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Full Length Research Paper

Interaction between genotype and climates for Holstein milk production traits in Iran

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This study was designed to investigate the interaction between genotype and climate for milk and fat production traits of Iranian Holstein dairy herds. Milk and fat production data were grouped in 5 climates, on the basis of Extended De Martonne method. (Co)Variance components and genetic parameters of first lactation records from 514 herds were estimated by DFREML procedure. Estimation of genetic parameters by univariate animal model showed that heritability of milk and fat yields were from 0.22 to 0.30 and 0.06 to 0.26, respectively; that proved by the results of multivariate model. Genetic correlations between different climates ranged from 0.66 to 1 for milk yield and 0.16 to 1 for fat yield, respectively. Calculated genetic correlation between milk production traits in 5 various climates of Iran showed that there is a significant interaction between humid climate with other climates for both milk and fat yield traits. Using Spearman and Rank correlation for estimation of correlation between bulls breading values, for two traits showed the significant genotype by environment interaction between humid climate and Meditrranean climate for milk yield and between humid climate and other climates for fat yield.

Key words: Holstein, genetic correlation, breeding value, genotype by environment interaction.

INTRODUCTION

Genotype by environment interaction occurs when the genotypes respond to the environment changes in different forms (Falconer, 1996). One of the problems about using semen straws is genotype by environment interaction that can alter ranking of sires in different conditions. This problem in countries like Iran with more climate diversity is more considered. Iran situates in the southern half of geographic crown of temperate zone, between northern latitudes of 25 to 30°C and 39 to 47 and eastern lengths of 44 to 55 and 18 to 63 of the Greenwich meridian. Most of its regions are arid and semi-arid areas and its average annual rainfall is less than 250 mm. The weather coefficient of variation is 70%; therefore, the variety of its climate is large. When the genotypes of one environment, which its value is clear, introduce into the same environments, they usually will have similar performance; however, if these genotypes enter into different environments, their performance may actually be influenced. The G×E interaction is very important in order to identify population genetic progress in one environment per a selection of different genotypes (Ojango and Pollott, 2002). There are different methods to estimate genotype by environment interaction, including:

1. The correlation between breeding values, Mukherjee et al. (1980) showed that sires with the highest breeding values in one environment may not be the best in other environment, and particular sires are desirable in each environment.
2. Using multivariate cluster model, this method can consider the effect of climate differences of various countries in the model (SAS Institute, 1990).
3. Genetic correlation between environments using multivariate animal model.

Falconer (1996) suggested that the incidence of genes affecting one especial trait are not necessarily the same in two different environments and animals performance can be considered as two separate

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Table 1. Information of pedigree file.

Number of sire	Number of dam	Number of inbreed animal	Number of base animal	Number of non-base animal
3587	92360	27731	30902	143360

Table 2. Number of herds and animals in each climate.

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid	Total
Number of herds	39	315	87	13	60	514
Number of animals	2068	70213	21306	3169	6515	102371

traits. Thus, the interaction of genotype and environment can be estimated using genetic correlation between traits which measured in two different environments (Robertson, 1959). Saghi (2001) in his study on G×E interaction between climates for milk traits, reported that there is no significant genotype and environmental interaction between dry desert, semi dry and Mediterranean climates for milk production, but humid and semi humid climates had significant interaction with other climates of Iran. Cienfuegos-Rivas et al. (1999) also studied the effect of genotype and environment interaction between different regions of Mexico and the United States for milk production. In this study, genetic correlation coefficients between different regions of Mexico and United States were 0.6 to 0.71. Variation of sires breeding value in different regions of Mexico was significant relative to the United States. The objective of this study was to estimate the interaction between genotype and environment for Holstein milk and fat production traits in different climate of Iran.

MATERIALS AND METHODS

In this study, first lactation 305 days milk production and fat yield records from 102371 Holstein cows of Iran (daughters of 1863 bulls) were used. The data was collected by the Livestock Breeding Center of Iran from 1991 to 2001. Information regarding to the pedigree file which is used in the study is presented in Table 1. Only records of cows with calving age between 18 to 36 months were included and animals without records were removed. Based on advanced De Martonne classification method (Dumitriu-Tatararu and Popescu, 1990) and available weather information of Iran provinces, the data were divided into 5 climate groups (dry desert, semi dry, Mediterranean, humid and semi humid).

