Indian Journal of Animal Sciences **72** (6): 458-461, June 2002

Precision in estimation of heritability

G C GAHLOT[1] and K P PANT[2]

Rajasthan Agriculture University, Bikaner, Rajasthan 334 001 India

Received: 5 May 2001; Accepted:23 December 2001

ABSTRACT

The various effects such as year and period of calving, season of calving, parity and lactation length were included in the model. The effects of year of calving, season of calving and parity dam were significant ($P<0.001$) for the various traits. The estimates of heritability using 16 linear models showed a wide range of variation. The values ranged from 0.062 to 0.439 for total milk yield, 0.075 to 0.482 for 305 days' milk yield, 0.085 to 0.589 for peak yield and 0.06 to 0.432 for daily milk yield. The inclusion of lactation length in the model as a co-variable reduces the error mean squares, thereby increasing the efficiency (R^2 value) of the model. It also increased the heritability estimates, however, it reduced the mean square due to sires. The R^2 value was maximum for the model, which included year, season, parity, sire within year and regression of lactation length (linear and quadratic) for all traits. The results indicated that environmental factors adjustment affected the estimates of heritability and the magnitude of such variation usually depended upon the number of adjustments made.

Key words: Cattle, Environmental factors, Heritability, Linear models, Production traits, Tharparkar

An owner of a dairy enterprise would always try to maximise his profit by providing improved management and feeding practices. However, for a continuing enterprise he should require bulls of high genetic merit, selected with finest accuracy. For planning an effective selection and breeding programme knowledge of genetic architecture of his herd is necessary, and accuracy in the estimation of genetic parameters should be considered paramount important. For estimation of genetic parameters, a variety of methodologies are available. The least squares methodology is the one of them, in which adjustment of data is tried for significant environmental effects, before obtaining estimates of genetic differences. Hence, when different assumptions are made, estimate of genetic parameters tend to vary. This is especially so in tropical and sub-tropical climates, where year to year differences tends to mask relatively feeble sire to sire differences. It is, therefore, very essential that due consideration is made to the accuracy of procedures used for estimating genetic parameters for the data generated under such environmental situations. This has been one of the objectives of the present study. This work is expected to provide clues to similar procedural problems for ultimately increasing the accuracy of genetic parameters, which may directly and favourably, influence genetic progress and improvement.

Present address: [1]Assistant Professor, Department of Animal Breeding and Genetics, College of Veterinary and Animal Science, Bikaner, Rajasthan 334 003.

[2]Formerly Director, Central Institute for Research on Goats, Opposite IVRI Gate No. 2, D-81, Izatnagar 243 122.

MATERIALS AND METHODS

The data for this analysis consisted of 2380 normal lactation records from 1968 to 1996 of Tharparkar cows maintained at the Central Cattle Breeding Farm, Suratgarh. These animals were the progeny of 66 sires. The habitability of total lactation yield, 305 day's yield, peak yield and daily milk yield were estimated using 16 linear models. The total milk yield referred to the amount of milk produced from sixth day after calving till cow went dry, while 305 days' yield referred to the yield from sixth day to 305 days or the day of drying whichever was earlier. The peak yield referred to the maximum amount of milk produced on any one day within 3-4 months of calving. The daily milk yield referred to the milk yield per day of lactation length for individual cow. The analysis of variance ((LSMLW, Harvey, 1990) to obtain precise estimates of genetic parameters for production traits, was undertaken, which investigate the change in the estimates of heritability when data are adjusted for different environmental factors. The environmental factors were year/ period and season of calving, parity of calving, lactation length and age at first calving. The linear and quadratic regression effect of lactation length and age at first calving were studied. In order to improve the accuracy of heritability estimate by increasing the number of records per sire and per year, season, the multiple lactation records (first to eighth lactation) were included.

At the first instance all 5 environmental factors were included in the model along with sire and genetic parameters along with standard error were estimated. Then the changes in genetic parameters were studied by estimating them from the models that did not include environmental effects. Lastly genetic parameters were also estimated from model (model I), which include the sire effect only. In models XII to XIV, the years were grouped into periods based on period of calving. In case of models XI and XVI, a nested analysis was done with years/period and sires nested in periods. The mean squares due to sires and error, and the sire component of variance in model I to XVI were expressed as percent of the same obtained in model I, which include only sire effect for comparison purposes. The following models were used in this analysis.

