GENETIC AND PHENOTYPIC CORRELATIONS FOR SOME ECONOMIC TRAITS IN DAIRY CATTLE

Manzoor Ahmad, J. H. J. van der Werf[1] and Khalid Javed[2]
Livestock Production Research Institute Bahadurnagar, Okara, Pakistan,
[1]Department of Animal Science, University of New England, Armidale, Australia,
[2]Research Institute for the Physiology of Animal Reproduction, Bhunikey (Pattoki), Pakistan.

ABSTRACT

Data on lactation records of 1113 purebred Sahiwal and 784 Holstein Friesian X Sahiwal (FS) and Jersey X Sahiwal (JS) crossbred cows kept at the Livestock Production Research Institute (LPRI) Bahadurnagar, District Okara and Qadirabad District Sahiwal for the period 1973-1995, were analysed to study genetic and phenotypic correlations among various productive and fertility traits. Eight traits of economic importance including age at first calving, lactation length, 305-day milk yield, total milk yield, milk yield per day of calving interval, calving interval, dry period and service period were studied. The overall means for age at first calving, 305-day milk yield and lactation milk yield were 1163 ± 188.9 days, 1755 ± 615.6 kg and 1848 ± 732.6 kg, respectively. Milk yield per day of calving interval averaged 3.81 ± 1.67 kg. The means for lactation length, calving interval, dry period and service period were 288 ± 70.5, 507 ± 110.2, 220 ± 118.3 and 227 ± 118.7 days, respectively. The genetic correlations (bivariate analysis) of lactation milk yield with 305-day milk yield, milk yield per day of calving interval, dry period, service period, calving interval and age at first calving were 0.82, 0.64, -0.96, -0.49, -0.56 and 0.63, respectively. The corresponding values for phenotypic correlations were 0.95, 0.78, -0.34, 0.27, 0.28 and -0.26, respectively. The genetic correlations of milk yield per day of calving interval by multivariate (tetravariate) analysis with lactation milk yield, 305-day milk yield, lactation length, calving interval, service period and dry period were 0.63, 0.87, 0.76, 0.95, 0.95 and 0.51, respectively. The corresponding values for phenotypic correlations were 0.96, 0.99, 0.70, -0.34, -0.33 and -0.64, respectively. The genetic and phenotypic correlations among other traits were also estimated from multivariate analysis and were compared with bivariate analysis.

Keywords: Sahiwal crossbred cattle, productive and fertility traits, genetic and phenotypic correlations.

INTRODUCTION

The possible genetic improvement in a trait depends upon its genetic and phenotypic correlations with other traits and on some other genetic parameters. The degree of association between genes responsible for the additive variance of different traits is measured through genetic correlation, while the phenotypic correlation is an expression of observed relationship between the phenotypic performance of different traits. Knowledge of this relationship is valuable when traits related this way are considered for selection. If genetic correlation among two traits is positive and high, the selection for one trait would result in an improvement for the other trait. This stands true for milk yield and total fat production. If the animals are selected for increased milk yield, the fat production increases simultaneously. However, the fat percent will decrease, because milk yield and fat percent are negatively correlated. Generally, the fertility traits have low genetic variance. The evaluation of farm animals should be based upon multitrait procedures, especially for fertility traits because these have low heritability estimates and can use additional information from correlated traits. This study presents genetic and phenotypic correlations for some economic traits in Sahiwal and their crosses with Jersey and Friesian breeds in Pakistan.

MATERIALS AND METHODS

Data on lactation records of 1113 purebred Sahiwal and 784 Holstein Friesian X Sahiwal (FS) and Jersey X Sahiwal (JS) crossbred cows for first parity

District Sahiwal, Pakistan for the period 1973-1995, were analysed to compute genetic and phenotypic correlations among eight traits of economic importance including age at first calving, lactation length, 305-day milk yield, total milk yield, milk yield per day of calving interval, calving interval, dry period and service period. The data were edited carefully as far as the accuracy and reliability of the records were concerned for pedigree information. The number of records vary depending upon the type of trait. A total of 152 records (about 8%) were excluded from the analysis being incomplete due to disease, abortion, still birth and culling etc. Calving intervals exceeding 750 days were not included, while the upper limit for age at first calving was 70 months (2130 days).

