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Use of the random regression model for the genetic parameters estimation of milk yield in a Holstein cows herd

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ABSTRACT

To estimate genetic parameters for daily milk yield, test day records of first lactation Holstein cows were used. The data included 9782 test day records of 1140 Mahdasht herd cows recorded from 2001 to 2009. Analysis of test day records was performed using the REML procedure in DFREML software. Legendre polynomials on days in milk of order 5 were used to fit the population mean as fixed regression and of order 3 for both additive genetic and permanent environmental effect as random regression. Residual variances for the model considered to be constant for all days in milk and estimated as 305. The minimum value for heritability estimate (0.039) occurred in early lactation but had increase increased toward the lactation and in the ninth month of lactation reached the maximum value (0.280). Phenotypic variance of daily milk yield was higher in early and late lactation. The maximum (18.750) and minimum (2.360) values of genetic variance were in month 10 and early lactation respectively. The maximum values for genetic and phenotypic correlations were between records of adjacent days in milk and as the distance between the days increased the correlations decreased. Using test day records, increased accuracy for genetic parameters will be achieved.

Key words: Genetic parameters, Test day records, Random regression model and Holstein.

INTRODUCTION

Dairy production is the most important branches of animal science. About 91 percent of milk in the world is produced by the cow [1]. In regular genetic evaluation, the 305-day milk yield records of animals are used, while methods based on test day records could result in more information about different factors influencing milk yield during different days in milk.

Animal breeders using relevant data could have done evaluation and selection of genetic in shorter time and increasing response to genetic selection and reduce generation interval and costs**.** In 1994, a random regression model was proposed for the analysis of test day records. In this model the covariance structure of repeated data during time or life was considered [2, 3 and 4].

The major objectives of this study was to study the effect of different factors on daily milk yield of first lactation Holstein cows in Mahdasht herd and estimation of variance components they cause.

MATERIALS AND METHODS

9782 test day records from 1140 first lactation Holstein cows of Mahdasht herd located near the city of Sari in Iran's Northern Province, Mazandaran, was used. Data edition performed using the EXCEL (2007) software.

For determining significant factors on milk yield a general linear model (GLM) was fitted using SAS (2003) software. Estimation of variance components was done using the following random regression animal model.

$$y_{ijkn} = cys_i + CA_j + \sum_{n=1}^{2} b_n (TD_{ijn})n + \sum_{n=0}^{k} \beta_n \phi_n (\dim_{ijkn}) + \sum_{n=0}^{ka-1} \alpha_{pn} \phi_n (\dim_{ijkn}) + \sum_{n=0}^{kp-1} \gamma_{pn} \phi_n (\dim_{ijkn}) + e_{ijkn}$$

Where y_{ijkn} denotes the observed daily milk yield of each animal; cys_i, the effect calving year-season; CA_j, the effect of age at calving; $Ø_n$, the n^{th} Legendre polynomials; dim_{ijkn}, days in milk; β_n, the n^{th} fixed regression coefficient to fit population mean; α_{pn}, the n^{th} random regression coefficient for additive genetic effect of the p^{th} cow and γ_{pn}, the n^{th} random regression coefficient for permanent environmental effect of the p^{th} cow.

Estimation of genetic parameters performed by restricted maximum likelihood (REML) procedure using DXMRR package of DFREML software. Order of fit for both the additive genetic and permanent environmental effect was set to 3 and the convergence criteria to stop iteration was10^{-8}. Table 1 shows the basic information from the data and pedigree of population.

RESULTS AND DISCUSSION

Effect of calving year-season and calving age on daily milk yield in all months of lactation were significant ($p<0.05$). Milk yields after 2004 were more than the previous year's which generally indicated on improvement in population genetic and management.

Animals calved in summer had lower milk yield and those calved in winter and fall had more milk yield. The most important factor describing this could be summer heat stress and reduced feed intake. Cows that calved at older age had more average milk yield.

The milk average and standard deviation for milk yield due to different months of lactation are presented in Table 2. With the onset of lactation period, Milk production increased and reached its maximum in TD_2 (38.94) and then decreases. This change has also been reported by other researchers [5 and 6]. Figure 1 presents the changes in milk production.

