Pakistan Vet. J., 2008, 28(1): 21-24.

GENETIC CONTROL OF TEST-DAY MILK YIELD IN SAHIWAL CATTLE

G. BILAL, M. S. KHAN, I. R. BAJWA AND M. SHAFIQ[1]

Department of Animal Breeding and Genetics, University of Agriculture, Faisalabad;
[1]Research Centre for Conservation of Sahiwal Cattle, Jhang, Pakistan

ABSTRACT

Heritabilities of test-day (TD) and 305-day milk yield were estimated using performance records of 780 first lactation Sahiwal cows, following two models. In the first model, estimated 305-day lactation milk yields were analyzed through an individual animal model with period-season of calving as fixed effect and additive genetic effect as random factor. The second model was a repeatability model where monthly milk yield records were analyzed using period-season of calving as fixed effect and additive genetic effect and permanent environmental effect as random factors. The age at calving, ratio of days in milk to 305-day (as linear and quadratic components) and their reciprocal logs were used as covariables. The heritability estimates for 305-day and TD milk yields were 0.082 and 0.024, respectively. Heritability estimates of individual TDs ranged from 0 to 0.274. The relative proportion of permanent environment variance to total variance was 0.498. Heritability of individual test-day milk yield was highest in the mid-lactation (TD6-TD8). Lower genetic control of test day and lactation milk yield in the present study needs validation using larger data sets with accurate pedigree recording.

Key words: Genetic parameters, Sahiwal cattle, test day model.

INTRODUCTION

Dairy cattle have traditionally been evaluated on the basis of 305-day lactation yield. A 305-day lactation yield is usually obtained from 7-10 test-day (TD) records taken at monthly intervals. TD yields are affected by several factors like breed, herd management and management group within a herd, days in milk, age at calving and test, pregnancy status and milking times per day (Swalve, 1995; Jamrozik and Schaeffer, 1997). These factors on each test-day are averaged in the lactation yield. But these factors for a cow are not the same for each test-day and it would be difficult to model for 305-day yields. Now-a-days, test-day model is therefore used instead of 305-day model for the genetic evaluation of dairy cattle.

Test-day model is the statistical procedure that considers all genetic and environmental effects directly on a test-day basis (Ptak and Schaeffer, 1993). The use of test-day yield depends on the relative amount of genetic variation during a lactation. Test-day model improves the accuracy of genetic evaluation and provides better modeling. It maximizes the amount of information to be gathered for each animal. Moreover, it avoids the use of factors to extend partial lactation records (Wiggans and Goddard, 1996) and is a possible solution for the problem of differences in the amount of information contributing to the 305-day prediction. Furthermore, test-day models reduce the cost of milk recording by making fewer measurements through allowing longer intervals between milk recording and less frequent collection of milk samples. Regardless the length of the interval between tests, a test-day model can appropriately weigh the recorded TD information by considering the covariances among TD yields. Two distant TD yields would contribute more information than those which are close and highly correlated. Use of TD data would allow the use of information from lactations with long intervals between milk recordings because estimation of yields for unrecorded intervals would not be required. On the other hand, a test-day model cannot overcome the loss in accuracy from fewer TD and allows yields from any combination of TD to be included appropriately (Wiggans and Goddard, 1997).

Most of the research on test-day model has been carried out in countries with well-established breeding programme, official milk recording schemes and accurate pedigree information. In Pakistan, official milk recording schemes in cattle and buffaloes have only been implemented in small proportions of the populations where pedigree information is not always available, and within herd variation is high. The test-day models have been suggested as the method of choice for the analysis of milk yield traits in order to maximize the use of all available information. This method, therefore, becomes even more important in countries with less well-established milk recording schemes. The present study was planned to estimate heritability of milk yield for 305-day cumulative milk yield and test-day milk yields in Sahiwal cattle using an animal model.

MATERIALS AND METHODS

The 4-weekly milk yield records of 780 first lactation Sahiwal cows calving between 1985 and 2005 at the Livestock Experiment Station, Jahangirabad (Khanewal), Pakistan were used for the present study. The test-day (TD) information was stored in data files containing cow identification number, date of birth, calving date, sire, dam and milk yield. Editing was done on the basis of missing identification, birth and calving or test date. All the cows with missing sire identification were not used in the final data file. All the cows with lactation length less than 60 days were also excluded. Age at test-day was defined as number of months from birth. Test-day yield was limited to 1-30 liters of milk. In the TD analysis, only first 10 test-day yields were used. The final data file contained 590 first lactation records of Sahiwal cows. Year of calving was divided into three periods (1985-1991, 1992-1998 and 1999-2005). Four calving seasons were defined: winter (December to February), spring (March to May), summer (June to August) and autumn (September to November). In this study, only a combination of period and season of calving with 12 levels was used. The 305-day milk yield was defined as milk yield upto 305-days of lactation. The 305-day lactation yield was calculated by multiplying the monthly test day yield with 30.5. The number of test-day records per cow averaged 6.69 (Table 1).