The estimates were obtained by using Restricted Maximum Likelihood (REML) method (Patterson and Thompson, 1971) with an animal model. This method describes REML for the general mixed model by maximizing only that part of likelihood which is independent of fixed effects. The maximum of a likelihood function is at the point where the first derivative is zero and second derivative is less than zero. To locate the point of maximum likelihood function for parameters to be estimated, algorithms using first and second derivatives of the likelihood function were applied. This procedure also made allowance for unequal design matrices and missing observations. The covergence criterion for the iteration, based on the norm of the update vector, was set 10^{-10}. Standard errors and sampling covariances of estimates of genetic correlations among various traits of economic importance under this option were obtained by Derivative Free Restricted Maximum Likelihood (DFREML) program (Meyer, 1998). Two types of analyses were carried out, in one considering two traits at a time (bivariate analysis) and an other considering four traits at a time (multivariate analysis). The results obtained by bivariate analysis were compared with the results of multivariate analysis. The years were divided into four seasons, viz. winter (December – February), spring (March –May), summer (June-August) and autumn (September-November). The model contained fixed effects of herd-year-season and breed group. The age at first calving was taken as covariate for all other traits except when age at first calving used as a trait. The additive genetic effect of the cow was also included in the model. The same model was used with bivariate and multivariate analysis except for the number of traits for analysis.

RESULTS AND DISCUSSION

The results of bivariate analysis for genetic and phenotypic correlations among various production and reproduction traits are given in Table 1 and results from multivariate analysis are presented in Table 2 and 3.

BIVARIATE ANALYSIS

Genetic Correlations

Genetic correlations of lactation length with other traits

The genetic correlations of lactation length with milk yield, 305-day yield, milk yield per day of calving interval, calving interval, service period and dry period were positive and high. (Table 1). The standard errors for the genetic correlations were also high. In most of the cases it was either above one or approximation of standard error could not be done. Khan et al. (1988) reported very high genetic correlations (0.86 and 0.94) for lactation length and lactation milk yield in Sahiwal and Friesian X Sahiwal crossbred cows, respectively. The estimates of Mohiuddin et al. (1991) for the lactation length and lactation milk yield were low (0.16) but significant, however, their estimates between lactation length and calving interval were higher (0.99) in Sahiwal cattle. Tewari et al. (1995) analysed data on 186 Jersey X Sahiwal cows. They found that genetic correlation of first lactation length with first dry period was negative and significant (-0.76), suggesting that cows which gave more milk have shorter dry periods. A very high genetic correlation means that essentially same genes are controlling different traits.

The genetic correlations of lactation milk yield with 305-day milk yield and milk yield per day of calving interval were very high and positive but with calving interval, service period and dry period were negative (Table 1), suggesting that due to the stress of higher milk production and less available energy to the animal, the fertility traits are affected. In other words, high yielders have longer service period, dry period and calving interval. Singh *et al.* (1968) reported the genetic correlation of first lactation milk yield with first service period and first calving interval to be 0.04 ± 0.30 and - 0.08 ± 0.04. Both values were non-significant. Tewari *et al.* (1995) reported that genetic correlation of first lactation milk yield with first dry period was negative (-0.34) in crossbred cattle. Javed (1999) reported genetic correlation of milk yield with lactation length, calving interval and dry period as 0.49, 0.46 and 0.49, respectively.

Genetic correlation of 305-day milk yield with other traits

The genetic correlations of 305-day milk yield with calving interval, service period and dry period were negative (Table 1), which is desirable. Similar to lactation milk yield, 305-day milk yield also had high positive genetic correlation with milk yield per day of calving interval. The reason may be that the later is an efficiency trait, with production in the nominator, so the correlation is high.

Genetic correlation of milk yield per day of calving interval with other traits

The genetic correlations of milk yield per day of calving interval with calving interval and service period were positive. However, the genetic correlation of milk yield per day of calving interval with dry period was negative and high (Table 1).

Genetic correlation of calving interval with other traits

The genetic correlations of calving interval with service period and dry period were positive and high (Table 1). Singh *et al.* (1969) reported very high and positive genetic correlation of 0.98 between first calving interval and first service period.

Genetic correlation among age at first calving and other traits

The genetic correlations of age at first calving with first lactation length, first lactation milk yield, 305-day milk yield, milk yield per day of calving interval, calving interval, service period and dry period ranged from 0.30 to 0.99 (Table 1). All these correlations were positive but undesirable. Dutt and Tomar (1972) reported the genetic correlation of age at first calving with milk yield (-0.54 ± 0.32) and lactation length (-0.89 ± 0.15) to be negative while positive with service period (0.31 ± 0.38). Selection, therefore, based on early maturity leads to animals with higher milk yield in first lactation. Misra *et al.* (1980) observed that genetic correlations between age at first calving and milk yield were 0.79 ± 0.14 in Hariana cattle.

