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Estimates of Genetic and Phenotype Parameters for Milk Production in Iran Holstein-Friesian Cows

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Abstract: Heritability, repeatability and genetic phenotypic correlations among milk yield, fat yield and fat percentage were estimated using an animal model and 19855 records of 10225 Holstein-Friesian cows enrolled in the Iran, Natural Resources Research center of W. Azarbaijan, Urmia, between 1995 and 2005. Heritabilities for milk yield, fat yield and fat percentage were 0.26, 0.24 and 0.36, respectively and their repeatabilities were 0.31, 0.29 and 0.37, respetively. Genetic correlations of milk yield with fat yield and with fat percentage were 0.96 and -0.29, respectively and correlation of fat yield with fat percentage was -0.06. Phenotypic correlations were 0.96 between milk and fat yields, -0.27 between milk yield and fat percentage and -0.03between fat yield and percentage. It was concluded that these genetic and phenotypic parameter could be used for the genetic evaluation of dairy cattle in Iran.

Key words: Genetic, phenotype, milk production, parameters, heritability, repeatability

INTRODUCTION

To satisfy the growing demand of the human population for milk, the Iran government set up a plan in 1985 to increasing milk production. The important genetic strategies were the introduction of improved dairy cattle, the institution of milk recording and the extension of Artificial Insemination (AI). Thus, more than 8000 Holstein and Friesian heifers were purchased annually from Europe. In 1999, the number of improved cows was 175000 (Dadpasand, 1999). However, development and realization of animal breeding plans require knowledge of genetic parameters of the traits considered.

The objective of this study were to estimate heritabilities and repeatabilities for milk and fat yields and fat percentage, as well as genetic and phenotypic correlations among them from lactation records of Holstein-Friesian cows enrolled in the Iran official milk-recording program. These parameters were needed to plan out future breeding programs as well as to predict breeding values.

MATERIALS AND METHODS

The data analyzed were kindly provided by the Livestock Service of the Ministry of Jihad Agriculture and concerned Holstein-Friesian cows involved in the Natural Resources Researches Center of W. Azarbaijan Province. Test day yields for milk and fat percentage were the basic information used for calculation of yields. Milk recording practiced in Iran is classified as type A. During lactation, morning and evening milking of each cow was recorded once a month within an interval of 26-35 days. Data were restricted to records for which the first milk recording had occurred between 5 and 73 days and spacing of consecutive sample days was not more than 68 days. Lactation records were standardized to 305 days, except records of cows that went dry with less than 305 days of milk. Data were edited for errors, redundancy and incomplete observations. Further editing was carried for pedigree checks, consistent lactation number, data of calving and calving age. The final data file was restricted to cows milked twice a day, calving from 1995 to 2004, age at calving from 24-118 months, parity from 1-5, milk yield range from 871-10030 kg and over 210-days lactation. Although in Iran 80% of herds have less than 5 cows (Dadpasand, 1999) in this study herds that had less than three cows were omitted. Moreover, records with missing values on any of the traits of interest (milk yield, fat yield and fat percentage) were discarded. The remaining records included 19885 records from 10225 cows located in 281 herds.

Statistical analyses: The total number of animal in the analysis was 20010 (10225 individual, 1425 sires and 8800 dams). The traits studied were milk yield, fat yield and fat percentage during 305 days of lactation. Data were first analyzed by last-squares analysis of variance in order to

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identify the fixed effects to include in the model. The statistical model included the age of cow (<30 months, >30 to <42 months, >42 to <54 months, >54 to <66 months, >66 to < 78 months, > 78 to < 90 months and >months). Calving season (October through March and April through September) and the herd year of calving. All the effects were significant for all traits and hence were included in the model. First order interaction between effects were not tested and hence were assumed to be negligible.