Table 1: The data structure for 305-day and test-day (TD) models

Item	No.
No. of first lactation records	590
No. of TD records	3949
No. of animals	1010
Periods	3
Seasons	4
Period-season	12
Sires	112
Dams	470
Mean TD records per cow (limited to first 10 TD records)	6.69

For 305-day lactation milk yield, following individual animal model was used:

$Y_{ijk} = PS_i + b_1X_{1ijk} + b_2X_{2ijk} + a_j + e_{ijk}$ (Model I)

Y_{ijk} = 305-day milk yield record

PS_i = fixed effect of period and season of calving (12 combinations)

X_1 = age at calving (as a covariable)

X_2 = (age at calving)^2 (as a covariable)

a_j = animal's random additive genetic effect

e_{ijk} = random residual effect.

For test-day milk yield, following repeatability animal model was used:

$Y_{ijk} = PS_i + b_1X_{1ijk} + b_2X_{2ijk} + b_3X_{3ijk} + b_4X_{4ijk} + b_5X_{5ijk} + a_j + pe_j + e_{ijk}$ (Model II), where

Y_{ijk} = milk yield record from a single TD

PS_i = fixed effect of period and season of calving (12 combinations)

X_1 = age at calving (as a covariable)

X_2 = DIM/c (as a covariable), where c is a constant set to 305

X_3 = (DIM/c)^2(as a covariable)

X_4 = ln(c/DIM) (as a covariable)

X_5 = [ln(c/DIM)]^2 (as a covariable)

a_j = animal's random additive genetic effect

pe_j = effect of random permanent environment of the cow during lactation

e_{ijk} = random residual effect.

The repeatability model used in the present study was similar to that of Kaya *et al.* (2003). Test-day yields were taken as repeated measurements and four covariates were used to account for the shape of lactation curve. Variance components for 305-day and TD milk yields were estimated by DFREML programme (Meyer, 1997) which uses REML procedure for variance component estimation.

RESULTS AND DISCUSSION

Phenotypic means and standard errors of 305-day milk yield and test-day milk yield for the first lactation Sahiwal cows are given in Table 2. Average 305-day milk yield was found to be 1142 ± 26 kg, while test-day (TD) yield was 5.6 ± 0.11 kg.

Estimates of (co)variance components, heritability estimates for TD and 305-day milk yields are presented in Table 3. The heritability estimate for 305-day and

Table 2: Phenotypic means and standard error for 305-day and test-day milk yield (kg)

Trait	No. of records	Milk yield (± SE)
305-day milk yield	590	1142 ± 26.00
TD1	590	6.1 ± 0.10
TD2	590	6.4 ± 0.12
TD3	585	6.0 ± 0.12
TD4	518	5.7 ± 0.11
TD5	465	5.3 ± 0.11
TD6	404	4.9 ± 0.12
TD7	310	4.8 ± 0.12
TD8	222	4.8 ± 0.14
TD9	160	4.6 ± 0.14
TD10	104	4.3 ± 0.18
Overall test-day milk yield	3949	5.6 ± 0.11

TD milk yields were 0.082 and 0.024, respectively. These estimates were lower than the earlier work on test-day model (Swalve, 1995; Kaya *et al.,* 2003; Ilatsia *et al.,* 2007). It might be due to the smaller number of observations, different environmental conditions and model used for the analysis. In the present study, the heritability of TD milk yield was lower than that of 305-day milk yield. This is in line with the studies of Swalve (1995), Kaya *et al.* (2003) and Shadparvar and Yazdanshenas (2005). The relative proportion of permanent environment variance to total variance was 0.498, which is similar to that reported by Bhatti *et al.* (2007).

Higher values of residual variance in the present study may be due to the inclusion of period-season effects in the model. Residual variances could be lowered with the inclusion of herd-test-date effects in the model but data were too limited to opt for that. The magnitudes of heritability estimates were lower in the present study. Meyer e*t al.* (1989) and Swalve (1995) reported that when the herd-test-date effect was included in the model instead of herd-year-season effect, higher heritability estimates were obtained. Detection of differences among animals at genetic and environmental level was enhanced by assigning the cows year-season of test-day milk yield instead of year-season of calving. More environmental variation was removed by comparing the cows based on test-day sampling than on the period of calving (Rekaya *et al.,* 1999; Ilatsia *et al.,* 2007).

