Efficacy of Auxiliary Traits in Estimation of Breeding Value of Sires for Milk Production

G. Sahana* and M. Gurnani[1]

Division of Dairy Cattle Breeding, National Dairy Research Institute, Karnal-132 001 (Haryana), India

ABSTRACT : Data pertaining to 1111 first lactation performance record of Karan Fries (Holstein-Friesian×Zebu) cows spread over a period of 21 years and sired by 72 bulls were used to examine the efficiency of sire indices for lactation milk production using auxiliary traits. First lactation length, first service period, first calving interval, first dry period and age at first calving were considered as auxiliary traits. The efficiency of this method was compared with simple daughter average index (D), contemporary comparison method (CC), least-square method (LSQ), simplified regressed least-squares method (SRLS) and best linear unbiased prediction (BLUP) for lactation milk production. The relative efficiency of sire evaluation methods using one auxiliary trait was lower (24.2-32.8%) in comparison to CC method, the most efficient method observed in this study. Use of two auxiliary traits at a time did not further improve the efficiency. The auxiliary sire indices discriminate better among bulls as the range of breeding values were higher in these methods in comparison to conventional sire evaluation methods. The rank correlation between breeding values estimated using auxiliary traits were high (0.77-0.78) with CC method. The rank correlation among auxiliary sire indices ranged from 0.98 to 0.99, indicating similar ranking of sire for breeding values of milk production in all the auxiliary sire indices. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 4 : 511-514*)

Key Words : Breeding Value, Auxiliary Trait, Sire Evaluation

INTRODUCTION

Selection programme in dairy cattle is aimed to genetically improve milk production and also to reduce the cost of milk production. Selection for several traits simultaneously may bring about overall improvement in cows' economic value but will slow the improvement in milk production. On the other hand, selection based on daughters' milk production only will bring about faster improvement in milk production but may improve economic value of animals at slower rate. The traits of economic importance are correlated to each other due to both genetic and environmental causes. Each trait contributes information that may have value in predicting other traits of interest. Since under Indian condition the number of daughters per sire being small, combination of other traits along with milk production may improve the accuracy and efficiency of sire evaluation. Therefore, it seems desirable to use one or more associated traits in conjunction with milk yield record of daughters for progeny testing. The genes affecting milk yield may also have pleiotropic effects, so that the segregation of these genes may produce variation in a number of other traits of the individual which are ancillary to the main trait. Such effects tend to cause correlation between the concerned traits at the genotypic as well as phenotypic levels. The breeding value of the sires for milk yield, therefore, depends on the phenotypic value of its progeny of milk yield as well as other correlated traits. Narain (1985), considering this principle, proposed a sire index method for estimation of breeding value of milk production using auxiliary traits, such as age at first calving, first calving interval or length of first lactation

along with milk yield of daughters. It was shown by theoretical study that use of auxiliary traits reduced the number of progeny required to attain a pre-assigned level of accuracy in comparison with sire evaluation based on milk yield only.

In Indian condition, reliable estimates of breeding values by progeny testing of sires could not be obtained because the estimates were based on small number of daughters' record. Therefore, this study was designed to examine the effectiveness of estimation of sire breeding values for lactation milk yield using prevalent sire evaluation methods verses alternative method of estimating breeding value using auxiliary traits. The efficiency and accuracy of estimation of sire's breeding value by various methods was compared.

MATERIALS AND METHODS

The present study was carried out on Friesian×Zebu (Tharparkar) cross bred cattle (Karan Fries) data maintained at National Dairy Research Institute (NDRI), Karnal located at North India. The data comprised of 1111 first lactation performance records of Karan Fries cows born out of 72 sires and were spread over a period of 21 years (1974 to 1994). The number of daughters per sire ranged from 5 to 50 with an average of 15.5. The heritability, genetic and phenotypic correlation among traits were estimated using paternal half-sib correlation method (Harvey, 1990) considering sire, season of calving and period of calving as independent variables in the model.