I –Yjm = μ + Sj + ejm
II –Yijm = μ + Vi + Sj + eijm
III –Yijkm = μ + Vi + Sj + Mk + eijkm
IV –Yijklm = μ + Vi + Sj + Mk + Ll + eijklm
V –Yijklm = μ + Vi + Sj + Mk + Ll + bL (Aijklm-AA) + eijklm
VI –Yjklm = μ + Vi + Sj + Mk + Ll + bL (Aijklm-AA) + bQ (Aijklm-AA) + eiklm
VII –Yjklm = μ + Sj + Mk + Ll + ejklm
VIII –Yjllm = μ + Sj + Mk + Ll + bL (Aijklm-AA) + bQ (Aijklm-AA) + ejkllm
IX –Yijlm = μ + Vi + Sj + Ll + bL (Aijklm-AA) + bQ (Aijklm-AA) + eijlm
X –Yijkm = μ + Vi + Sj + Mk + bL (Aijklm-AA) + bQ (Aijklm-AA) + eijkm
XI– Yijklm = μ + Vi + Sij + Mk + Ll + bL (Aijklm-AA) + bQ (Aijklm-AA) + eijklm
XII– Yijkm = μ + Pi + Sj + Mk + bL (Aijklm-AA) + bQ (Aijklm-AA) + eijkm
XIII –Yijkm = μ + Pi + Sj + Mk + eijkm
XIV– Yijklm = μ + Pi + Sj + Mk + Ll + eijklm
XV –Yijklm = μ + Pi + Sj + Mk + Ll + bL (Aijklm AA) + bQ (Aijklm-AA) + eijklm
XVI –Yijklnm = μ + Pi + Sij + Vin + Mk + Ll + bL (Aijklm-AA) + bQ (Aijklm-AA) + eijklnm

where,
Yijklm is the observation on mth cow sired by jth sire in ith year/period, kth season and lth parity; μ is the overall mean; Sj is the random effect attributed to jth sire; Vi / Pi is the fixed effect of year/period of calving; Mk is the fixed effect of season of calving; Ll is the fixed effect of parity; bL, bQ is the linear and quadric regression of lactation length; Aijklm is the lactation length corresponding to Yijklm; AA is the average lactation length; Yin is the nested effect of nth year with in ith period of calving; eijklm is residual error under standard assumption, which makes analysis valid i.e. NID (0,2)

RESULTS AND DISCUSSION

The various effects such as year and period of calving, season of calving, parity and lactation length included in the model I to XVI showed significant (P<0.001) effect on all the production traits.

The heritability values (Table 1) showed wide variation when different models were used for their estimation. The heritability values ranged from 0.062 to 0.439 for total lactation yield, 0.075 to 0.482 for 305 days yield, 0.085 to 0.589 for peak yield and 0.060 to 0.432 for daily milk yield. The values were higher for total milk yield, 305 days milk yield, peak yield and daily milk yield when estimated from the model XII. The heritability values were lowest for total lactation

Table 1. Heritabilities and their standard error of production traits estimated from different models

Models	Total yield	305 days yield	Peak yield	Daily milk yield
XII	0.439 ± 0.084	0.482 ± 0.089	0.587 ± 0.102	0.432 ± 0.083
X	0.369 ± 0.075	0.419 ± 0.081	0.521 ± 0.094	0.368 ± 0.075
VIII	0.169 ± 0.047	0.175 ± 0.048	0.190 ± 0.050	0.156 ± 0.045
XVI	0.164 ± 0.047	0.174 ± 0.048	0.198 ± 0.050	0.137 ± 0.045
I	0.146 ± 0.043	0.232 ± 0.056	0.479 ± 0.098	0.358 ± 0.074
VII	0.129 ± 0.041	0.140 ± 0.043	0.181 ± 0.049	0.159 ± 0.046
XIII	0.119 ± 0.039	0.224 ± 0.055	0.582 ± 0.102	0.424 ± 0.082
VI	0.114 ± 0.039	0.131 ± 0.042	0.195 ± 0.051	0.098 ± 0.037
IX	0.114 ± 0.039	0.129 ± 0.041	0.197 ± 0.051	0.098 ± 0.036
V	0.113 ± 0.039	0.115 ± 0.039	0.195 ± 0.051	0.096 ± 0.036
III	0.111 ± 0.038	0.191 ± 0.050	0.516 ± 0.093	0.353 ± 0.073
XV	0.108 ± 0.038	0.123 ± 0.040	0.168 ± 0.047	0.097 ± 0.036
XI	0.107 ± 0.060	0.097 ± 0.060	0.085 ± 0.059	0.060 ± 0.058
II	0.102 ± 0.037	0.182 ± 0.049	0.518 ± 0.093	0.349 ± 0.072
IV	0.073 ± 0.033	0.085 ± 0.035	0.180 ± 0.049	0.095 ± 0.036
XIV	0.062 ± 0.031	0.075 ± 0.033	0.154 ± 0.044	0.095 ± 0.036

yield, 305 days yield, peak yield and daily milk yield when estimated from the model IV and XIV. The higher estimate of heritabilities was due to the effect of period, season and lactation length in the model. The parity effect was possibly confounded with the sire effect, which resulted in higher estimate of heritabilities. The lower estimate of heritabilities was obtained from the model, which included the effect of year/period, season and parity. This might be probably due to the fact that in the present set of data the effect of lactation length was could not be separated out from sire effect and it went to error component, which resulted in to lower estimate of heritabilities.

These results showed that the estimates of heritability values change markedly with different models that include effects, which are not independent of each other. The effect of parity was clearly evident when heritability value was estimated from the model VI which included period, season, parity and regression on lactation length (linear and quadric) as compared to the model X which did not include parity effect.

