Statistical Genetic Studies on Cattle Breeding for Dairy Productivity in Bangladesh: I. Genetic Improvement for Milk Performance of Local Cattle Populations

K. B. Hossain, S. Takayanagi, T. Miyake, K. Moriya[1], A. K. F. H. Bhuiyan[2] and Y. Sasaki*

Laboratory of Animal Breeding and Genetics, Division of Applied Biosciences, Graduate School of Agriculture

Kyoto University, Kyoto 606-8502, Japan

ABSTRACT : Genetic parameters for dairy performance traits were estimated, breeding values for the traits of all breeding sires and cows were predicted and the genetic trends were estimated using the breeding values in the Central Cattle Breeding Station (CCBS). A total of 3,801 records for Bangladeshi Local, 756 records for Red Sindhi and 959 records for Sahiwal covering the period from 1961 to 1997 were used in this analysis. Traits considered were total milk production per lactation (TLP), lactation length (LL) and daily milk yield (DMY). The genetic parameters were estimated by the REML using MTDFREML program. The breeding values were predicted by a best linear unbiased prediction (BLUP). In all sets of data, the genetic trends for the dairy performance traits were computed as averages of breeding values for cows born in the particular year. The estimates of heritability for TLP (0.26 and 0.27) and DMY (0.28 and 0.27) were moderate in Bangladeshi local and Red Sindhi breed, respectively. Furthermore, the heritability estimate for LL (0.24) was moderate in Red Sindhi. The estimates of heritabilities for all traits were low in Sahiwal. The repeatability estimate was high for TLP, moderate for LL and moderate to high for DMY. All variances estimated in Bangladeshi Local were low, comparing the respective values estimated in both Red Sindhi and Sahiwal. On the other hand, additive genetic variances for the three traits were estimated very low in Sahiwal. The genetic trends for the three dairy production traits have not been positive except for the recent trend in Bangladeshi Local. *(Asian-Aust. J. Anim. Sci. 2002, Vol 15, No. 5 : 627-632)*

Key Words : Bangladeshi Cattle, Milk Performance, Genetic Parameters, Genetic Trend

INTRODUCTION

The population of cattle in Bangladesh is about 23 million (Directorate of Livestock Services, 1994). Bangladeshi Local cattle are small and horned and are used for ploughing in Bangladesh. Their production level is low even under good dietary, management and environmental conditions. In 1936, a thousand pure Hariana bulls were imported from India for upgrading the local cattle through natural services. Sahiwal and Red Sindhi bulls were imported from Pakistan in 1950 for the improvement of Bangladeshi Local breed through artificial insemination. In 1973, Friesian and Jersey cows were imported from Australia. Deep-frozen semen of Sahiwal bulls was imported from Kenya. At present time, the cattle of Bangladesh are composed of 22.75 million pure breeds and 0.25 million crossbreds.

In general, two breeding strategies are available for improvement of cattle, i.e., selection breeding within a breed and crossbreeding among breeds (Falconer and Mackey, 1996). In Bangladesh, pure breeds such as Bangladeshi Local, Red Sindhi, Sahiwal and cross-breds among various breeds are mixed at the present time. It is

important which breeding strategy for dairy cattle is more appropriate not only in Bangladesh but also in developing countries in a similar situation.

Whether the dairy performance can be improved by selection breeding enough to attain the need of people must be evaluated. Firstly, it is needed how the production traits measured under a certain condition are heritable. Estimation of genetic parameters for the production traits in foreign countries have been reported by many researchers (Afifi et al., 1992; Alba and Kennedy, 1985, 1994; Ahlbom and Dempfle, 1992; Brotherstone and Hill, 1994; Bhatnagar et al., 1983; Pundir and Raheja, 1994; Visscher and Goddard, 1995; Meyer, 1984, 1985; Katoch and Yadav, 1990; Campos et al., 1994). Secondly the existence of the genetically superior animals is important to attain the goal. Finally, the actual genetic trend in the particular herd should be traced periodically.