The relationship between the breeding value of sire and the average phenotypic value of progeny for (K+1) characters (milk yield and K auxiliary traits) can be expressed as

$$E[G(y)] = b_0 D(y) + \sum_{i=1}^{k} b_i D(x_i)$$

where, E[G(y)] is the expected breeding value of a

sire for lactation milk yield; D(y) is the sire's daughter average lactation milk yield; D(X$_i$) is sire's daughter average for ith auxiliary trait; b$_0$ and b$_i$ (i=1,...k) are constants and are estimated by maximising the multiple correlation coefficient between the breeding value of sire and its expectation on the basis of daughters milk yield and auxiliary traits. Substituting the optimum values of b$_0$, b$_i$,...,b$_k$ the generalised index for estimation of breeding value of sire was proposed by Narain (1985). Using the above principle the sire index considering daughters' milk yield and one auxiliary traits is as follow:

$$S = 2nW[D(y) - \frac{(R_p-C)}{(1-R_pC)+(n-1)(h_i^2-h^2C^2)/4} D(x)]$$

Where,

$$w = \frac{[(1+a)(1-R_pC)+(n-1)(1-C^2)-(n-1)(1-h_i^2)/h_2]}{[(1+a)^2(1-R_p^2)+2(1+a)(n-1)(1-R_pC)+(n-1)^2(1-C^2)-(n+a)(n-1)(1-h_i^2/h^2)]}$$

S=Sire index value,

a=(4-h^2)/h^2,C=R$_g$ $\sqrt{(h_i^2/h^2)}$

D(y)=Daughters' average lactation milk yield,

D(x)=Daughters' average for auxiliary trait,

h^2 and h$_i^2$ are heritability of milk yield and auxiliary trait respectively,

R$_p$ and R$_g$ are phenotypic and genetic cormelation between milk yield and auxiliary trait respectively,

n is number of progeny of the sire.

Sire index taking two auxiliary traits along with milk yield is as follow:

$$S=2nW[D(y) - \frac{1+a}{1-b^TQ^{-1}c} [(r-c)^T-b^TQ^{-1}(cr^T-rc^T)]Q^{-1}D(x)]$$

where,

W=(1-b^{T}Q^{-1}c)/(a-b^{T}Q^{-1} b); D^T(x)=[D(X$_1$), D(X$_2$)];

b^T=(1+a)(r$_{p1}$, r$_{p2}$)-(n-1)(r$_{g1}$h$_1$/h, r$_{g2}$h$_2$/h);

r^T=(r$_{p1}$, r$_{p2}$); c^T=(r$_{g1}$h$_1$/h, r$_{g2}$h$_2$/h);

a=n+a; Q=[(1+a)r$_{p12}$+(n-1)(r$_{g12}$h$_1$h$_2$/h^2)]

T=transpose of matrix/vector

Other abbreviations are as described above. Subscript 1 and 2 are used for auxiliary trait 1 and auxiliary trait 2, respectively.

The accuracy of sire evaluation is the correlation between the additive genetic value of sire and its expectation on the basis of the performance of its progeny. The accuracy was measured in terms of the maximised multiple correlation coefficient between the genetic value of the sires and the estimated breeding value based on progeny performance in case of auxiliary sire indices (Narain, 1985). When only daughters' milk yield records are used for breeding value estimation, the accuracy of sire evaluation was estimated as described by Searle (1964).

Age at first calving (AFC), first service period (FSP), first calving interval (FCI), first dry period (FDP) and first lactation length (FLL) of daughters were considered as auxiliary traits in this study. Sire breeding values for lactation milk yield were calculated using one auxiliary trait at a time along with milk yield of daughters. Two auxiliary traits in different combinations along with milk yield records were also used for estimation of sire breeding values.

Sire breeding values were also calculated for milk yield using five prevalent sire evaluation methods viz. simple daughter average index (Jain and Malthotra, 1971), contemporary comparison method (Jain and Malhotra, 1971), least square method (Harvey, 1990), simplified regressed least squares method (Harvey, 1979) and best linear unbiased prediction (Henderson, 1973). The effectiveness of sire evaluation methods was judged using two criteria viz., within sire variance or error variance and rank correlation between breeding value by different methods.

RESULTS AND DISCUSSION

The estimates of heritabilities (h^2), genetic (r$_g$) and phenotypic (r$_p$) correlation between various first lactation traits are presented in table 1. The phenotypic correlation between most of the traits were statistically significant. However, the genetic correlation had very high standard errors and in few cases r$_g$s were not estimable. The small data size may be the reason for high standard error of genetic correlation.