Additive genetic and residual variance components and heritability estimates for individual test-days (TD1-TD10) are presented in Table 4. The additive genetic variance increased with increasing length of lactation. Highest additive variance was observed in the mid-lactation (TD6-TD8). Additive variance decreased towards the end of lactation. Residual variance showed a decreasing trend with increasing length of lactation and was lowest at the end of lactation. Heritability estimates of individual test day records were highest in the mid-lactation (TD6-TD8) and values ranged from 0.221 to 0.274. These findings are in agreement with the previous studies (Ptak and Schaeffer, 1993; Shadparvar and Yazdanshenas, 2005). Heritability estimates in the beginning and end of lactation were unexpectedly lower. The first test-day yield is comparatively less reliable than the subsequent yields. It usually takes few days after calving and many environmental factors like feeding before calving affect the trait (Shadparvar and Yazdanshenas, 2005). Very low heritability estimates may be due to the lower number of observations used in the present study as well as pronounced fluctuations due to feeding and managemental conditions which masked the estimation of additive genetic variance. Random regression models generally give higher heritability estimates compared to ordinary test-day models (Jamrozik and Schaeffer, 1997). Kettunen *et al.* (1998) observed that random regression models gave higher estimates of heritability than that of multiple trait models.

Conclusions

The Present study attempted to document the genetic control of milk yield recorded at 4-week interval and cumulative lactation milk yield for first parity Sahiwal cows. The residual variances were high and additive genetic variances were low. The test-day models are more precise than the lactation yield models but the data set used in the present study was limited for genetic parameter estimation.

Table 3: Estimates of variance components, heritability estimates and permanent environment effects for 305-day and test- day models

Trait	σ^2A	σ^2E	σ^2PE	h^2 (± SE)	r
305-day	31961.2	356549.0	-	0.082 ± 0.0768	-
Pooled test-day	0.16	3.19	3.33	0.024 ± 0.0464	0.52

σ^2A= Additive genetic variance; σ^2E= Residual variance; σ^2PE= Permanent environmental variance; h^2 = Heritability; PE= Relative portion of permanent environment to total variance; r = Repeatability

Table 4: Additive (σ^2A) and residual (σ^2E) variance components and heritability estimates (h^2) of individual test-day (TD) milk yield records

Trait	TD1	TD2	TD3	TD4	TD5	TD6	TD7	TD8	TD9	TD10
N	590	590	585	518	465	404	310	222	160	104
σ^2A	0.00	0.01	0.31	0.075	0.45	1.21	1.24	0.96	0.00	0.00
σ^2E	5.82	7.17	7.22	6.02	4.91	4.02	3.09	3.25	3.18	3.04
h^2	0.000	0.001	0.039	0.011	0.081	0.229	0.274	0.221	0.00	0.00
SE	-	-	0.082	0.084	0.105	-	0.143	0.260	-	-

SE = Standard error of heritability estimate.

Acknowledgements

Financial support for this study was provided by an Agricultural Linkage Program (ALP), Pakistan Agricultural Research Council (PARC), Islamabad, Pakistan.

REFERENCES

Bhatti, A. A., M. S. Khan, Z. Rehman, A. U. Hyder and F. Hassan, 2007. Selection of Sahiwal cattle bulls on pedigree and progeny. Asian-Aust. J. Anim. Sci., 20: 12-18.

Ilatsia, E. D., T. K. Muasya, W. B. Muhuyi and A. K. Kahi, 2007. Genetic and phenotypic parameters for test day milk yield of Sahiwal cattle in the semi-arid tropics. Animal, 1: 185–192.

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

Kaya, I., Y. Akbas and C. Uzmay, 2003. Estimation of breeding values for dairy cattle using test-day milk yields. Turkish. J. Vet. Anim. Sci., 27: 459-464.

Kettunen, A., E. A. Mantysaari, I. Stranden, J. Poso and M. Liddaur, 1998. Estimation of genetic parameters for first lactation test-day milk production using random regression models. Proc. 6th World Congr. Genet. Appl. Livest. Prod., Armidale, New South Wales, Australia. 23: 307.

Meyer, K., H. U. Graser and K. Hammond, 1989. Estimates of genetic parameters for first lactation test day production of Australian Black and White cows. Livestock Prod. Sci., 21: 177–199.

Meyer, K., 1997. DFREML Version 3.0. User Notes. http://agbu.une.edu.au/~kmeyer/dfreml.html).

Ptak, E. and L. R. Schaeffer, 1993. Use of test-day yields for genetic evaluation of dairy sires and cows. Livestock Prod. Sci., 34: 23-34.

Rekaya, R., M. J. Carabano and M. A. Toro, 1999. Use of test day yields for genetic evaluation of production traits of Holstein-Friesian cattle. Livestock Prod. Sci., 57: 203-217.

Shadparvar, A. A. and M. S. Yazdanshenas, 2005. Genetic parameters of milk yield and milk fat percentage test-day records of Iranian Holstein cows. Asian-Aust. J. Anim. Sci., 18: 1231-1236.

Swalve, H. H., 1995. Genetic relationship between dairy lactation persistency and yield. J. Anim. Breed. Genet., 112: 303-311.

Wiggans, G. R. and M. E. Goddard, 1996. A computationally feasible test day model with separate first and later lactation genetic effects. Proc. N.Z. Soc. Anim. Prod., 56: 19.

Wiggans, G. R. and M. E. Goddard, 1997. A computationally feasible test-day model for genetic evaluation of yield traits in the United States. J. Dairy Sci., 80: 1795-1800.