The objectives of this study are to estimate genetic parameters for the dairy performance traits, to predict breeding values for the traits of all breeding sires and cows used in the Central Cattle Breeding Station (CCBS) and to estimate the genetic trends for the traits of the local cattle populations.

MATERIALS AND METHODS

Central cattle breeding station (CCBS)

The CCBS is operated under the oversight of the

Ministry of Livestock and Fisheries, Peoples Republic of Bangladesh, for improvement of the breeding cattle.

Crossbreeding experiments of cattle have been carried out at the CCBS since 1961. The experimental animals were divided into 8 pure breeds, namely Bangladeshi Local (L), Sahiwal (S), Sahiwal Kenyan (S.K), Red Sindhi (R), Friesian (F), Holstein-Friesian (H), Jersey (J), Tharparker (T), and their various crosses. A total of 14,512 records were collected covering the period from 1961 to 1997.

The information on cows has been recorded in the same format from the establishment of CCBS. The first lot of earmark numbers from 1 to 9,999 was finished by August 26, 1983. The second lot of earmark numbers again started from 1 to 9,999 on August 27, 1983. This problem was solved by converting the pedigree information into another unique ID number system.

Standard conditions of feeding and management practices were adopted for all animals. The feeding and management system in the CCBS is as uniform as possible throughout the year. Concentrate feeds are given twice a day, in the morning before milking and in the evening, according to their body requirements as per recommendation of Directorate of Livestock Services. Concentrate feeds include wheat bran, till oil cake, rice polish, khesheri and salt. The green grasses like para, napier, maize, oats etc. are supplied on the basis of year round availability. The cows were milked twice daily, early morning and afternoon using hand-milking for low yielding cows and machine milking for high yielding cow.

Data

Records on productive performance of local cows kept at the CCBS, Dhaka, were used for this study. The data selected for this analysis were composed of 3,801 records for Bangladeshi Local breed, 756 records for Red Sindhi and 959 records for Sahiwal breed covering the period from 1961 through 1997. Production traits considered were (1) total milk production per lactation (TLP); (2) lactation length (LL) and daily milk yield (DMY).

Four seasons were defined as 1:Summer (March to May), 2:Rainy Summer (June to August), 3:Autumn (September to November) and 4:Winter (December to February). Fifteen parity classes consisted of the 15 lactation numbers. Thirty-seven years classes were 1:1961 through 37:1997.

Estimation of genetic parameters by MTDFREML

The analytical model included the effects of parity, calving year, and calving season as fixed effects, and cow included as a random effect. The following statistical model was used for the estimation of genetic parameters for production traits:

$$Y_{ijklm}=\mu+P_i+N_j+S_k+a_l+r_l+e_{ijklm}$$

where, Y_{ijklm} is an observed trait for the $ijklm^{th}$ record; μ is the population mean; P_i is the fixed effect of the ith parity; N_j is the fixed effect of the jth calving year; S_k is the fixed effect of the kth season; a_l is the additive genetic effect of the lth cow; r_l is the permanent environmental effect of the lth cow and e_{ijklm} is the random environmental effect. Variance components for the dairy production traits were estimated by Multiple Trait Derivative-Free Restricted Maximum Likelihood computer program denoted as MTDFREML written by Boldman et al. (1993).

The estimates of variance components with MTDFREML using single trait approach were investigated. In all sets of data, the initial values were set to 1.00 for genetic variance (σ^2_a), 0.50 for uncorrelated random variance (σ^2_r) and 1.00 for environmental variance (σ^2_e). The estimates were obtained considering pedigree information traced back to generation two from the experimental cows which was used in setting up the numerator relationship matrix. It was suggested that the unbiased estimate of the base population would be obtained using the pedigree information traced, back to the generation (Moriya et al., 1994). The convergence criterion value for variance of the log likelihood function was initially set to 1.0 E-5. Several cold starts were made to avoid estimated parameter's value stopping at a local maximum of the likelihood function. For each cold start, solutions at convergence of previous run were used as initial values. When converged parameter value was the same as initial value under convergence criterion value of 1.0E-5, then convergence criterion was changed to 1.0 E-8. Cold start was repeated in the same way until final convergence was attained.

