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Genotype by Environmental Interactions for Milk and Fat Production Across Western Provinces of Iran

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Abstract: This study was carried for investigation interaction between genotype and environment for milk and fat production traits of Holstein cattle in western provinces of Iran. In this study, used 2213 records of first lactation Holstein dairy cattle in this zone of Iran. These data get from Iranian Animal Breeding Center from 1996-2006. The edited sets include 2213 first lactation for milk and fat. Records were divided in two climates. Heritability estimates using REML method and derivative-free algorithm for milk and fat yield in semidry climate and Mediterranean climate 0.2014±0.06 and 0.2468±0.03, respectively. For estimation of Genetic correlation were used from multivariate animal model. Genetic correlation was -0.04 and 0.013 for milk yield and fat yield, respectively. EBVes correlation mean was -0.019 and 0.031 for proofs between climate for milk and fat traits, respectively. Low genetic correlation and EBVes correlation for milk and fat traits between climates Indicate to proofs have not same difference performance in both climates. In addition, Germany Sperms cause increase milk and fat yield in both climate and Iranian and American Sperms decrease milk and fat yield in both climate.

Key words: Sperm, climate, genetic correlation, genotype by environmental interactions, Iran

INTRODUCTION

Environmental factors such as nutrition, type of management, temperature, etc. have minor effects on qualitative traits that are economically insignificant, while they have significant effects on quantitative traits that are being regarded as production and economic traits. The higher effects of environmental factors on quantitative traits relative to qualitative ones traces back to the involvement and cooperation of a large number of genes in the emergence of such traits. In other words, since many genes are involved in the appearance of one quantitative trait, therefore, the effect of environmental conditions on the appropriate function of these genes play a decisive role in the appearance of a hereditary feature.

The interaction of a genotype with the environment occurs when genotypes respond differently to the environmental conditions (Robertson, 1959). The presence of genotype-environment interaction may mean that the best genotype in one environment is not the best in another one (Falconer and Mackay, 1996). One issue concerning external sperms is the likelihood of a genotype-environment interaction that can lead into a change in ranking of the bull in different conditions. For that purpose, one method is using a multi-trait model and the correlation between environments. That is any trait in different environments is considered as a separate trait (Robertson, 1959). In this study, the performance of the bull for the traits of milk production and the fat content was studied in two climates: the semidry and the Mediterranean and the responses of their daughters in the two climates were analyzed.

MATERIALS AND METHODS

In this study, 2213 records of milk production and fat content of the first milking of Holstein cattle in West Iranian Provinces (Ilam, Kurdistan, Kermanshah and Hammedan) being collected by the Iranian Animal Breeding Center from 1996-2006 were used. In this study, the records of 305 days and twice milking per day were used. Animals with the age from birth beyond the range of 22-36 months and those lacking a record were discarded from the study. Classification of climates was made using the rainfall data, the air temperature and the advanced Marathon method. Also, the four Provinces were divided into two groups: those with a semidry climate (Kermanshah and Hammedan) and those with a Mediterranean climate (Ilam and Kurdistan). Then a genetic link between the climates was made that is any of the bulls in both climates had a daughter.

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The statistical model

Single trait model: Estimation of the variance-covariance traits and hereditability of the traits of milk production and the milk fat content were made using the single trait animal model and the DFREML software. The statistical model being used was the same for both traits, as follows:

$$y_{ijklm} = \mu + HYS_i + b\,(Age)_j + C_k + M_l + a_j + e_{ijklm}$$

Where,

- y_{ijklm} = Trait value
- μ = Mean of trait in population
- b = liner dependence coefficient for first calving
- Age = The effect of age in first lactation
- HYS_i = The effects of herd-year-season of calving
- C_k = The random effect due to sire k
- M_J = The effect of calving season in first caling
- a_j = Random additive genetic effect of animal j
- e_{ijklm} = The residual effect

After analysis of data, the correlation between the breeding values of the common cattle was computed.

Multi-trait model: For finding the genetic correlation coefficient of any trait between different climate zones the multi-trait animal model was used. The increasing and residue genetic variances that were estimated from the single-trait animal model for any trait in any climate were used as pre-estimates of increasing and residue genetic variances in the multi-trait analysis and the increasing and residue genetic variances and genetic correlation investigated whit them.

The matrix form of the model would be as follows:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} + \begin{bmatrix} U_1 \\ U_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

i = 1, 2 indexes are concerned to semidry climate and Mediterranean climate, respectively.

