80.26 kg and peak yield of first three lactation were 11.35±0.72 kg, 13.97±0.60 kg and 16.02±0.42 kg, respectively. The lifetime milk production was observed as 11,305.16±1,004.52 kg in crossbred cattle. The average first lactation fat yield was observed as 102.06±0.01 kg and peak fat yield of first three lactation were 0.458±0.01, 0.490±0.01 and 0.500±0.02 kg, respectively. The lifetime fat production was estimated as 502.31±45.90 kg. LTMP and LTFP had reasonably good additive genetic variance which could be exploited either through mass selection/combined with family or pedigree selection. FLMY, peak yields and LTMP had significant positive phenotypic correlation with FLFY and LTFP and the correlation at the genetic level were also higher and positive for these traits. Finally, peak week milk yield of first lactation (PMY1) was the earliest available trait having desirable and significant correlation at phenotypic and positive at genetic level with FLFY, PFY1 and PFY2, PFY3 and LTFP and selection for this trait will help in early evaluation of sires and dams and will increase genetic advancement per unit of time. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 9 : 1242-1246)***

Key Words : Milk and Fat Production Traits, Heritability, Phenotypic and Genetic Correlations, Zebu×European Crossbreds

INTRODUCTION

The first lactation milk and fat yield reflects the real economic worth of the cow and is considered as a selection criterion for the improvement of genetic potential of dairy animals by using different progeny testing programme in which superior germplasm can be identified on the basis of performance of their progeny under farm and field condition. In the recent past the main thrust in breeding in India has been emphasized on crossbreeding to improve genetic potentiality for milk and milk products by introducing exotic inheritance in purebred locals. By introducing the exotic inheritance at different levels in purebred locals the milk and their products have been increased many folds however, the estimates of heritability of milk production traits in crossbred population, using mixed models with breed group effects (Meyer, 1987; Wilmink et al., 1986) were higher than published value from purebreds (Maijala and Hanna, 1974; Hill et al., 1983). Among other factors, non-additive might have inflated the heritability estimates. Vander Welf and De Boar (1989a) proposed a mixed model for analysis of such data in which care has been taken for fixed effects of heterosis and recombination for the estimates of variance components from crossbred population. They also used parent group model and found that estimates of additive variance were unbiased using this model, however, the estimates of residual variance was slightly higher. In the present study it was not possible to include the effect of heterosis and recombination in the model due to lack of proper data structure/records, hence parent group model was used to utilize the available records. Keeping this in view the above facts and to plan a sound-breeding programme for further propagation of these crossbred animals having different levels of exotic inheritance, it is essential to know the extent of genetic variability and co-variability among different milk and fat production traits.

MATERIALS AND METHODS

The records utilized for this investigation pertained to 335 crossbred cows comprising of 1/2 Friesian (F)+1/2 Hariana (H), 1/2 F+1/4 Jersey (J)+1/4 H, 1/2 F+1/4 Brown Swiss (BS)+1/4 H, 1/2 F+1/4 Red Dane (R)+1/4 H, FR (I) and FRH (I) genetic groups extending over a period of 21 years (1970-1990) maintained at Animal Farm of CCS HAU, Hisar. FR (I) and FRH (I) are interse crosses. The animals that completed their first 300 days lactation were included in the study. The records like those resulting from abortions, premature birth, stillbirth and incomplete lactations due to death and culling were excluded from the study. The data were grouped according to genetic groups of the grand parents of the animal, season of calving and period of calving to quantify the effects of these factors. The genetic group was divided into two sire groups (SG_l)