Then, genetic connectedness was created between climates groups, by considering at least one daughter per sire in two considered climates. Summary statistics of number of herds and cows in each climate are in Table 2. Variance-covariance components in each climate group and the correlation coefficient between these regions were estimated, using univariate and multivariate animal models (each of the trait in various regions were considered separately as different traits) with restricted maximum likelihood method and DFREML program (Meyer, 2000). Normal distribution of data was tested using SAS 6.2 software (SAS Institute, 1990), and suitable statistical model was determined through the GLM procedure for each trait. The univariate model used for all traits was as follows:

$y_{ijkl} = \mu + HYS_i + b(Age)_j + a_k + e_{ijkl}$

Where, y_{ijkl} is the observation on animal; μ is the overall mean; HYS_i is the fixed effect of i^{th} herd-year-season of calving; b is the coefficient of linear regression of age at first calving; age_j is the j^{th} cow's age at first calving; a_k is the random additive genetic of k^{th} animal and e_{ijkl} is the residual effect.

To estimate genetic correlation coefficients for each trait in two different climates, bivariate animal model was used. Additive genetic and residual variances which estimated from univariate models for each trait in each climate were used as a prior in bivariate models. Powell method of DFREML program was used in bivariate analysis. In matrix notation, the equations used for the multivariate analysis was as follows:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

Where, subindice 1 and 2 identify two climates which are considered in each model; y_i is the vector of observations of first lactation in the i^{th} region; X_i is the incidence matrix of fixed effects in i^{th} region; b_i is the vector of fixed effects in i^{th} region; Z_i is the incidence matrix of random effects in i^{th} region; u_i is the vector of random effect in i^{th} region and e_i is the vector of residual effect.

RESULTS AND DISCUSSION

Milk production

Results showed that the effect of herd, year and season of calving as fixed factors and age of calving as a covariate, was significant for milk production (p<0.01). Statistical summary of data for milk production (kg) in various climates of Iran is presented in Table 3. Averages of milk production was estimated 6378.05, 5967.28, 5854.18, 5537.53 and 4873.43 kg for semi dry, Mediterranean, dry desert, semi-humid and humid climate, respectively. Semi-humid climate showed the lowest coefficient of variation. Coefficient of variation of dry desert climate, despite having the lowest number of animals, was much more than other climates that may be due to the different management systems which exist among the flocks. Coefficient of variation for semi dry climate was the lowest; this can be due to better

Table 3. Statistical summary for milk production records in various climates of Iran.

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
N	2068	70213	21306	3169	5615
Average	5854.18	6378.05	5967.28	4873.43	5527.53
Standard deviation	1334.37	1284.46	1308.26	1070.81	1168.38
Coefficient of variation	17.46	16.54	18.11	18.94	15.06
R- square	0.55	0.38	0.36	0.28	0.59

Table 4. Correlation coefficients for first lactation milk production in various climates.

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
Dry desert	1				
Semi dry	1	1			
Mediterranean	0.99 (none-sign)	0.98 (none-sign)	1		
Humid	0.84 (sign)	0.73 (sign)	0.66 (sign)	1	
Semi humid	0.96 (none-sign)	0.98 (none-sign)	1	1	1

Table 5. Pearson correlation between breeding values of common sires for milk trait in various climates

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
Dry desert	1				
Semi dry	1	1			
Mediterranean	1	0.99 (none-sign)	1		
Humid	0.96 (none-sign)	0.93 (none-sign)	0.87 (sign)	1	
Semi humid	0.99 (none-sign)	0.99 (none-sign)	1	1	1

management practices in semi dry climate than other ecosystems.

The average heritabilities for milk production trait were 0.28±0.06, 0.30±0.07, 0.24±0.05, 0.29±0.06 and 0.26±0.05 in dry desert, semi-dry, Mediterranean, humid and semi-humid climate, respectively. The results of this research were similar to the findings of Eghbal saeid (2003) and Saghi (2001), who estimated heritability for milk production in different climates of Iran. Fikse et al. (2003) evaluated first lactation Grenzy cows' records of four countries (Australia, Canada, the United States and South Africa) to determine the genotype by environment interaction for milk production, using different statistical models. They reported the heritability of milk production as 0.33 for univariate model and 0.4 and 0.25 for multivariate models between countries and multivariate cluster model, respectively. In order to determine the genotype by environment interaction, genetic correlation between different climates were calculated, using two-trait animal model (Table 4). Falconer (1996) stated that if the genetic correlation is less than 0.9, so there is the interaction of genotype and environment. In other words, genetic correlation of more than 0.9 indicated no existence of the interaction of genotype by environment.