- y_i = Records concern to each one of traits in climate I
- X_i = Incidence matrix associated with vectors of fixed effects concern to each one of traits in climate I
- b_i = Vector of fixed effects concern to each one of traits in climate I
- Z_i = Incidence matrix associated with vectors of random effects concern to each one of traits in climate I
- u_i = Vector of random effects concern to each one of traits in climate I

RESULTS

The mean, the standard deviation and the variation coefficient of the traits of milk production and milk fat content in both climates are summarized in Table 1. The highest mean of the trait of milk production (5954.6) and the lowest mean of variation coefficient of the trait of milk production (25.91) belonged to the cold Mediterranean climate. Assuming that the distribution of sperms in both climates is completely at random, one can say that environmental factors in the herds present in the cold semidry led into an increase in the mean of milk production and could pave the way for the appearance of the genetic ability of the animals. The mean of the trait of milk fat in the Mediterranean climate (Ilam and Kurdistan), too, was higher than that in the semidry climate. Since the cows have the same fathers, they have the same genetic basis and one can conclude that the environmental conditions (for example, nutrition, management, hygiene, etc.) were better in the Mediterranean climate where, the animals could better show their genetic potential.

Estimation of variance and covariance components: In execution of the Breeding Programs of a herd, estimation of variance and covariance components is highly important. The variance components are necessary for estimation of genetic parameters such as hereditability and genetic correlation. Moreover, estimation of variance and covariance components is necessary for prediction of the breeding value and computation of the genetic progress before selection. Therefore, breeding of the animals through selection entails estimation of genetic parameters and prediction of the genetic value of the animals for the traits in question (Lasley, 1987). In this study, the components of variance and hereditability of milk production and the milk fat content in both climates are computed and summarized in Table 2. The hereditability for the trait of milk production in the Mediterranean and the semidry climates were 0.2486 and 0.2014, respectively. Hereditability of the milk fat content trait were 0.096 and 0.081, respectively. The hereditability amount for both traits in both climates was low. Considering the data in Table 2, it is seen that for any trait in the Mediterranean climate, the bull could better show their genetic potential. Carabano *et al.* (1990), estimated the hereditability of milk production in the Spanish and US Holstein cattle as 0.16 and 0.33, respectively. Suzuki and Van Vleck (1994), estimated the hereditability of the trait of milk production and milk fat content for the first period of lactation in Japanese Holstein cattle as 0.3 for both traits. Roman *et al.* (2000), estimated the

Table 1: Statistical summary of the data on each trait based on climatic classification based on the dryness coefficient

Traits	Number	Mean±SD	SE	Max.	Min.	CV
Cold semidry						
Milk (kg)	1564	5723.940±1564.88	27034.00	10858.0	2064.00	27.33
Fat (kg)	1564	195.810±44.34	22.65	353.8	44.34	22.64
Cold mediterranean climate						
Milk (kg)	649	5954.600±1542.92	25.91	11022.0	1895.00	25.91
Fat (kg)	649	203.584±53.43	26.20	397.0	70.90	26.24

Table 2: The components of variance and hereditability of milk production and milk fat content in different climates

Traits	Climate	σ^2_a	σ^2_e	σ^2_p	H^2
Milk production	Semidry	488592.35	1937976.34	2426568.69	0.2014±0.0600
	Mediterranean	597576.44	1806194.71	2403771.15	0.2486±0.0300
Fat Amount	Semidry	160.35	1797.33	1957.68	0.0810±0.0040
	Mediterranean	288.24	2689.43	2977.67	0.0960±0.0020

Table 3: Genetic and phenotypic correlations between the traits of milk production and the milk fat content in both climates

Parameters	Climate	Traits	p-value
Genetic correlation	Mediterranean	Milk	-0.040
	Semidry	Fat	0.031
Phenotypic correlation	Mediterranean	Milk	-0.036
	Semidry	Fat	0.070

hereditability of the trait of milk production and milk fat content in Jersey cattle as 0.26 and 0.31, respectively. Gacula *et al*. (1968), Wilcox *et al*. (1972), Benya *et al*. (1976), Sharma *et al*. (1983) and Moya *et al*. (1985) estimated the hereditability of the trait of milk production in Jersey cattle as 0.38, 0.25, 0.26, 0.26 and 0.31, respectively. They also, estimated the hereditability of the trait of milk fat content, which were 0.31, 0.2, 0.41, 0.27 and 0.48, respectively.