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and (SG_2) and four dam groups (DG_1, DG_2, DG_3 and DG_4). Total duration of 21 years was divided into four periods i.e. P_1 (1970-1976), P_2 (1977-1981), P_3 (1982-1986) and P_4 (1987-1990). On the basis of climatic conditions, each year was further sub-divided into four seasons viz. S_1 (Winter), S_2 (Summer), S_3 (Rainy) and S_4 (Autumn). The seasons were made on the basis of fluctuations of atmospheric temperature, relative humidity, rainfall and sunshine hours over a period of 21 years (1970-1990). The four periods were classified on the basis of preliminary year wise analysis of records and the years that did not differ significantly from each other were included into different periods to overcome the differences in managemental practices. The average numbers of female progenies per sire were 8.8. The first lactation milk yield (FLMY) and fat yield (FLFY) was calculated by summing up the milk and fat yield of first 300 days of lactation (excluding colostrums during first three days). Total milk and fat production in the first four and above lactations were considered as lifetime milk yield (LTMY) and fat production (LTFP) of the animal. The maximum milk (PMY) and fat yield (PFY) in a day during lactation were considered as peak milk and fat yield of that lactation. The peak milk (PMY_1, PMY_2 and PMY_3) and fat yield (PFY_1, PFY_2 and PFY_3) were taken for first three lactations of the animal.

To study the effect of certain important factors such as sire, sire group, dam group, season and period of calving and to overcome the problems of non-orthogonality for these effects due to disproportionate frequencies and to estimate the genetic and phenotypic parameters the mixed model technique as explained by Harvey (1987) was applied. The age at first calving was used as a covariate and statistical model used for each trait was:

$$Y_{ijklmn}=\mu+S_i+SG_j+DG_k+S_l+P_m+b_1(A_{ijklmn}-\bar{A})+b_2(A_{ijklmn}-\bar{A})^2+e_{ijklmn}$$

Where,

Y_{ijklmn}=observation on n^{th} animal calving in m^{th} period and l^{th} season belonging to k^{th} dam and j^{th} sire group and of i^{th} sire

μ=population mean

S_i=random effect of i^{th} sire (i=1, 2------38)

SG_j=effect of j^{th} sire group (j = 1, 2)

DG_k=effect of k^{th} dam group (k= 1, 2, 3, 4)

S_l=effect of l^{th} season of calving (l = 1, 2, 3, 4)

P_m=effect of m^{th} period of calving (m = 1, 2, 3, 4)

b_1 and b_2=linear and quadratic regression coefficient of Y_{ijklmn} on age at first calving

A_{ijklmn}=age at first calving corresponding to Y_{ijklmn}

$\bar{A}$=arithmetic mean of age at first calving

e_{ijklmn}=random error associated with Y_{ijklmn} observation assumed to be NID (0, σ_e^2)

Table 1. Averages and heritability estimates of first lactation milk and fat yield

Parameters	No. obs.	Averages±SE	Heritability±SE
FLMY	335	2,486.24±80.26	0.02±0.10
PMY_1	335	11.35±0.72	0.01±0.05
PMY_2	335	13.97±0.60	0.03±0.12
PMY_3	335	16.02±0.42	0.05±0.05
LTMP	335	11,305.16±1,104.52	0.25±0.18
FLFY	335	102.06±4.22	0.11±0.06
PFY_1	335	0.458±0.01	0.01±0.19
PFY_2	335	0.490±0.01	0.01±0.15
PFY_3	335	0.500±0.02	0.06±0.14
LTFP	335	502.31±45.90	0.22±0.10

No. obs.=Number of observations, SE=Standard error.

The differences of means were tested by Duncan's multiple range tests. The data were adjusted for significant effects of sire, sire group, dam group, seasons, periods and age at first calving. The heritability estimates for different traits were obtained by the paternal half-sib correlation method on adjusted data. The standard errors of heritability estimates were obtained by using the formula given by Swiger et al. (1964). Genetic and phenotypic correlations among different traits were calculated from sire components of variance-covariance analysis. The standard errors of genetic and phenotypic correlations were estimated by Robertson (1959) and Snedecor and Cochran (1968), respectively.