According to Table 4, it is considered that genetic correlation coefficient between the humid climate and dry desert, semi-arid and Mediterranean climates (0.84, 0.73 and 0.66, respectively) is less than 0.90 which reflects the significant interaction of genotype by environment; and in the other climates interaction of genotype and environment is not significant. Saghi (2001) reported that there is no significant genotype and environmental interaction between dry desert, semi dry and Mediterranean climates for milk production, but humid and semi humid climates had significant interaction with other climates of Iran.

Pearson and Rank correlations between breeding values of bulls in different climates are also given in Tables 5 and 6, respectively. The estimated values for the correlation between climates were higher than the genetic correlation, so that genotype by environment interaction was significant only for Mediterranean climate with humid climate. It is considered that the results of Rank correlation are inconsistent with the results of Pearson correlation. Pearson and Rank correlation are not well justifiers for genotype and environment

Table 6. Rank correlation between breeding values of common sires for milk trait in various climates.

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
Dry desert	1				
Semi dry	1	1			
Mediterranean	1	0.99 (none-sign)	1		
Humid	0.95 (none-sign)	0.99 (none-sign)	0.78 (sign)	1	
Semi humid	0.99 (none-sign)	0.99 (none-sign)	1	1	1

Table 7. Statistical summary for milk fat records in various climates of Iran

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
N	2067	70213	21306	3169	5615
Average	182.35	196.60	174.54	159.46	167.59
Standard deviation	43.02	42.10	49.48	38.89	40.64
Coefficient of variation	18.12	15.38	16.75	20.19	14.84
R- square	0.55	0.53	0.67	0.33	0.70

Table 8. Correlation coefficient for first lactation fat yield in various climates

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
Dry desert	1				
Semi dry	1	1			
Mediterranean	0.90 (none-sign)	0.90 (sign)	1		
Humid	0.26 (sign)	0.16 (sign)	0.65 (sign)	1	
Semi humid	0.96 (none-sign)	0.84 (sign)	0.78 (sign)	0.68 (sign)	1

interaction, but confirm the results of genetic correlation.

Milk fat yield

Analysis of variance results of the first calving fat yield data in different climates showed that all the fixed variables and covariates were significant at 1% level, except the auxiliary variable of age at calving, in dry desert climate which was significant at 5% level. Statistical summary of fat yield data from different climates are presented in Table 7. Average fat yield for semi dry climate, dry desert climate, Mediterranean climate, semi-humid and humid climate was 196.60, 182.35, 174.54, 167.59 and 159.46 kg, respectively. The lowest coefficient of variation was related to semi-humid (14.84) and the highest coefficient was related to humid climate (20.19) that is in accordance with the results of milk production trait.

Using two-trait animal model, the average of heritability for fat yield was estimated as 0.12±0.05, 0.26±0.08, 0.22±0.1, 0.23±0.02 and 0.14±0.05 in dry desert, semi dry, Mediterranean, humid and semi-humid, respectively. Results of this study were more than results of Eghbal saeid (2003) but they were similar to Saghi's (2001) results. Visscher and Thompson (1992) using first lactation milk records, estimated heritability of milk yield and fat yield to be 0.40 and 0.37, respectively. Albuquerque et al. (1995) estimated the average heritability of milk yield, fat yield and protein yield, using multivariate animal model to be 0.30±0.02, 0.31±0.01 and 0.29±0.01, respectively for California Holstein cows and to be 0.33±0.01, 0.35±0.01 and 0.3±0.01, respectively for New York Holstein cows.