Tomar and Singh (1981) reported the genetic correlations of age at first calving with first lactation milk yield, first lactation length and first calving interval to be 0.80 ± 0.01, 0.66 ± 0.08 and -0.07 ± 0.07 in Hariana cattle. Mohiuddin *et al.* (1991) reported that genetic correlation between age at first calving and first lactation milk yield in Sahiwal cattle was high (0.44) and significant ($P < 0.01$). Javed (1999) analysed data on performance traits of a purebred herd

Table 1: Genetic* and phenotypic correlations for different traits from bivariate analysis.

Traits	Lactation Length	Milk Yield	305-day yield	Milk/day of CI	Dry Period	Service period	Calving interval	Age at Calving
Lactation length		0.74	0.63	0.45	-0.30	0.26	0.25	-0.05
Lact. milk yield	0.91 (***)		0.95	0.78	-0.34	0.27	0.28	-0.26
305-day milk yield	0.96 (***)	0.82 (***)		0.83	-0.27	-0.37	0.14	-0.02
Milk yield/day of Cal. interval	0.51 (***)	0.64 (**)	0.82 (**)		-0.61	-0.37	-0.36	0.05
Dry period	0.73 (**)	-0.96 (**)	-0.99 (**)	-0.90 (0.10)		0.83	0.84	-0.07
Service period	0.99 (**)	-0.49 (**)	-0.70 (**)	0.21 (0.27)	0.98 (0.09)		0.98	-0.09
Calving interval	0.99 (**)	-0.56 (**)	-0.62 (**)	0.24 (0.25)	0.96 (0.08)	0.99 (0.01)		-0.53
Age at first calving	0.30 (0.51)	0.63 (***)	0.99 (***)	0.75 (***)	0.33 (***)	0.40 (***)	0.50 (0.16)	

* Genetic correlations with standard errors (in brackets below) are below diagonal while phenotypic correlations are above diagonal, ** Standard error for genetic correlations above one, *** approximation of standard error failed

of Sahiwal cattle in Pakistan and reported genetic correlations of age at first calving with milk yield, lactation length and service period as 0.61, 0.99 and 0.50, respectively.

Phenotypic Correlations

Phenotypic correlations of lactation length with other traits

The phenotypic correlations of lactation length with milk yield, 305-day milk yield, calving interval and service period were positive. However, the phenotypic correlation between lactation length and dry period was negative (Table 1). Khan (1985) reported that the lactation length was positively correlated with milk yield (0.51), service period (0.19) and calving interval (0.34) but negatively correlated (-0.24) with dry period in crossbred cows. Yeotikar and Deshpande (1991) observed that correlation of lactation length with dry period was 0.45 for rural crossbred cows in India. Sreemannarayana and Rao (1994) stated that there was high positive correlation of lactation length with service period in Jersey X Ongole cows in India.

Correlations of lactation milk yield with other traits

The phenotypic correlations of lactation milk yield with 305-day milk yield, milk yield per day of calving interval, calving interval and service period were positive. However, the phenotypic correlation between lactation milk yield and dry period was negative (Table 1) which is desirable. Singh (1969) reported the phenotypic correlation between first lactation milk yield and first dry period to be -0.09 ± 0.05, which was non-significant, indicating that dry period is not influenced by first lactation milk yield in the matter of phenotypic expression.

Tomar and Balaine (1973) observed the correlation coefficient between milk yield and service period to be positive and significant for first, second and third lactations. This indicates that with an increase in service period, there would be an increase in lactation milk yield. The service period of 4 to 5 months was optimum for maximum production. The correlation between dry period and subsequent milk yield were low and non-significant. However, Yeotikar and Deshpande (1991) observed that correlation of lactation milk yield with dry period was 0.75 for rural

Table 2: Genetic* and phenotypic correlations among various production traits (tetravariate analysis)

Traits	Lactation milk yield	305-day milk yield	Lactation length	Milk yield/day of calving interval
Lactation milk yield		0.96	0.76	0.96
305-day milk yield	0.76 (**)		0.67	0.99
Lactation length	0.98 (**)	0.33 (**)		0.70
Milk yield/day of calving interval	0.63 (**)	0.87 (**)	0.76 (**)	

* Genetic correlations (with standard error below) below diagonal, phenotypic ccorrelations above diagonal.