The breeding values for all animals included in the analyzed data were predicted by the best linear unbiased prediction (BLUP) using MTDFREML program (Boldman et al., 1993). In all sets of data, the genetic trends for the dairy performance traits were estimated by averaging of breeding values for cows born in the particular year (Henderson, 1973).

RESULTS AND DISCUSSION

Means and their standard deviations for TLP, LL and DMY analyzed in this study are shown in table 1 for Bangladeshi Local breed, Red Sindhi and Sahiwal breed. The mean LLs of Sahiwal and Red Sindhi breeds were longer by about 40 days than that of Bangladeshi Local breed. However, the former is shorter than those of exotic breeds. LL for Friesian was reported as 332 to 342 days in Egypt under farm conditions (Afifi et al., 1992). LL for

Table 1. Mean and standard deviation (S.D.) of three dairy production traits for Bangladeshi Local. Red Sindhi and Sahiwal cattle raised in CCBS during 1961 to 1997

| Breed | Trait | Statistics | | |
		N	Mean	S.D.
	TLP (kg)	3,801	661.1	353.1
Bangladeshi Local	LL (days)	3,801	249	95
	DMY (kg/day)	3,801	2.57	0.89
	TLP (kg)	756	1,023.4	537.8
Red Sindhi	LL (days)	756	287	103
	DMY (kg/day)	756	3.49	1.30
	TLP (kg)	959	1,031.0	545.5
Sahiwal	LL (days)	959	288	107
	DMY (kg/day)	959	3.47	37.80

TLP: total milk production per lactation; LL: lactation length; DMY: daily milk yield; N: number of records.

Holstein was reported as 315 days in Korea (Moon, 1994).

The mean TLPs of Red Sindhi and Sahiwal breeds were 50% more than that of Bangladeshi Local breed. However, the former was much lower than those of exotic dairy breeds. TLP for Friesian raised in Egypt was reported to be 2,460 kg to 2,922 kg under farm conditions (Afifi et al., 1992) and 2,778 kg for Holstein-Friesian raised in New Zealand (Ahlborn and Dempfle, 1992). TLP for Jersey breed in New Zealand was 2,217 kg (Ahlborn and Dempfle, 1992). TLP for Holstein was 9,000 kg in Japan (Hasegawa et al., 1993), and 5,948 kg to 6,242 kg in Korea (Moon, 1994). Average DMY of Red Sindhi and Sahiwal breeds were higher than that for Bangladeshi Local breed but much lower than those for Holstein which were 18.8 kg to 21.9 kg in Korea (Moon, 1994), 30 kg in Japan (Hasegawa et al., 1993) and 31.9 kg in Florida of USA (Martin et al., 1986).

Estimates of population parameters for TLP. LL and DMY are presented in table 2 for Bangladeshi Local. Red Sindhi and Sahiwal breeds. Heritability for TLP was very low in Sahiwal breed but moderate in Bangladeshi Local and Red Sindhi breeds. Heritability estimates for TLP obtained in this study correspond to lower edge of the range of estimates reported for other populations by many

researchers: 0.28 to 0.49 for Holstein Friesian (Ahlborn and Dempfle. 1992; Campos et al., 1994; Short and Lawlor, 1992; Lee et al., 1992; Chauhan and Hayes, 1991; Rege. 1991; Akbas et al., 1993 and Pander et al., 1992), 0.26 to 0.32 for Jersey (Campos et al., 1994; Ahlborn and Hohenboken. 1991); 0.27 to 0.40 for Sahiwal (Rege et al., 1992); 0.40 to 0.52 for Pinzgauer (Soliman et al., 1990); 0.20 to 0.28 for Australian dairy cattle (Visscher and Goddard, 1995).

The heritability estimates for LL were low to moderate, which seems to be the same as reported values: 0.067 to 0.23 Sahiwal (Yadev et al., 1992; Gandhi and Gurnani, 1988; Khanna et al., 1980); 0.08 to 0.19 for Friesian (Khattab and Sultan, 1990; Oferrall, 1990); 0.11 to 0.24 for Hariana (Kumar et al., 1992; Khanna et al., 1980); 0.30 for Gir (Shaha and Khan, 1987); 0.06 for Holstein (Abubakar et al., 1986) and 0.03 to 0.39 for Tharparkar (Basu et al., 1982; Bhat et al., 1980).