The breeding value of 305 day or less milk yield of Karan Fries sires were estimated by various sire evaluation methods as described in materials and methods. Sires were evaluated by five prevalent methods besides using sire indices incorporating auxiliary traits.

Table 1. Estimates of heritability, phenotypic correlation and genetic correlation and SE for first lactation traits in Karan Fries cattle

	305MY	FLL	FSP	FDP	FCI	AFC
305MY	0.46±0.11	0.38**±0.03	0.21**±0.04	-0.13**±0.03	0.21**±0.04	0.16**±0.03
FLL	0.01±0.24	0.13±0.07	0.85**±0.02	0.04±0..04	0.86**±0.02	0.11**0.03
FSP	0.64**±0.28	0.87**±0.17	0.04±0.06	0.21**±0.04	0.97**±0.01	0.05±0.04
FDP	-0.08±0.25	0.29±0.45	-0.64±0.91	0.12±0.08	0.30**±0.04	0.03±0.04
FCI	0.61**±0.22	0.94**±0.05	NE	0.41±0.55	0.07±0..07	0.10*±0.04
AFC	0.30±0.18	0.68**±0.17	NE	0.22±0.33	0.57±0.34	0.22±0.08

Values underlined are heritabilities, above the diagonal are phenotypic correlation and below the diagonal are genetic correlation; NE is not estimable; * significant at 5% level and ** significant at 1% level.

Thus there were a total of 20 sire index values for lactation milk yield of each sire estimated by various methods. Average breeding values, range of breeding value, error variance and relative efficiency of various methods are presented in table 2. Range of breeding values as well as within sire variance was higher in auxiliary sire evaluation methods in comparison to prevalent methods. The lowest range of breeding values was found in case of SRLS method. The higher ranges of breeding value in auxiliary sire indices indicated that the auxiliary sire indices discriminate better among sires.

Table 2. Average breeding values of lactation milk yield, their ranges and relative efficiency of various method of sire evaluation in Karan Fries cattle

Methods	Average BV	Range of BV	Error various	Relative Efficiency
D	3094	1736	2143648	13.17
CC	2918	2015	282215	100.00
LSQ	2886	1470	484160	58.29
SRLS	2895	862	483761	58.34
BLUP	2905	956	514898	54.81
Auxiliary Indices*				
FLL	2929	2186	897015	31.46
FSP	2927	2146	867387	32.54
FDP	2916	2489	1207978	23.36
FCI	2918	2424	1167383	24.18
AFC	2919	2428	1164947	24.23
FLL+FSP	2924	2196	994582	28.38
FLL+FDP	2927	2105	918490	30.73
FLL+FCL	2924	2172	972864	29.01
FLL+AFC	2910	2288	1111129	25.40
FSP+FDP	2931	2415	1153617	24.46
FSP+FCI	2927	2105	918738	30.72
FSP+AFC	2927	2106	918490	30.73
FDP+FCI	2924	2090	927434	30.43
FDP+AFC	2927	2105	918490	30.73
FCI+AFC	2914	2324	1134008	24.89

* The abbreviations indicates the trait(s) used as auxiliary trait.

Efficiency of sire evaluation methods

The results (table 2) showed that contemporary comparison method (CC) had lowest error variance and, therefore, it was considered to be the most efficient method out of all the methods. Maximum error variance was found in case of simple daughters average method, so it was the least efficient method. In the present set of data, CC method was most efficient in reducing the error variance in progeny testing caused by environmental factors and chance deviation. The results obtained in the present investigation were contrary to the reports from the developed countries that reported that Hendeson's BLUP method was most efficient (Dempfle, 1977; Harvey, 1979; Hagger and Dempfle, 1981; Danell, 1982; Mityut'ko, 1988 and Anacker and Diett, 1990).

When auxiliary traits were used along with the milk yield of daughters, the error variance in all the auxiliary indices were higher than contemporary comparison method, least-squares method (LSQ), simplified regressed

least-squares method (SRLS) and BLUP. However, the error variances in auxiliary sire indices were lower than the error variance found in case of simple daughters average index (D). Among the sire indices incorporating auxiliary traits, the lowest error variance was found when first service period (FSP) was considered as auxiliary trait. The highest error variance was observed when first dry period (FDP) was considered as auxiliary trait. Sire indices using two auxiliary traits at a time had lower relative efficiency in comparison to CC method and the values ranged from 24.46% to 30.73%.