Variance components for yields and percentage were estimated for each trait separately with derivative-free REML procedures using the MTDFREML program of Boldman *et al.* (1995). The basic single trait repeatability model in matrix notation was:

$$y = Xb + Za + Wpe + e$$

Where, y is a vector of observations, b is a vector of fixed effects with incidence matrix X, $a \sim N(A\sigma^2_a)$ is a vector of random animal effects with incidence matrix Z, $pe \sim N(I_c\, \sigma^2_{pe})$ is a vector of random permanent environmental effects with incidence matrix W and $e \sim N(0, I_n \sigma^2 e)$ is a vector of random residual effects.

σ^2_a is the additive genetic variance, σ^2_{pe} is the permanent environmental variance, σ^2_e is the residual variance, A is the additive genetic relationship matrix and I_c and I_n are identity matrics of order equal to the number of cows and number of records, respectively.

Convergence of the derivative-free iterative process was considered reached when the variance of simplex values (-2 log-likelihood) was less than 10^{-8}. To ensure a global maximum; each analysis was restarted with previous converged values until the estimated value of the -2 log-likelihood function did not differ in its first 3 decimal places. Solution for fixed and random effects were from the last round of iteration in which the global maximum was achieved.

Similar derivative-free REML procedures were used for bivariate analyses to estimate correlation between traits. The model included the same fixed effects and the animal effects only. Estimates from single-trait analyses were used to obtain starting values for bivariate analyses. Convergence was first obtained when the simplex variance was less than 10^{-3} and then when the simplex variance was less than 10^{-8} .

RESULTS AND DISCUSSION

Fixed effects: Unadjusted mean, standard deviation and coefficient of variation for milk, fat yield and fat percentage are presented in Table 1. Mean of yield of milk

Table 1: Number of records, unadjusted means, standard deviation and coefficient of variation for milk yield, fat yield and fat percentage of Holstein-Friesian cows

Trait	Number of records	X	SD	CV (%)
Milk yield (kg)	19885	5123.20	1519.90	27.60
Fat yield (kg)	19885	181.20	50.20	25.50
Fat (%)	19885	3.52	0.25	5.84

and fat and fat percentage were 5123.2, 181.2 kg and 3.52%, respectively. Performance levels for yields were higher than earlier estimates by Boujenane and Ba (1986) in Black and White cows enrolled in the official milk record-keeping program from 1975-1982, indicating a positive trend in the interval between the two studies. Moreover, coefficient of variation for yields (27.6 and 25.5%) were larger than that for fat percentage (5.84%).

The estimates for age at calving indicated that milk and fat yields wee highest for calving at 78-90 months, whereas fat percentage was highest for calving at less than 30 months (Table 2). Milk and fat yields increased with in increasing age at calving until 78-90 months and declined slightly thereafter. Differences between the highest and lowest age classes for milk and fat yields were 759.7 and 25.6 kg, respectively. For fat percentage, there was a lack of trend with age. The difference between the extreme classes was 0.03%. The influence of age at calving on milk yield and composition was consistent with published results (Campos *et al.*, 1994; Dedkova and Wolf, 2001; Jaime *et al.*, 2005).

Yields of milk fat were highest for cows calving from October through March and lowest for those calving from April through September. Conversely, fat percentage was highest for cows calving from April through September and lowest for those calving from October through March. Differences between season of calving for milk yield, fat yield and fat percentage were -132.5 -4.66 kg and 0.001 %, respectively. The influence of season of calving on lactation is well recognized (Campos *et al.*, 1994; Dedkova and Wolf, 2001). Seasonal variation in cow performance was expected to be primarily a manifestation of variation in feed quantity and quality.