The estimate of heritability for DMY is 0.28 for Bangladeshi Local, 0.27 for Red Sindhi and 0.02 for Sahiwal. The heritability estimate of 0.314 was reported for Friesian×Sahiwal cows (Singh et al., 1989), and was 0.11 to 1.58 for Tharparker cattle (Taneja and Bhatnagar, 1985; Rao

Table 2. Estimates of heritabilities (h^2). repeatabilities (r), additive genetic (σ^2_a). permanent environmental (σ^2_t), environmental (σ^2_e) and phenotypic (σ^2_y) variances for three dairy production traits of Bangladeshi Local. Red Sindhi and Sahiwal cattle raised in Bangladesh from 1961 to 1997

Breeds	Trait	h^2	r	σ^2_a	σ^2_p	σ^2_e	σ^2_y
	TLP	0.26	0.44	29,903.4	21,007.7	65,349.7	116,260.8
Bangladeshi Local	LL	0.06	0.26	549.2	1,742.1	6,363.5	8,654.9
	DMY	0.28	0.38	0.19	0.07	0.43	0.69
	TLP	0.27	0.42	78,704.4	45,435.7	171,240.4	295,380.5
Red Sindhi	LL	0.24	0.25	2,606.8	116.8	7,938.3	10,661.8
	DMY	0.27	0.38	0.44	0.17	0.99	1.60
	TLP	0.02	0.36	5,070.1	99,344.9	188,178.0	292,593.0
Sahiwal	LL	0.10	0.22	1,054.4	1,293.9	8,079.7	10,428.0
	DMY	0.02	0.24	0.04	0.36	1.25	1.66

TLP: total milk production per lactation; LL: lactation length; DMY: daily milk yield.

and Dommerholt. 1981).

A certain level of heritability and an sufficient genetic variation for the target trait are needed so that the population mean can be improved by selection breeding. The adopted breeding plan is sure to affect the genetic gain. The estimates of heritability for TLP (0.26 and 0.27) and DMY (0.28 and 0.27) were moderate in Bangladeshi Local and Red Sindhi breed, respectively. Furthermore, the heritability estimate for LL (0.24) was moderate in Red Sindhi. The results indicate that genetic improvement of these traits can be achieved through selection breeding in these breeds.

The repeatability estimates for TLP were high and similar to the values reported in the literature; 0.52 to 0.54 for Japanese Holstein (Suzuki and Van Vleck. 1994), 0.43 for Friesian-Hariana (Kaushik et al., 1984), 0.55 for Brown Swiss-Hariana (Kaushik et al., 1984), 0.39 for Jersey-Hariana (Kaushik et al., 1984), 0.49 for Jersey (Shah and Singh, 1984), 0.44 for Milking Criollos (Alba and Kennedy, 1994) and 0.46 for Red Kandhari (Dhumal et al., 1993).

The repeatability estimates for LL were moderate in this study. The estimates of repeatability for LL reported in the literature were 0.15 for Pitangueiras cows (Lobo et al., 1980), 0.34 for Gir cattle (Magnabosco et al., 1993), 0.18 for Purebred Gir cows (Souza et al., 1995) and 0.22 for high grade Gir cows (Souza et al., 1995).

The repeatability estimates for DMY were moderate to high in this study but lower than the estimates reported in the literature; 0.538 for Red Kandhari (Dhumal et al., 1993) and 0.43 for Gir cattle (Magnabosco et al., 1993).

About the estimates of variances, all variances estimated in Bangladeshi Local seem to be low, comparing the respective values estimated in both Red Sindhi and Sahiwal. On the other hand, additive genetic variances for the three traits were estimated to be very low in Sahiwal.