** Standard error for genetic correlations above one,

Table 3: Genetic and phenotypic correlations among various performance traits (tetravariate analysis)

Traits	Calving interval	Service period	Dry period	Milk yield/day of calving interval
Calving interval		0.98	0.80	-0.34
Service period	0.99 (0.01)		0.86	-0.33
Dry period	0.69 (0.07)	0.67 (0.07)		-0.64
Milk yield/day of calving interval	0.95 (0.08)	0.95 (0.25)	0.51 (0.10)	

* Genetic correlations (with standard errors below) below diagonal, and phenotypic correlations above diagonal

crossbred cows in India. Sreemannarayana and Rao (1994) reported that there was a high positive correlation of lactation milk yield with service period in Jersey X Ongole cows in India. Javed (1999) reported phenotypic correlation of first lactation milk yield with lactation length, calving interval and dry period as 0.35, 0.39 and 0.35, respectively.

Correlations of 305-day milk yield with other traits

The 305-day milk yield was positively correlated with milk yield per day of calving interval, and calving interval but its correlations with service period and dry period were negative (Table 1). Javed *et al.* (1990) reported a high phenotypic correlation (0.62) of 305-day milk yield with milk yield per day of calving interval in Nili Ravi buffaloes.

Correlation of milk yield per day of calving interval with other traits

The phenotypic correlations were -0.36, -0.37 and -0.61 for milk yield per day of calving interval with calving interval, service period and dry period, respectively. The correlations of milk yield per day of calving interval with calving interval, service period and dry period were negative (Table 1), which are desirable.

Correlation of calving interval with other traits

The phenotypic correlations among calving interval, service period and dry period, were positive and highly significant (Table 1). The phenotypic correlation between service period and dry period was high and positive. It is possible because if a cow has a tendency to conceive early it will give milk for longer period and subsequently the dry period becomes shorter. Many other workers reported similar findings, i.e., Ahmad and Sivarajasingam (1998) and Ahmad (1999). Khan (1985) reported that calving interval was positively and significantly correlated with dry period (0.82 - 0.96) and service period (0.91- 0.99) in Sahiwal and crossbred cattle. Yeotikar and Deshpande (1991) reported that correlation of calving interval with dry period was 0.61 for rural crossbred cows in India.

Correlation among age at first calving and other traits

The phenotypic correlations of first calving age with lactation length, milk yield, 305-day milk yield, milk yield per day of calving interval, calving interval, service period and dry period are given in Table 1. All the phenotypic correlations were negative except correlation among milk yield per day of calving interval and age at first calving which was positive but very low (0.05). The negative correlations of age at first calving with production traits are desirable, since a reduction in age at first calving would increase the milk yield and the productive life of the cow. Khan (1985) reported negative and non-significant correlation of age at first calving with lactation length, milk yield, dry period, service period and calving interval in native and crossbred cattle. However, Singh *et al.* (1969) reported the phenotypic correlation of age at first calving with first lactation milk yield, first service period and first dry period to be 0.05, 0.12 and 0.09, respectively, but these correlations were low. Javed (1999) reported phenotypic correlation of age at first calving with milk yield, lactation length and service period as 0.67, 0.15 and 0.30, respectively.

MULTIVARIATE ANALYSIS

Genetic and phenotypic correlations estimated by multivariate analysis for the same data set are given in Tables 2 and 3. The same statistical model was used, as in bivariate analysis. A multivariate analysis of all traits was not feasible in one step; therefore, analyses were conducted in two steps. The traits were divided into two groups. The first group included lactation length; milk yield, 305-day milk yield and milk yield per day of calving interval (Table 2). The second group included calving interval; service period, dry period and milk yield per day of calving interval (Table 3). The comparison of these estimates with bivariate analysis (Table 1) showed an increase in genetic correlation of lactation length with total milk yield from 0.91 to 0.98 and lactation length with milk yield per day of calving interval from 0.51 to 0.70. The phenotypic correlations for these traits also increased from 0.74 to 0.76 and 0.45 to 0.70, respectively.

The genetic correlations of milk yield per day of calving interval with calving interval, service period and dry period were also higher than bivariate analysis. An improvement was also noticed in the correlations of 305-day milk yield with milk yield per day of calving interval. Although it is a good idea to include more traits in an analysis at a time, it is hard to produce consistent (positive definite) variance covariance matrices.