Single-trait analyses: Table 3 shows heritability and repeatability estimates derived from the variance component estimates with single-trait analyses. The heritability estimates were 0.26 for milk yield, 0.24 for fat yield and 0.36 for fat percentage. The heritability estimate for milk yield agrees with those given by many authors (Albuquerque *et al.*, 1995; Boldman *et al.*, 1995; Chauhan and Hayes, 1991; Dejager and Kennedy, 1987; Meiner *et al.*, 1989; Walper and Freeman, 1992), was slightly lower than those from other studies (Abdollah and McDanie, 2000; Hill *et al.*, 1983; Silvestere *et al.*, 2005) and was slightly higher than those from yet other studies

Table 2: Number of records effects of age and season of calving on milk yield, fat yield and fat percentage of Holstein-Friesian

		Milk Yield (kg)		Fat Yield (kg)		Fat (%)	
Effects	Number	Difference[a]	Row mean	Difference[a]	Row mean	Difference[a]	Row mean
Age (month)							
[Age<30][b]	4550	0.0	5012.3	0.0	182.5	0.00	3.55
30<age<42	1610	168.2	5010.8	5.1	181.7	-0.002	3.59
42<age<54	2120	355.3	5398.3	11.8	191.5	-0.015	3.6
54<age<66	3320	498.6	5480.8	17.9	196.3	-0.024	3.61
66<age<78	2250	733.1	5323.7	24.6	201.5	-0.029	3.57
78<age<90	1630	650.2	5387.8	24.5	200.1	-0.027	3.59
age>90	2360	745.8	5550.8	21.2	189.6	-0.032	3.6
Calving season							
10085	0	5366.8	5366.8	0.00	194.8	0.00	3.61
[Oct-March][b]	9800	-128.8	5214.5	-4.47	185.6	0.002	3.62
April-Sept.							

[a]Estimates of deviation from reference class, [b]The reference class from which deviations were taken is brackets

Table 3: Variance components, heritability and repeatability estimates for milk yield, fat yield and fat percentage from single-trait analyses

Parameter[a]	Milk yield	Fat yield	Fat%
σ^2_P	799598.5	954.1	0.024
σ^2_a	231547.1	254.7	0.010
σ^2_{ep}	39544.1	41.8	0.000
σ^2_e	511410.8	655.8	0.014
h^2	0.26	0.24	0.360
C^2	0.05	0.04	0.000
e^2	0.67	0.65	0.610
t	0.33	0.31	0.360

a σ^2_P = Phenotypic variance; σ^2_a = Additive genetic variance; σ^2_{ep} = Permanent environmental variance; σ^2_e = Residual variance; h^2 = Heritability; C^2 = Permanent environmental variance as a proportion of phenotypic variance; e^2 = Residual variance as a proportion of phenotypic variance; t = Repeatability

(Dematawewa and Berger, 1998; Meyer, 1985; Tom *et al*., 2005). The heritability of fat yield was comparable to those of Chauhan and Hayes (1991), Dejager and Kennedy (1987) and Van Vleck *et al.* (1988). The estimate of heritability for fat percentage was similar to that of Meyer (1985), but markedly smaller than those previously mentioned (Campos *et al*., 1994; Dejager and Kennedy, 1987; Hill *et al*., 1983; Vleck and Dong, 1988).

These heritabilities indicated that there was a considerable amount of variation in milk yield similar to that found for fat that would be used for selection. The heritability was higher for fat percentage than those for milk and fat yields. This is n agreement with results reported in the literature (Chauhan and Hayes, 1991; Dejager and Kannedy, 1987; Hargrove*et al*., 1981; Walper and Freeman, 1992). The estimate of heritability for milk yield was higher than that for fat yield. This result is similar to those of Boichard and Bonaiti (1987), Dematawewa and Berger (1998) and Van Vleck *et al.* (1988). But contrary to other reports (Chauhan and Hayes, 1991; Hargrove *et al*., 1981; Meiner *et al*., 1989).

The low heritabilities found in the present study may be explained by the low mean performance of Moroccan cows. Hill *et al.* (1983) showed that heritability estimates of milk yield and composition may increase as the production as the production level of herds increases.

Permanent environmental variance as a proportion of phenotypic variance was low and varied from almost zero for fat percentage to 0.05 for milk yield. The repeatability estimates for mil and fat yields and fat percentage were 0.31, 0.29 and 0.37, respectively. The estimates for yields were higher than their corresponding heritabilities, but that of fat percentage was similar.