Enough variation for a trait in the population is needed so that the level for the trait can be changed along the breeding objective. Although the variation can be estimated by the additive genetic variance, the size was expressed visually as a range of predicted breeding values for TLP, LL and DMY of Bangladeshi Local, Red Sindhi and Sahiwal breeds as shown in table 3. The maximum predicted breeding value of Red Sindhi was the largest for TLP, LL and DMY, but they were still only 491.3 kg, 88 days and 1.49 kg/day, respectively. As the population mean for TLP was 1,023 kg (table 1), the mean of the next generation is expected theoretically to become about 1,500 kg (=1,023+491).

The genetic trends among Bangladeshi Local, Red Sindhi and Sahiwal breeds are presented in figure 1 for TLP; figure 2 for LL and figure 3 for DMY. The genetic trends in Bangladeshi Local breed showed almost all the same pattern for the three traits. The levels were static until 1970, but decreased after that time. However, the genetic

Table 3. Range of predicted breeding values for three dairy production traits of sires and cows in Bangladeshi Local, Red Sindhi and Sahiwal cattle raised in Bangladesh from 1961 to 1997

| Traits | Breeds | Range of predicted breeding value | |
		Maximum	Minimum
TLP	Bangladeshi Local	384.6	-261.2
	Red Sindhi	491.3	-410.5
	Sahiwal	40.1	-29.6
LL	Bangladeshi Local	31	-28
	Red Sindhi	88	-94
	Sahiwal	51	-33
DMY	Bangladeshi Local	1.19	-0.83
	Red Sindhi	1.49	-1.00
	Sahiwal	0.12	-0.14

TLP: total milk production per lactation; LL: lactation length; DMY: daily milk yield.
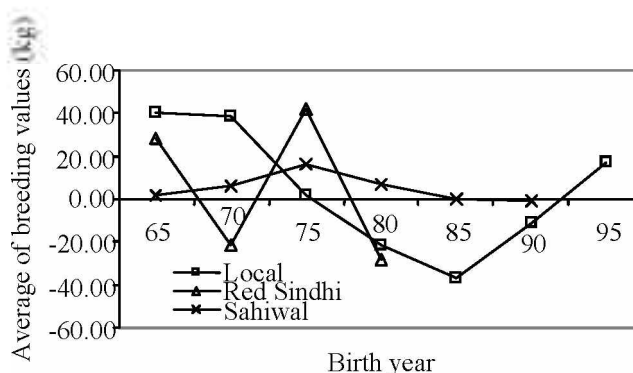
Figure 1. Genetic trends for TLP of Bangladeshi Local, Red Sindhi and Sahiwal breeds raised in Bangladesh from 1961 to 1997.
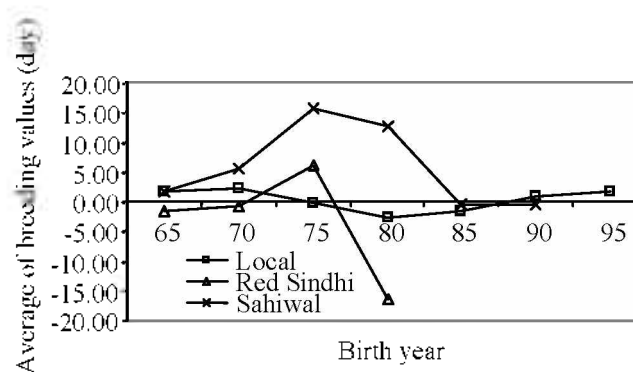
Figure 2. Genetic trends for LL of Bangladeshi Local, Red Sindhi and Sahiwal breeds raised in Bangladesh from 1961 to 1997.
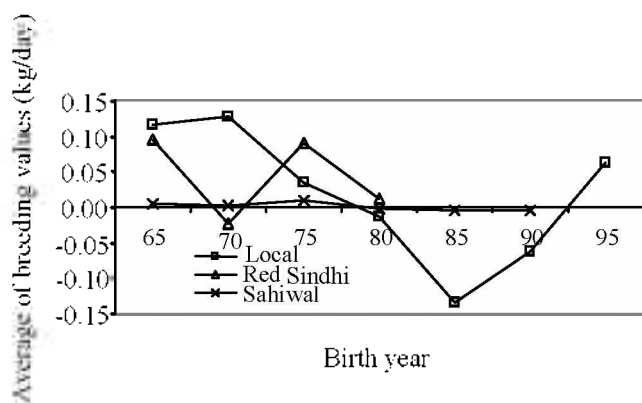
Figure 3. Genetic trends for DMY of Bangladeshi Local, Red Sindhi and Sahiwal breeds raised in Bangladesh from 1961 to 1997.