Genetic and phenotypic correlation of milk production and milk fat content between the two climates: The Genetic and phenotypic correlation of milk production and milk fat content between the two climates is given in Table 3. Considering Table 3, you can show that the genetic correlations of the traits of milk production and the milk fat content in both climates are significantly different from one, showing that the bulls in the two climates have different performances representing an interaction between the genotype and the environment. Farthing and Legates (1956) reported the genetic correlation between milk production and milk fat content for 5458 daughter Holstein cattle and their mothers as 0.38±0.06 and for 1825 Jersey cattle as -0.57±0.06. In a research conducted with the aim of finding factors affecting the genotype-environment interaction using the records of the first time milking in 17 countries, the cattle were grouped and studied based on 13 genetic, managerial and climatic variables (the peak milk production, milking continuity, the herd size, the age at the first calving, calving season, the SD of milk production, days of peak milk production, the amount of removal, fat to protein ratio, father's PTA for milk production, the proportion of common genes, the maximum temperature in the month and the annual rainfall). Among these variables, the herd size, the peak milk production, the temperature and the proportion of common genes had the least correlation among the groups, showing the importance of uniform production environments. It was found that if the herds were grouped based on these variables, genetic evaluations could be conducted for each unique (uniform) production system rather than based on political boundaries, This can improve genetic progresses through international genetic evaluations for any managerial situation (Zwald *et al*., 2003). Carabano *et al*. (1990) reported genetic correlation for the milk production and the milk fat content and the milk fat percentage between New York and Wisconsin as 0.99, 0.98 and 0.99, respectively that were higher than those between California and Wisconsin (0.95, 0.95 and 0.98) for the same traits. Robertson (1959) stated that biologic differences could appear when the correlation between the environments is <0.8. Genetic correlation between some regions for the milk fat content is low, one explanation, for which may be errors in measuring the milk fat content out of the milk fat percentage. In a study, conducted by Fikse *et al*. (2003) for investigation of the interaction of the genotype and the environment for the traits of milk production by Jersey cows in the 4 countries of Australia, Canada, USA and South Africa using five statistical models: Single-Trait across country (ST), Single-Trait across country with heterogeneous residual variance (SThet), Multiple-Trait across country (MT), Multiple-trait Hers Cluster (HC) and Reaction Norm (RR), the genetic correlation between the countries in the MT model was estimated at between 0.78 and 0.9, while that for the RR model showed an heterogeneity between the countries as regards genetic variances. Klassen *et al*. (1992) computed the genetic and the phenotypic correlations between the traits of life span and milk production between 0.99-0.91 and showed that there are many similar factors involved in the control of these traits. They also, computed the lowest correlations (genetic and phenotypic) between the number of milking cycles and the life span traits so that the phenotypic correlation was found to be 0.91-0.93 and the genetic correlation was 0.92-0.95. Koivula *et al*. (2005), computed the genetic correlation of Clinical Mastitis (CM) between the first and the second lactation period as 0.73. Also, they estimated the genetic correlation of the Somatic Cells Count (SCC) before and after CM for the first and the second lactation periods as 0.92 and 0.98. In their study, it was found that CM and SCC at the first and the second lactation periods, had a positive correlation (0.59-0.68) though the correlations at the second lactation period were lower.

DISCUSSION

The Genotype-Environment interaction (G×E) occurs when there are differences in the expression of genotypes in different environments. The Genotype-Environment interaction (G×E) can occur in two different forms: the Scaling effect among environments and change in the real grading of fathers among the environments. The scaling effect occurs when the difference in grading in the fathers' test are in two unequal environments. Forn Second grading occurs when, for example, a trait such as milk production in two environments has different genetic bases. If the grade value is high, the genetic correlation between milk productions in the environment will be necessarily <1 and by using the tests conducted in the first environment will not be a reliable prediction of the aptitude in the second environment. It is this form of genotype-environment that is especially, interested by animal breeders (Cromie *et al*., 1999). In this study, the genetic correlation of the milk production and the milk fat content between climates was estimate at -0.04 and 0.031, respectively, which significantly differed from one and the findings show that there is a difference between the semidry and the Mediterranean climates as regards performance. Considering the difference in genetic parameters and the low correlation in these regions, one can say that the performance of bulls was different and since the grading of bulls, too is not the same, then there is a genotype interaction but this G×E interaction is not a result of scaling effect. Therefore, it is more appropriate to consider environmental conditions of the region in choosing the semen, as an effective factor.

CONCLUSION

The finding of this study shown that the genotypic correlation of the fat content trait is significantly <1, showing different performance of bulls and environmental conditions in the two climates (Mediterranean and Semidry). Also in Semidry climate, the American sperms as compared with the Iranian one, led into the reduction in mean milk production, while in the Mediterranean climate the reverse is true.

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