RESULT AND DISCUSSION

Averages

The adjusted means and their standard errors for different traits have been presented in Table 1. The averages for first lactation milk yield was 2,486.24±80.26 kg and peak yield of first three lactation were 11.35±0.72 kg, 13.97±0.60 kg and 16.02±0.42 kg, respectively. The lifetime milk production was observed as 11,305.16±1,004.52 kg in crossbred cattle. The average first lactation milk yield of Friesian×Hariana reported by Stepanov and Zhamerkov (1983) as 1,811 kg whereas Dalal et al. (1991) reported as 3,009.33±31.28 kg. Moreover, Jadhav and Bhatnagar (1984) observed the highest first lactation milk yield as 3,505.20±59.86 kg in Friesian×Tharparkar crossbreds. The average peak yield of first lactation reported by Mudgal et al. (1986) was 18.43±0.47 kg in Sahiwal×Friesian crossbreds. Koul et al. (1977) estimated second lactation peak milk yield as 11.05 ±0.46, 10.21±0.47 and 8.93±0.28 kg in Friesian×Hariana, Brown Swiss×Hariana and Jersey×Hariana crossbreds. Singh (1981) observed as 14.73±0.41 and 17.08±0.40 kg peak milk yield in second and third lactation of Brown Swiss×Hariana and Friesian×Hariana crossbred animals.

Table 2. Genetic and phenotypic correlations among various traits

Traits		FLFY	PFY_1	PFY_2	PFY_3	LTFP
FLFY	P	0.933±0.01	-0.085*±0.05	-0.015*±0.05	0.042*±0.04	0.334±0.05
	G	0.856±0.39	-0.289±1.22	1.222±0.10	0.385±1.31	1.435±2.15
PMY_1	P	0.676±0.03	0.028±0.05	0.096*±0.05	0.136±0.05	0.293±0.05
	G	0.815±0.63	0.032±0.76	0.743±0.93	0.743±0.93	1.115±0.85
PMY_2	P	0.399±0.05	-0.013*±0.05	0.063±0.05	0.133*±0.05	0.275±0.05
	G	0.316±0.84	-0.790±0.56	-0.302±0.58	-0.100±0.05	0.997±0.42
PMY_3	P	0.434±0.04	-0.107*±0.05	-0.017*±0.05	0.060*±0.05	0.296±0.05
	G	0.346±0.96	-0.699±0.73	-0.085±0.69	-0.073±0.69	1.299±0.61
LTMP	P	0.293±0.05	-0.923±0.02	0.035*±0.05	0.290±0.05	0.970±0.02
	G	0.923±0.88	-0.034±0.55	0.954±0.55	0.954±0.55	0.981±0.02

* Significant at ($p<0.05$).

The attainment of higher FLMY and peak yields reflects the manifestation of maximum milk secretion in lactation and there is a high probability that it will influence future shape of the lactation.

The average first lactation fat yield was observed as 102.06±0.01 kg and peak fat yield of first three lactation were 0.458±0.01, 0.490±0.01 and 0.500±0.02 kg, respectively. The lifetime fat production was estimated as 502.31±45.90 kg. Saxena (1982) observed first lactation fat yield as 81.26, 84.26 and 87.00 kg in Brown Swiss×Hariana, Friesian×Hariana and Jersey×Hariana crossbreds. Moreover, Jadhav and Bhatnagar (1984) reported as 152.50±577, 141.16±2.06, 141.45±4.14 and 135.99±2.95 kg in Holstein ×Sahiwal, Holstein×Tharparkar, Brown Swiss×Tharparkar and Brown Swiss×Sahiwal crossbred heifers. Godara et al. (1990) reported that lactation fat yield was higher in Jersey ×Hariana followed by Friesian×Hariana crossbreds and the lowest yield was observed in Brown Swiss×Hariana crossbreds. The variability in the performance of different herds of crossbred cattle for fat yield suggested that there is scope for improvement in this trait.

Heritability estimates

The heritability estimate of first lactation milk yield and lifetime milk production were 0.02±0.10 and 0.25±0.18, respectively. The heritability estimates of first three lactation were observed as low (0.01±0.05 to 0.05±0.05). The heritability estimate for first lactation fat yield was observed as 0.11±0.06 and lifetime fat production was 0.22±0.10. The peak fat yield for first three lactations were observed as 0.01±0.19, 0.01±0.15, 0.6±0.14, respectively. The higher estimate of heritability for first lactation milk yield was reported by Batra et al. (1969), Jogi (1978) and Godara et al. (1990) as 0.43±0.02, 0.57±0.04 and 0.48±0.12 in Friesian×Guernsey, Friesian×Tharparkar and European× Zebu crossbreds, respectively. The medium estimates of heritability was reported by Kathpal (1970), Saxena (1982), Vander Welf and De Boer (1989), Taneja and Rai (1989), Singh and Tomar (1990), Harris et al. (1992), Welper and Freeman (1992). Pander et al. (1992) and Hibner (1993) in different crossbreds and exotic breeds of cattle.