trends became positive after around 1985. On the other hand, the genetic levels of Red Sindhi and Sahiwal breeds fluctuated randomly with a decreasing trend in recent years.

When the selection breeding is considered, another important point is whether enough genetic variation for the trait to attain the breeding goal exists or not in the population. The average LL of Red Sindhi was 287 days and maximum breeding value predicted in the breed was 88 days. These values indicate that LL of Red Sindhi can be improved by selection to the same level as that of the exotic breeds. Although there exist a big genetic variation, however, the levels of either TLP or DMY seem to be difficult to attain the goal, as both the population levels and the predicted breeding values of animals which would have highest genetic dairy performance were too low though their heritabilities were not low.

As a conclusion, a certain level of production will be attained in both Red Sindhi and Bangladeshi Local by selection within each breed, but the level seems not to be satisfactory for the demand of people in Bangladesh.

REFERENCES

Abubakar, B. Y., R. E. Mcdowell and L. D. Van Vleck. 1986. Genetic evaluation of Holsteins in Colombia. J. Dairy Sci. 69:1081-1086.

Afifi, E. A., M. H. Khalil, M. F. Abd El-Glil and Z. A. Sultan. 1992. Estimation of genetic parameters and sire values for milk production of Friesian cattle raised in Egypt. Egypt. J. Anim. Prod. 29:197-214.

Ahlbom, breier and W. D. Hohenboken. 1991. Additive and nonadditive genetic effects on milk production in dairy cattle: evidence for major individual heterosis. J. Dairy Sci. 74:592-602.

Ahlbom, G. and L. Dempfle. 1992. Genetic parameters for milk production and body size in New Zealand Holstein-Friesian and Jersey. Livest. Prod. Sci. 31:205-219.

Akbas, Y., S. Brotherstone and W. G. Hill. 1993. Animal model estimation of non-additive genetic parameters in dairy cattle, and their effect on heritability estimation and breeding value prediction. J. Anim. Breed. Genet. 110:105-113.

Alba, J. de. and B. W. Kennedy. 1985. Milk production in the Latin-American Milking Criollo and its crosses with the Jersey. Anim. Prod. 41:143-150.

Alba, J. de. and B. W. Kennedy. 1994. Genetic parameters of purebred Milking Criollos in tropical Mexico. Anim. Prod. 58:159-165.

Basu, S. B., D. S. Bhatnagar and V. K. Taneja. 1982. Estimates of genetic parameters for first lactation performances in Tharparkar cattle. Indian J. Anim. Sci. 52:279-283.

Bhat, P. N., B. S. Sharma and R. C. Garg. 1980. Genetic studies on production traits in Tharparkar cattle. Indian J. Anim. Sci. 50:542-547.

Bhatnagar, D. S., V. K. Taneja, S. B. Basu and K. M. K. Murthy. 1983. Genetic parameters for some economic traits in Sahiwal cattle. Indian J. Dairy Sci. 36:402-406.

Boldman, K. G., L. A. Kriese, L. D. Van Vleck and S. D. Kachman. 1993. A manual for use of MIDFREML. A set of programs to obtain estimates of variances and covariances [DRAFT]. U.S. Department of Agriculture, Agriculture Research Service.

Brotherstone, S. and W. G. Hill. 1994. Estimation of non-additive genetic parameters for lactation 1 to 5 and for survival in Holstein-Friesian dairy cattle. Livest. Prod. Sci. 40:115-122.

Campos, M. S., C. J. Wilcox, C. M. Becerril, and A. Diz. 1994. Genetic parameters for yield and reproductive traits of Holstein and Jersey cattle in Florida. J. Dairy Sci. 77:867-873.