Heritability of daily milk production (Figure 2) decreased during the first two months of lactation and then increased. (0.281) this trend of heritability changes is consistent with reports from other researchers [7]. However the observed initial decrease in heritability is greater than of other reports but the increasing trend from the second month towards the end of lactation is similar to reports by other researchers [7, 8 and 9]. In a study to estimate genetic parameters for milk production in Yasuj Holstein cows using test day records, the heritability range was from 0.116 to 0.258 [7], and apart from the first month change, it was in agreement with this study.

In a study on Portugal dairy cows, heritability estimates ranged from 0.021 to 0.23 and the maximum value occurred in mid-Lactation [10]. In a study on milk production in Holstein cows of North Carolina, the range of heritability was from 0.092 to 0.149 which the minimum value was in second month and the maximum value was in month 8 [9]. Another research has reported the maximum value of heritability of daily milk production in months 8 of lactation [11].

With a constant residual variance, the increase in heritability can be a result from an increase in genetic variance and reduce in permanent environmental variance (Figure 4 and 5).

Maximum value for Repeatability of daily milk production occurred in first month with a decreasing trend and reached a minimum value in month two (Figure 3).

The trend of repeatability between second months to 4^{th} month was increasing and after that decreased until month 6 and then increased again. However, the maximum value of Repeatability was in first month, but the maximum value of heritability occurred in month 9. The higher level of Repeatability in first month is due to higher variance of permanent environmental effects in this period. Repeatability range for daily milk production of Holstein cows in the Khorasan province were 0.355 to 0.507, which the least value was in first month and the 4^{th} month contained the highest value [12]. The amount of additive genetic variance in first month was high and then decreased in second month. Then amount of additive genetic variance increased with the progress of lactation and at the late of lactation reached the maximum. The least of Additive genetic variance was observed in second month (Figure 4). The trend of additive genetic variance is similar to heritability trend that was least in early lactation and highest in late lactation period (Table 3). Residual variance assumed to be constant for all days in milk and estimated as 305.

Trend of additive genetic variance is consistent with results from other researchers. A group of researchers reported similar trend in which the least additive genetic variance estimate was in early lactation and the highest estimate was in late lactation [7, 12, 13 and 14]. Some other researchers also showed a similar trend in which the maximum additive genetic variance estimate was in tenth month [9, 10 and 15]. A number of researchers estimated the highest additive genetic variance for the months 6 or 7 [5 and 6] which was not consistent with above studies.

Maximum value of permanent environmental variance was for first month which decreased to month 8 and then increased to month 10. So that the maximum estimate for permanent environmental variance was in first month and the least estimate was in month 8 (Figure 5). This Trend is somewhat different from reports of other researchers. A group of researchers estimated the minimum permanent environmental variance for first month and the maximum for month 10 but some others reported the least one in 3rd month and the highest one in month 10 [9 and 10].

The survey results were observed in the phenotypic variance decreased from the first month to the 3rd and then for the 4th month increased and then decreased in 5th month and increasing again to the late lactation. Minimum estimate of phenotypic variance occurred in month 5 and maximum estimate was in first month (Figure 6).

Increasing trend for phenotypic variance in final days of the first month is consistent with reports of many researchers. Some researchers showed the maximum phenotypic variance at the end of lactation and the minimum in the mid-lactation [7 and 12]. Some others reported a similar trend, in which the maximum estimate for phenotypic variance was in early lactation and the minimum one was in mid-lactation [5, 8 and 9]. Except for low Genetic correlation between the first month records and other months, Genetic correlation between records was high. The estimate of genetic correlation between two adjacent records in the mid and late lactation was higher than those in early lactation. Higher genetic correlation for daily milk production were between adjacent days in milk and the correlation reduced as the distance between the days in milk increased. Phenotypic correlation estimates had also similar property with the genetic correlation, i.e., was higher between adjacent days in milk and decreased with increasing distance between the days of lactation. Minimum phenotypic variance (0.177) was between records in second month and month 10, and the maximum (0.522) was between records in month 9 and 10 (Table 4). This trend is consistent with reports from other researchers. Some researchers estimated maximum genetic and phenotypic correlations between adjacent days in milk, so, the correlations decreased with increasing distance between days of lactation [8, 11, 16, 17 and 18]. Genetic and phenotypic correlations are presented in Table 4.