In this study, genetic correlation between dry desert and semi dry climates is 1, which is in consistence with a result obtained for milk production. This match means that the interaction between dry desert and semi dry climates for both traits are not significant. The interaction between humid climate and all other climates was significant and the lowest correlation was related to semi dry climate (0.16). These results indicated genotype by environment interaction intensity, fat yield in humid climate with other climates (Table 8). Costa et al. (2000) in a study of Holstein cows in Brazil and United States, estimated the genetic correlation for milk yield and fat yield as 0.85 and 0.88, respectively and they reported that the interaction between genotype and environment was non-significant. Albuquerque et al. (1995) reported the average genetic correlation between California and

Table 9. Pearson correlation between breeding values of common sires for fat yield in various climates

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
Dry desert	1				
Semi dry	1	1			
Mediterranean	0.99 (none-sign)	0.97 (none-sign)	1		
Humid	0.32 (sign)	0.31 (sign)	0.79 (sign)	1	
Semi humid	1 (none-sign)	0.95 (none-sign)	0.92 (none-sign)	0.86 (sign)	1

Table 10. Rank correlation between breeding values of common sires for fat yield in various climates

Climate	Dry desert	Semi dry	Mediterranean	Humid	Semi humid
Dry desert	1				
Semi dry	1	1			
Mediterranean	0.99 (none-sign)	0.98 (none-sign)	1		
Humid	0.30 (sign)	0.46 (sign)	0.83 (sign)	1	
Semi humid	1 (none-sign)	0.97 (none-sign)	0.93 (none-sign)	0.85 (sign)	1

New York regions as 0.63±0.01 and 0.52±0.02 for milk production and fat yield, 0.84±0.01 and 0.83±0.01 for milk production and protein yield, 0.73±0.01 and 0.68±0.01 for fat and protein yield, respectively. For fat yield in this study, there is also genotype by environment interaction between humid climate and semi dry and Mediterranean climates.

Pearson correlation and rank correlation between breeding values of common bulls for fat yield from various climates are shown in Tables 9 and 10. Results for both correlations showed the significant interaction of genotype and environment between humid climate and other climates. The lowest correlation was between humid climate and semi-dry climate (0.31), this result represents the highest genotype by environment interaction between these two climates. This interaction was not significant for other climates. Dong et al. (1989) in the study of New York Holstein cows from 24 herds and using multivariate animal model, reported the average of milk production as 8630 kg and the heritability of milk production, fat yield and protein yield as 0.36, 0.31 and 0.33, respectively. In the study by Costa et al. (2000), genetic correlation between United States and Brazil Holstein cows were calculated. The value of this correlation for milk yield and fat yield was obtained as 0.85 and 0.88, respectively. These coefficients show that there was no significant interaction between genotype and environment in Brazil and the United States.

Ojango and Pollott (2002) investigated the interaction between genotype and environment in Kenya and England, using 43056 records of 3185 beef cattle in these two countries. They reported heritability of first lactation milk production as 0.45 in England and 0.26 in Kenya. Genetic correlation of first lactation milk production between two countries was 0.49, which indicates significant G×E interaction. Fikse et al. (2003) reported genetic correlation between four countries namely Australia, Canada, the United States and South Africa as 0.87 to 0.92, using multivariate model; their results showed that the variance in different production environments is not the same and it is ranked based on the environment type. Zwald et al. (2003) estimated heritability of milk production for each variable and genetic correlation between groups, using 11 management factors and 2 climate variables and herds were divided into quintet groups. This study suggested considering traits based on production condition of each herd. Kearny et al. (2004) studied the effect of genotype by environment interaction for production traits, using two environment conditions (adlibitum grazing and limited grazing). They reported that heritability of milk production, fat yield and protein yield was in the range of 0.20 to 0.25, and the difference between adlibitum and limited grazing environments was low.

They estimated genetic correlation for milk production, fat yield and protein yield in two environments as 0.89, 0.88 and 0.91, respectively. These researchers also estimated ordinal correlation coefficients between breeding values of sires in two environments as 0.59, 0.63 and 0.66 for milk production, fat yield and protein yield respectively, and stated that differences of two environments are not enough to consider separated genetic evaluation for each system. Horan et al. (2005) investigated the interaction between Holstein-Frisian cows' species and feeding systems on milk production, body weight and body condition as genotype by environment interaction. They reported that the best species of Holstein-Frisian cows will have different performance in various feeding systems.

Conclusion

Calculated genetic correlation between milk production traits in 5 climates of Iran showed that there is a significant interaction between humid climate with other climates for both milk and fat yield traits. There was G×E interaction between semi humid climate with semi dry and Mediterranean climates for fat yield, as well. Using Spearman and Rank correlation for estimation of correlation between bulls breading values for two traits was the same and showed significant genotype by environment interaction between humid climate and Mediterranean climate for milk yield and between humid climate and other climates for fat yield.

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