Chauhan, V. P. S. and J. F. Hayes. 1991. Genetic parameters for first lactation milk production and composition traits for Holsteins using multivariate restricted maximum likelihood. J. Dairy Sci. 74:603-610.

Dematawewa, C. M. B. and P. J. Berger. 1998. Genetic and phenotypic parameters for 305-day yield, fertility, and survival in Holsteins. J. Dairy Sci. 81:2700-2709.

Dhumal, M. V., P. G. Sakhare and K. S. Deshpande. 1993. Note on repeatability of production and reproduction traits of red Kandhari and its crosses. Indian Veterinary Journal 70:925-926.

DLS. 1994. Annual Report of Directorate of Livestock Services.

Falconer, D. S. and T. F. C. Mackay. 1996. Introduction to Quantitative Genetics. 4th ed., Longman, London.

Gandhi, R. S. and M. Gurnani. 1988. Association among different productive and reproductive traits in Sahiwal cattle. Asian J. Dairy Research 7:171-174.

Hasegawa, N., Y. Syuji, K. Matoba and K. Sugawara. 1993. Behavior of high-producing dairy cattle in tie stall barn. Anim. Sci. Technol. 64:709-718.

Henderson, C. R. 1973. Sire evaluation and genetic trends. In: Proceedings of the Anim. Breed. Genet. Symposium in Honour of J. L. Lush. American Society for Animal Science, Blackburgh, Champaign, Illinois pp. 10-41.

Jamrozik, J. and L. R. Schaeffer. 1997. Estimates of genetic parameters for a test day model with random regressions for yield traits of first lactation Holsteins. J. Dairy Sci. 80:762-770.

Katoch, S. and M. C. Yadav. 1990. Genetic parameters of milk yield in Jersey cows. Indian Vet. J. 67:711-714.

Kaushik, S. N, B. D. Gupta and M. M. Saxena. 1984. Estimates of producing ability and Hariana-taurus crossbreds. Indian Vet. Med. J. 8:26-28.

Khanna, A. S., A. S. Kanaujia and D. S. Balaine. 1980. Influence of inbreeding on additive genetic variation (line formation) and covariation among various performance traits in Hariana and Sahiwal cattle. Haryana Agricultural University Journal of research 10:427-432.

Khattab, A. S. and Z. A. Sultan. 1990. Estimates of phenotypic and genetic parameters for first lactation performance in Friesian cattle in Egypt. Egyptian J. Anim. Prod. 27:147-160.

Kumar, V., V. P. S. Chauhan and B. P. Singh. 1992. Genetic parameters of 300 days and part lactation milk yields of Hariana cattle. Indian J. Anim. Sci. 62:655-658.

Lee, A. J., D. A. Boichard, S. J. Mcallister, C. Y. Lin, K. Nadarajah, T. R. Batra, G. L. Roy and J. A. Vesely. 1992. Genetics of growth, feed intake, and milk yield in Holstein cattle J. Dairy Sci. 75:3145-3154.

Lobo, R. B, F. A. M. Duarte and C. J. Wilcox. 1980. Environmental and genetic effects on length of lactation in a Brazilian tropical dairy breed. Revista Brasileira de Genetica 3:31-40.

Magnabosco, C. D. U., R. B. Lobo, L. A. F. Bezerra and M. L. Martinez. 1993. Estimate of genetic change in milk yield in a Gir herd in Brazil. Revista Brasileira de Genetica 16:957-965.

Martin, J. M., C. J. Wilcox, J. Moya and E. W. Klebanow.1986. Effects of retained fetal membranes on milk yield and reproductive performance. J. Dairy Sci. 69:1166-1168.

Meyer, K. 1984. Estimates of genetic parameters for milk and fat yield for the first three lactations in British Friesian cows. Anim. Prod. 38:313-322.

Meyer, K. 1985. Genetic parameters for dairy production of Australian black and white cows. Livest. Prod. Sci. 12:205-219.