Table 1: Some basic information from the data and pedigree of population

Record number	9782
Number of base animals	674
Number of animals with Record	1140
Number of Sires	273
Average of inbreeding coefficient	1.16

Table 2: average and standard deviation of daily milk yield in different months of lactation

Month	Days in milk interval	Number of records	Average	Standard deviation
1	5-30	1070	34.09	8.24
2	31-60	1175	38.94	7.97
3	61-90	1150	38.2	7.91
4	91-120	1139	36.58	7.45
5	121-150	1014	34.99	7.24
6	151-180	1006	33.46	7.22
7	181-210	915	31.51	6.98
8	211-240	862	29.21	6.9
9	241-270	771	27.21	6.79
10	271-305	680	25.3	7

Table 3 Additive genetic, permanent environmental and phenotypic variance, heritability and repeatability for daily milk records in different months of lactation in Mahdasht herd

Month	Additive genetic variance	Permanent environmental variance	Phenotypic variance	Heritability	Repeatability
1	9.06	30.78	70.4	0.129	0.556
2	2.36	27.26	60.17	0.039	0.492
3	3.656	26.86	61.08	0.06	0.499
4	6.963	24.48	62	0.112	0.507
5	9.976	20.59	61.2	0.163	0.5
6	12.36	17.27	60.19	0.205	0.492
7	14.46	15.75	60.77	0.238	0.497
8	16.52	15.68	62.76	0.263	0.513
9	18.21	16.14	64.9	0.281	0.529
10	18.75	18.16	67.47	0.278	0.547

Table 4 Genetic correlations (above diagonal) and phenotypic correlations (below diagonal) for daily milk records of first lactation Holstein cows of Mahdasht herd

months	1	2	3	4	5	6	7	8	9	10
1	-	0.724	0.01	0.199	0.174	0.068	0.07	0.201	0.298	0.343
2	0.46	-	0.682	0.526	0.537	0.609	0.69	0.753	0.786	0.788
3	0.352	0.467	-	0.979	0.975	0.972	0.95	0.907	0.855	0.814
4	0.283	0.43	0.492	-	0.997	0.98	0.937	0.875	0.81	0.765
5	0.246	0.391	0.463	0.494	-	0.991	0.958	0.904	0.846	0.805
6	0.226	0.347	0.415	0.457	0.483	-	0.988	0.952	0.909	0.875
7	0.213	0.297	0.354	0.402	0.447	0.481	-	0.988	0.963	0.941
8	0.197	0.248	0.293	0.343	0.4	0.455	0.494	-	0.993	0.981
9	0.172	0.207	0.246	0.297	0.359	0.423	0.476	0.512	-	0.997
10	0.128	0.177	0.222	0.272	0.329	0.389	0.442	0.486	0.522	-

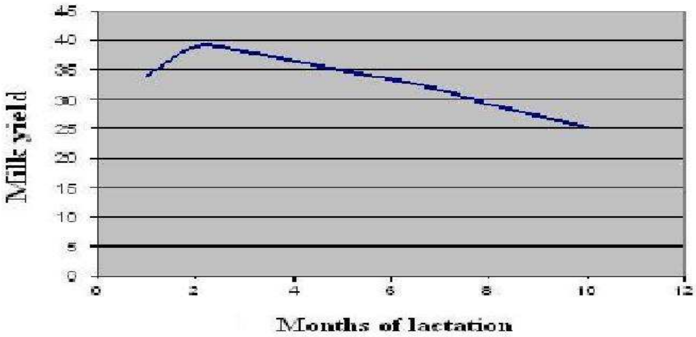

Figure 1 Changes in daily milk yield along the months of lactation

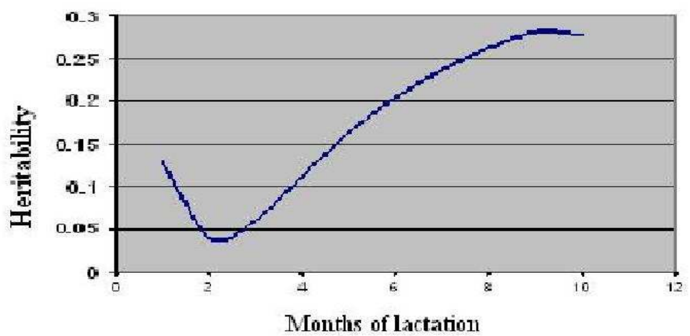

Figure 2 Changes in heritability for daily milk production during lactation months