The results of this study varied from those obtained by Rao and Dommerholt (1981) and Sachdeva and Gurnani (1995). Rao and Dommerholt (1981) used several procedures for estimating heritabilities of production traits of Tharparkar cows in India, and the heritability estimates for 305 days yield, total milk yield and average daily yield ranged from 0.03 to 1.48, 0.01 to 1.19 and 0.11 to 1.58, respectively, depending upon the model used. They reported highest estimates of heritability for production traits (total milk yield, 305 days milk yield and daily milk yield), when estimated from the model that included sire, season and linear regression of lactation length and age at first calving. The lowest estimates were obtained when estimated from the model that included periods, years and sire within periods. Sachdeva and Gurnani (1995) estimated the heritability of first lactation milk records using 8 linear models for adjustment of environmental factors. They found that heritability (0.07) was highest when data were adjusted for farm only and heritability (0.025) was lowest when data were adjusted for all significant effects like genetic groups, age groups, farms and periods. The heritability of un-adjusted data was 0.51.

An attempt was made to investigate the reasons for such variability in the heritability estimates by looking at the mean square and components of variance due to sire and error. The R^2 values were lower in the model, which did not include the regression of lactation length in comparison to other models that included regression of lactation length.

A perusal of mean squares due to sires and errors, and sire components of variance for different models for these traits, indicated that the inclusion of parity along with the year/period of calving in the model resulted in a decrease in both the mean sum of squares due to sires and sire components of variance. The decrease in sire components of variance and sire mean squares was much more in comparison to decrease in error mean squares for production traits. The mean sum of squares due to sire and sire variance decreased 38 and 60% for total milk yield, 52 and 69% for 305 days yield, 66% and 74% for peak yield, 67% and 80% for average daily milk yield, respectively, whereas error component of variance reduced only 9 % for total milk yield, 10 % for 305 days milk yield, 22% for peak yield, and 16 % for average daily milk yield. This clearly indicated that the effect of sires and effect due to parity and year could not be separated even when they are estimated separately and created doubt about the real contribution of sires to the variation in the traits analysed.

The inclusion of lactation length in the model contributed to significant reduction in the error mean sum of squares. The error mean squares reduced by 54% for total milk yield, 38% for 305 days yield, 16% for dry period, 50% for service period and 51 % for calving interval when lactation length was included in the model (models IV v/s VI and XIV v/s V). Therefore, increased the R^2 value of the model for these traits. This indicated that inclusion of lactation length in the model as a regression variable would reduce the error mean squares and increase the reliability of heritability estimates. However, inclusion of lactation length also resulted in a decrease in mean sum of squares due to sires. The reduction of error mean squares was very small for peak yield and daily milk yield (2-3%) indicating that inclusion of lactation length in these traits did not change mean squares or sire components of variance. The grouping of years in periods and the analysis of data using nested model with years and sire nested in years/periods (model XI and XVI) also did not change the error mean squares markedly. On the other hand there was reduction of the mean squares due to sires and sire component of variance, thereby resulting in lower heritability estimates.

The effect of inclusion of lactation length in the model, grouping of years in to periods and nested effect of sires within years/period obtained by Rao and Dommerholt (1981) in Tharparkar cows were similar to the findings of the present investigation. Basu (1983) also reported that inclusion of additional variable i.e. lactation length in the models affected the estimates of heritability (0.0 to 0.09). Schaeffer (1975) suggested that grouping of years in to period may improve the estimation of effects and thereby to increase the precision of parameter estimated. The present investigation showed that such grouping would not help in estimating reliable genetic parameters in the present set of data.

The results indicated that environmental factors adjustment affected the estimates of heritability and the magnitude of such variation usually depended upon the number of adjustments made. There was, perhaps, a serious confounding of the effects of sires with those of environmental factors and also with time scale. It is concluded that it would be difficult to estimate the contribution of sires to the variability in a trait independent of the other effects in case of a spread of data for long time. Too many years in a set of data therefore may not be desirable. This will further complicate the situation as the small sets of data per year, that are inherent in animal groups of tropical areas, may make any such effort entirely wasteful.

REFERENCES

Basu S B. 1983. Inclusion of covariate in the least-squares model for animal breeding data. *Indian Journal of Dairy Science* **36**: 413-15.

Schaeffer R L. 1975. Disconnectedness and variance component estimations. *Biomatrics* **31**: 969-77.

Schdeva G K and Gurnani M. 1995. Estimation of heritability of milk production under different models. *Indian Journal of Dairy Science* **48**: 668-71.

Rao M K and Dommerholt J. 1981. Estimation of reliable genetic parameters for production traits in a tropical breed of dairy cattle. *Zeitschrift fur Tierziichtung und Ziichtungsbeciologie* **98**: 290-320. (*fide Dairy Science Abstract* **44**: 5116.)

Harvey W R. 1990. User's Guide for LSMLWM and MIXMDL PC-2 Version. Mixed Model Least-squares and Maximum Likelihood Computer Programme. 4255 Mumford Drive, Columbus, Ohio 43220, USA.