The common environmental variance between the milk yield and auxiliary trait gets adjusted when auxiliary traits are used for estimation of breeding value of milk yield. This may be the reason for increase in efficiency of auxiliary sire indices over simple daughter average index. However, the auxiliary sire indices were not efficient enough to reduce the within sire variance to give efficient estimates of breeding value as observed in case of CC, SRLS, LSQ and BLUP. In the present study the numerical value of environmental correlation was maximum (0.43) between lactation milk yield and FSP. The relative efficiency among auxiliary sire indices were highest (32.54%) when FSP was used as auxiliary trait.

Rank correlation between sire evaluation methods

The rank correlation between the most efficient method observed in this study i.e. contemporary comparison method and other prevalent sire evaluation methods ranged from 0.77 with LSQ method to 0.85 with BLUP. The high and significant (p<0.01) rank correlation between the prevalent sire evaluation methods indicated that all these method did not differ significantly (p<0.01) in ranking of sires. Rao (1979) reported that rank correlation between D and LSQ was 0.91, D and CC 0.77 and, CC and LSQ 0.75. Cordovi er al. (1984) observed that there was little differences in ranking of bulls by CC, LSQ, and BLUP. Gandhi and Gurnani (1991) estimated rank correlation among 12 sire indices and the estimates of rank correlation ranged from 0.88 to 1.00. The rank correlation between CC method and auxiliary sire indices were also highly significant (p<0.01) and the value ranged between 0.81 to 0.84. The estimates of rank correlation among various auxiliary sire indices were near unity ranging from 0.98 to 1.0. The rank correlation indicated that all the auxiliary indices used in the study had ranked the sires similarly.

Accuracy of sire evaluation methods

The estimates of accuracy of various sire evaluation methods are presented in table 3. It was observed from the results that there was an increase in accuracy when auxiliary traits were used in some cases. The maximum increase in accuracy was 5.26% with first lactation length when one auxiliary trait was used and, when two auxiliary traits namely FCI and AFC were used, maximum increase (11.61%) in accuracy was observed.

Table 3. Accuracy of sire evaluation using auxiliary traits along with 305-day milk yield of daughters in comparison to that based on daughter milk yield records

Methods	Multiple correlation (R)	Coefficient of determination ($R^2\%$)	Percent increase in R^2
Without Auxiliary traits	0.812	65.99	--
FLL	0.833	69.46	5.26
FSP	0.819	66.99	1.52
FDP	0.820	67.21	1.85
FCI	0.818	66.98	1.50
AFC	0.820	67.19	1.82
FLL+FSP	0.844	71.22	7.93
FLL+FDP	0.818	66.90	1.38
FLL+FCI	0.819	67.04	1.59
FLL+ACF	0.847	71.72	8.68
FSP+FDP	0.854	72.93	10.52
FSP+FCI	0.818	66.93	1.42
FSP+AFC	0.817	66.75	1.15
FDP+FCI	0.829	68.77	4.21
FDP+FCI	0.818	66.90	1.38
FCI+AFC	0.858	73.65	11.61

* The abbreviations indicates the trait(s) used as auxiliary trait.

The accuracy of sire evaluation using auxiliary traits depends on the numerical difference $\Delta = r_g \sqrt{(h_i^2/h^2)}$ where, r_g, r_p, h_i^2 and h^2 are as described in materials and methods (Narain, 1985). The larger the Δ the higher will be the gain in efficiency using auxiliary trait. However, in the present study, the value of Δ ranged from a minimum 0.025 for FCI to a maximum 0.377 for FLL. The results also showed that gain in accuracy using auxiliary trait was minimum 1.50% in case of FCI and maximum 5.26% in case of FLL.

CONCLUSION

The efficiency of estimation of breeding value of sires for milk production using auxiliary traits of daughters along with their milk records was lower in comparison to CC, LSQ, SRLS and BLUP method. However, the auxiliary sire indices made better discrimination among the bulls since the range between maximum and minimum breeding values was high. The auxiliary traits may be used to increase the efficiency and accuracy of breeding value estimate when the environmental correlation are high between the milk yield and auxiliary traits.

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