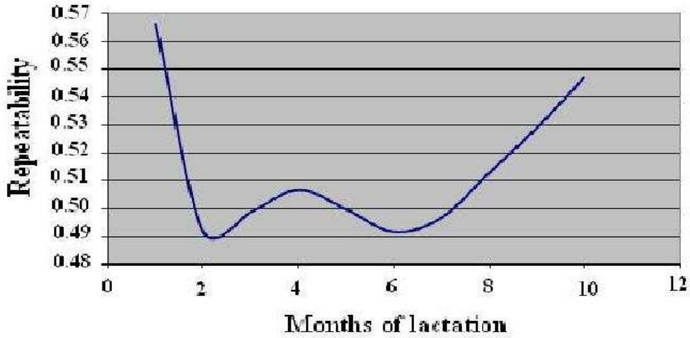

Figure 3 Changes in repeatability for daily milk production during months of lactation

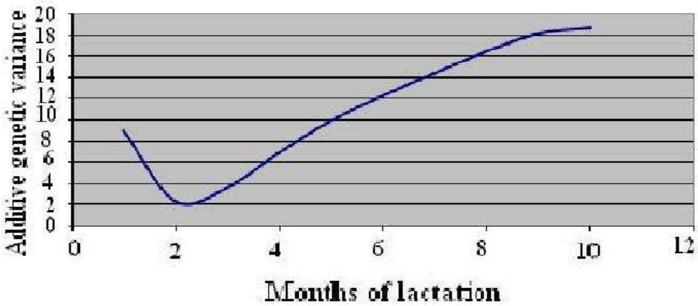

Figure 4 Changes in additive genetic variance for daily milk yield during the months of lactation

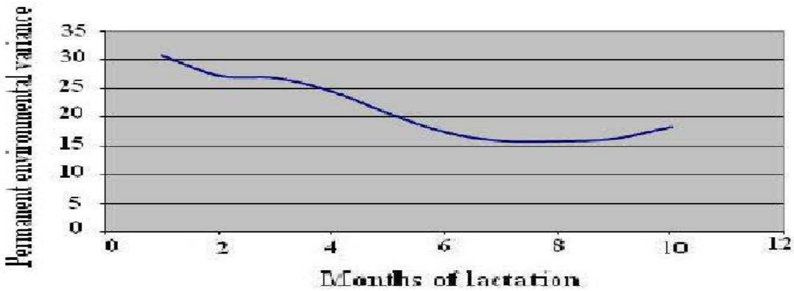

Figure 5 Changes in permanent environmental variance of daily milk production during the months of lactation

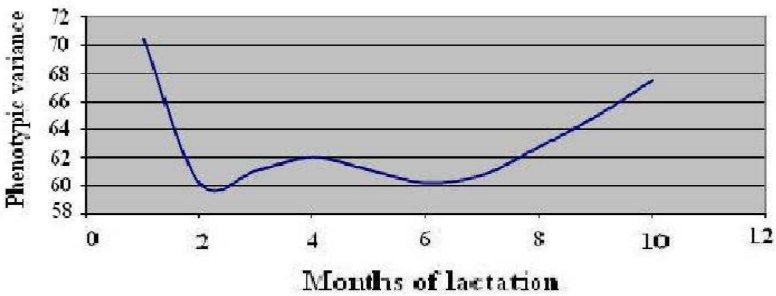

Figure 6 Changes in phenotypic variance of daily milk production during the months of lactation

CONCLUSION

Cows in Mahdasht herd which calved at older age had produced higher daily milk. Cows of this population which calved before the year 2004 produced less daily milk than cows calved after that. The cause of this increase is due to genetic and environmental effects improvement. In general, cows that had parturition in summer produced the least daily milk and winter calving cows had maximum daily milk production. This can caused due to heat stress reduced food intake caused by loss of appetite in summer, compared to suitable conditions and increased food intake in winter.

Higher estimates of heritability for daily milk production occurred in second half of lactation and higher value of repeatability was in the first half of lactation, thus, genetic selection of cows for milk production in the second half of lactation may be associated with more accuracy. The results showed that the genetic correlation estimate between records of adjacent months was high but with increase in distance between them the genetic correlations reduced. Genetic correlations were generally larger than phenotypic correlations.

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