CONCLUSIONS

This work provides information for genetic and phenotypic correlations among various production and fertility traits, which can be used for further genetic evaluation programmes in dairy cattle. The correlations were higher for production traits as compared with fertility traits, i.e., lactation length showed a very high genetic correlation with lactation milk yield, 305-day milk yield and milk yield per day of calving interval. It can be concluded that 305-day milk yield is a good indicator of total lactation yield. It was also shown that milk yield per day of calving interval had a negative correlation with fertility traits which means that the genetic improvement in fertility traits is also possible by selection for 305-day milk yield or milk yield per day of calving interval as a correlated response. Significant positive relationships were also found between fertility traits indicating that these traits are more influenced by environment. Furthermore, it is useful to analyse fertility traits in a multivariate analysis in evaluation programs, because, they are lowly heritable and can benefit from additional information from correlated traits. The correlations derived from multivariate analysis are also more accurate and precise as compared with bivariate analysis.

REFERENCES

Ahmad, M., 1999. Genetic evaluation of native and crossbred dairy cattle in Pakistan. Ph.D. Thesis, Uni. New England, Armidale, NSW, Australia.

Ahmad, M. and S. Sivarajasingam, 1998. Analysis on the productive and reproductive traits in Sahiwal cows. Proc. 6th World Cong. Genet. Appl. Livest. Prod. 23: 399-402.

Dutt, M. and S.P.S. Tomar, 1972. Effect of non-genetic factors on the inheritance of age at first calving in Hariana cattle. Indian J. Anim. Sci., 42: 333-336.

Javed, K., M. A. Khan., G. Mohiuddin and Salahuddin., 1990. Genetic parameters of some milk yield efficiency traits in Nili Ravi buffaloes. Sarhad J. Agri., 6(6): 543-546.

Javed, K., 1999. Genetic and phenotypic aspects of some performance traits in a purebred herd of Sahiwal cattle in Pakistan. Ph. D. Thesis, Univ. Agri. Faisalabad (Pakistan).

Khan, U. N., 1985. The adaptability of crossbred dairy cattle to environmental conditions in Pakistan. Ph.D. Dissertation. Univ. Georgia, Athens, U. S. A.

Khan, U. N., L. L. Benyshek., M. D.Ahmad., M. Z. Choudhary and S. M. Athar, 1988. Repeatability and heritability estimates for economic traits ofnative and crossbred dairy cattle. Pakistan Agri. Res., 9(4): 575-579.

Meyer, K., 1998. "DXMRR" A program to estimate covariance functions for longitudinal data by restricted maximum likelihood. Proc. 6th World Cong. Genet. Appl. Livest. Prod., 27: 465-466.

Misra, R. K., B. L. Rainda, and P. N. Bhat, 1980. Studies on the genetic and non-genetic factors affecting inter-calving period in pure-bred indigenous cattle and their crosses with Friesian. Indian J. Anim. Hlth., 19(1): 53-57.

Mohiuddin, G., Z. Ahmad., M. A. Khan., P. Akhtar and S. Ali, 1991. Genetic, phenotypic and environmental correlations between milk yield and some other economic traits in Sahiwal cattle. Pakistan Vet. J., 11(3): 113-116.

Patterson, H. D. and R.Thomson, 1971. Recovery of inter-block information when block sizes are unequal. Biompetrika, 58: 545-554.

Singh, D., 1969. Inheritance of production traits in Hariana cattle. Indian Vet. J., 46: 585-590.

Singh, D., R. M Acharya and D. Sundarasan, 1969. Effectiveness of different selection indexes for genetic advancement in Hariana cattle. Indian J. Anim. Sci., 89: 473-487.

Singh, M., R. M. Acharya and J. S. Dhillon, 1968. Inheritance of different measures of reproductive efficiency and their relation with milk production in Hariana cattle. Indian J. Dairy Sci., 21: 249-254.

Sreemannarayana, O. and A. V. N. Rao, 1994. Effect of service period and season of calving on lactation traits among crossbred cows. Indian Vet. J., 71(11): 1094-1097.

Tewari, S. K., D. Kumar., R. B. Parasad and V. P. Manglik, 1995. Genetic studies on first lactation yield in Jersey-Sahiwal crossbreds. Indian J. Dairy Sci., 48(9): 568-569.

Tomar, S. S. and D. S. Balaine, 1973. Effect of the length of service period and preceding dry period on the milk yield of Hariana cattle. Indian J. Dairy Sci., 26: 20-24.

Tomar, N. S. and B. P. Singh, 1981. Genetic trends of some economic trait in Hariana cows. Indian Vet. J., 58: 701-709.

Yeotikar, S. S. and K. S. Deshpande, 1991. Factors affecting dry period and calving interval in rural crossbred cows. Indian Vet. J., 68(10): 944-947.