The heritability estimates of first lactation fat yield was reported as 0.16±0.10 by Norman et al. (1988) in Ayreshire cattle and 0.76±0.12 by Saxena et al. (1982) in European× Zebu crossbred cattle. The medium to higher estimates of heritability for fat production traits were reported by Vander Welf and De Boer (1988), Godara et al. (1990) Harris and freeman (1991), Welper and Freeman (1991) and Pander et al. (1992) in different crossbreds and exotic breeds of cattle.

From the perusal of the estimates obtained for milk and fat production traits, it could be inferred that LTMP and LTFP have heritability of more than 20 percent. The estimates of heritability of FLFY, PMY_3 and PFY_3 were ranged from 5-11 percent whereas these estimates of heritability of FLMY, PMY_1, PMY_2, PFY_1 and PFY_2 less than 5 percent.

The results obtained in the present study are suggestive of the fact that the improvement in these traits may be brought out by exploiting the genetic variability present in some traits with little emphasis on pedigree and progeny testing programme.

Estimation of phenotypic and genetic correlations

The phenotypic and genetic correlations along with their standard errors are presented in Table 2. The phenotypic correlations of FLMY with FLFY and LTFP were significant ($p<0.05$) and moderate to high (0.33 to 0.99). The correlations with PFY_1, PFY_2 and PFY_3 were either negative or with low magnitude. The phenotypic correlations of PMY_1 to other fat production traits i.e. FLFY, PFY_1, PFY_2, PFY_3 and LTFP ranged from 0.09 to 0.67 with 5 per cent standard error. Similar phenotypic correlations were also obtained between PMY_2 and PMY_3 with other fat production traits except PMY_2 and PFY_1; PMY_3 with PFY_1 and PFY_2, having low and negative phenotypic correlation. The phenotypic correlation between LTMP with FLFY, PFY_2, PFY_3 and LTFP ranged from 0.03 to 0.98 and the correlation with PFY_1 was observed higher but in negative direction. The genetic correlations of FLMY with FLFY.

PFY_1 and PFY_3 were 0.85±0.39; -0.28±1.22 and 0.38±1.34, respectively. A high genetic correlation existed between PMY_1 with FLFY (0.81±0.63); PFY_2 (0.74±0.93) and PFY_3 (0.84±0.93) whereas negative genetic correlations were observed between PMY_2, PMY_3 and LTMP with PFY_1, PFY_2 and PFY_3. The genetic correlation between PMY_2 and LTFP was positive with high magnitude (0.99±0.42). Similarly high genetic correlations were obtained between LTMP with FLFY (0.92±0.88) and LTFP (0.98±0.02). The estimates of inter-relationship among other traits of this study had very high standard error at genetic level and in many cases they have crossed even the statistical limit for the defined range of such estimates and no conclusion can be drawn from such parameters. High genetic and phenotypic correlations for milk and fat yields were also reported by Batra (1969), Saxena (1982), Godara (1984) and Norman et al. (1988) in different crossbred cattle. The positive and high genetic and phenotypic correlations between milk yield and fat yield were also reported by Vander Welf and De Boer (1988), Godara et al. (1990), Harris and Freeman (1991) and Pander et al. (1992) in different breeds of exotic and crossbred cattle.

The overall picture of the results of the present investigation leads to the findings that FLMY, peak yields and LTMP had significant positive phenotypic correlation with FLFY and LTFP and the correlation at the genetic level were also higher and positive for these traits. This kind of relationship is an indicator of improving lactation milk and fat yield through the improvement in one of its component trait like peak yield of first lactation. The standard errors of phenotypic correlation of this trait with others are not high and hence precise. Finally, peak week milk yield of first lactation (PMY_1) was the earliest available trait having desirable and significant correlation at phenotypic and positive at genetic level with FLFY, PFY_1, PFY_2, PFY_3 and LTFP. This will help in early evaluation of sires and dams and will increase genetic advancement per unit of time.

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