Meyer, K., M. J. Carrick and B. J. P. Donnelly. 1994. Genetic parameters for milk production of Australian beef cows and weaning weight of their calves. J. Anim. Sci. 72:1155-1165.

Moon, S. J. 1994. Relationships between milk production and reproduction traits of holstein cows in Korea. Korean J. Anim. Sci. 36:362-368.

Moriya, K., T. Dohogo and Y. Sasaki. 1994. Restricted maximum likelihood estimation of heritabilities for carcass traits in the base and current populations of Japanese Black cattle. Anim. Sci. Technol.(Jpn) 65:720-725.

Pander, B. L, W. G. Hill and R. Thompson. 1992. Genetic parameters of test day records of British Holstein-Friesian heifers. Anim. Prod. 55:11-21.

Pryce, J. E., R. J. Esslemont, R. Thompson, R. F. Veerkamp, M. A. Kossaibati and G. Simm. 1998. Estimation of genetic parameters using health, fertility and production data from a management recording system for dairy cattle. Anim. Sci. 66:577-584.

estimated breeding value for first lactation and lifetime traits in Sahiwal and Hariana cattle. Indian. J. Anim. Sci. 64:1219-1225.

Rao, M. K. and J. Dommerholt. 1981. Estimation of reliable genetic parameters for production traits in a tropical breed of dairy cattle. Zeitschrift fur Tierzuchtung and Zuchtungsbiologie 98(4):290-302.

Rege, J. E. O. 1991. Genetic analysis of reproductive and productive performance of Friesian cattle in Kenya: I. J. Anim. Breed. Genet. 108:412-423.

Rege, J. E. O., M. A. Lomole and J. W. Wakhungu. 1992. An evaluation of a long-term breeding programme in a closed Sahiwal herd in Kenya. I. Effects of non-genetic factors on performance and genetic parameter estimates. J. Anim. Breed. Genet. 109:364-373.

Shah, S. M. and C. S. P. Singh. 1984. Lactation yield, part lactation, persistency of milk yield and rate of decline in Jersey cows. Asian J. Dairy Res. 2:19-24.

Shaha, D. N. and F. H. Khan. 1987. Lactation length in Gir cows. Indian J. Heredity 19:18-22.

Short, T. H. and T. J. Lawlor. 1992. Genetic parameters of conformation traits, milk yield, and herd life in Holsteins. J. Dairy Sci. 75:1987-1998.

Sing, R. and S. S. Tomar. 1991. Performance characteristics of Karan Fries cows. Indian J. Anim. Sci. 61:192-195.

Singh, S. R., H. R. Mishra, C. S. P. Singh and S. K. Singh. 1989. Genetic analysis of milk producing efficiency in crossbred cattle. Indian Veterinary Medical Journal 13:253-257.

Soliman, A. M., K. H. Khalil, A. A. Ashmawy and A. Essl. 1990. Analysis of milk production traits of Pinzgauer cattle in Austria: Genetic parameters. J. Anim. Breed. Genet. 107:43-51.

Souza, E. M. D., J. C. Milagres, M. L. Martinez, A. J. Regazzi and M. D. A. E. Silva. 1995. Effect of genetic and environmental factors on lactation length in Gir dairy herds. Revista da Sociedade Brasileira de Zootecnia 24:150-163.

Suzuki, M. and L. D. Van Vleck. 1994. Heritability and repeatability for milk production traits of Japanese Holsteins from an animal model. J. Dairy Sci. 77:583-588.

Taneja, V. K. and D. S. Bhatnagar. 1985. Genetic parameters for some measures of milk production in Tharparkar cattle. Indian J. Anim. Sci. 55:351-353.

Visscher, P. M. and M. E. Goddard. 1995. Genetic parameters for milk yield, survival, workability, and type traits for Australian dairy cattle. J. Dairy Sci. 78:205-220.

Yadev, A. S., S. S. Rathi and S. P. Dahiya. 1992. Genetic parameters for economic traits in Sahiwal Cattle. Journal of Dairying Foods and Home Sciences 11:81-89.

Pundir, R. K. and K. L. Raheja. 1994. Relationship between sires'