The repeatability estimates of the present study were lower than those reported by other workers (Abdollah and McDanie, 2000; Dematawewa and Berger, 1998; Ibrahim *et al*., 2003; Vleck *et al*., 1988; Welper and Freeman, 1992). The medium repeatabilities indicated that temporary environmental factors contributed appreciably to the variation in milk traits among parities, hence, culling of cows on single performance should be avoided.

Two-trait analyses: Table 4 shows estimates of genetic correlations, phenotypic correlations and average for heritability from all bivariate analyses. The heritability estimates for milk and fat yield (0.31 and 0.29, respectively) were higher than those obtained from single-trait analyses, but those for fat percentage were similar (0.37).

There was a very high positive genetic correlation of 0.96 between milk and fat yields suggesting that selection for milk yield would increase fat yield. Reported estimates of genetic correlations between milk and fat yields ranged from 0.39-0.95 (Albuquerque *et al*., 1995; Chauhan and Hayes, 1991; Dejager and Kennedy, 1987; Dematawewa and Berger, 1998; Hargove *et al*., 1981; Jaime *et al*., 2005; Van Vleck *et al*., 1988; Welper and Freeman, 1992).

Milk yield hd a negative genetic correlation of -0.32 with fat percentage. This correlation was in the range of those reported in the literature (Chauhan and Hayes, 1991; Dejager and Kennedy, 1987; Hargrove *et al*., 1981; Tom *et al*., 2005; Welper and Freeman, 1992) falling between -0.02 and -0.56. The negative correlation between milk yield and fat percentage indicated that selection for former would decline fat percentage.

Table 4: Heritabilities, genetic and phenotypic correlations from bivariate analyses among milk yield, fat yield and fat percentage of Holstein-Friesian

	Trait		
Trait	Milk yield	Fat yield	Fat %
Milk yield	0.31	0.96	-0.32
Fat yield	0.96	0.29	-0.06
Fat %	-0.27	-0.03	0.37

[a]Heritabilities, on the diagonal, are the average values from all bivariate analyses. Genetic and phenotypic correlations are shown above and below the diagonal, respectively

The genetic correlation between fat yield and fat percentage was slightly negative(-0.06), but lower than the correlation between milk yield and fat percentage. The estimates of correlation for fat yield and fat percentage differed from the positive relationships reported in the literature (Chauhan and Hayes, 1991; Dejager and Kennedy, 1987; Tom *et al*., 2005; Welper and Freeman, 1992). This antagonism between fat yield and percentage occurs mainly because the former depends more on milk yield than on fat content.

The phenotypic correlation was positive and high between milk and fat yields (0.96), negative and medium between milk yield and fat percentage (-0.27) and close to zero between fat yield and fat percentage (-0.03). The phenotypic correlation between yields was similar to its corresponding genetic correlation and nearly in agreement with previous works (Chauhan and Hayes, 1991; Dedkova and Wolf, 2001; Dejager and Kennedy, 1987; Dematawewa and Berger, 1998; Silvestere *et al*., 2005; Tom *et al*., 2005; Van Vleck *et al*., 1988; Welper and Freeman, 1992). However, the phenotypic correlation between fat yield and fat percentage close to zero was different from the positive and medium relationship reported in the literature (Chauhan and Hayes, 1991; Dejager and Kennedy, 1987; Meiner *et al*., 1989; Tom *et al*., 2005; Welper and Freeman, 1992).

CONCLUSION

This report is the first documentation of genetic and phenotypic parameter in West Azarbaijan province. The estimates of genetic parameters obtained in Holstein-Friesian cows were very similar to those reported in the literature. Heritabilities indicated that there was considerable amount of variation in milk yield, similar to that found for fat. The genetic correlation between yields was shown to be high. However, the negative correlation between milk and fat percentage will nor permit a rapid genetic change under divergent selection. In Iran where milk, butter and other derived products are partly imported in order to satisfy the human population`s demand, the desired breeding goal would seem to be the increase in milk yield, while holding the fat percentage constant.

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