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Original Research Article

EFFECT OF DIFFERENT MILK PRODUCTION LEVELS ON VARIANCE IN IRANIAN DAIRY CATTLE

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Abstract: In this research, effect of different milk production levels in Holstein dairy cattle in Iran was studied by using collected data from 1991 to 2010. The data set included the following: 161328 records of first, 123369 records of second and 81013 records of third lactations. Records were divided in three categories based on mean herd- year production of low (less than 0.5 SD to mean), medium (between less than 0.5 SD to mean and more than 0.5 SD to mean) and high (more than 0.5 to mean). Bartlett test for heterogeneity of variance components was significant among all subgroups. Genetic parameters and heritabilities were estimated for all production levels in the first three lactations. Additive variance was the highest in high milk yield and residual variance was the highest in high milk yield, but in the high milk yield within the second and third lactations, all variance components were the highest amount. Estimated heritability and variance components for production levels were similar in univariate and multivariate animal model analyses.

Key words: production level, variance, dairy cattle

Introduction: Variance component and genetic parameters are needed for genetic improvement programs to predict the breeding values of candidates for genetic selection, to choose among mating plans and to predict selection response (Montaldo et al., 2012). Knowledge of the type and amount of genetic variation and distribution of animals for traits considered for selection in the population can help design optimum breeding programs (Willham and Pollak, 1985). The accuracy of genetic evaluation and (co) variance components depends on how well the assumptions match the data. An important assumption is the homogeneity of variance components of random factor(s) across all possible stratification of data. Heterogeneity of genetic, permanent environmental and residual variance components have been reported by Deveer (1987). The problem of heterogeneous variance components in genetic evaluation of dairy cattle is that, above average animals may be over evaluated in more variable herds, and as a result, a greater

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proportion of animal would be chosen from these herds. A positive relation between means of production and heritability or variance of the production traits has been reported (Van vleck et al., 1988). Boldman & Freeman (1990) used reported lactation records in the US and showed that genetic, permanent environmental and residual variance increased with production levels. In Iran, the level of production varies across herds, and it is assumed that the variance components are homogeneous across herds and production levels. The objectives of this study were to: 1) study the heterogeneity of variance at production levels, 2) estimate variance components and heritability at different levels of production and 3) logarithmic data transformation to remove heterogeneity of variance.

Material and Methods

Data

In this study, data consisted of 161328 milk production records of first lactation, 123369 milk production records of the second lactation and 81013 milk production records of third lactation (based on 305 day lactation), which were collected during 1983-2004. To estimate genetic parameters at three production levels. Records were divided in to three categories based on mean herd- year production of low (less than 0.5 SD to mean), medium (between less than 0.5 SD to mean and more than 0.5 SD to mean) and high (more than 0.5 to mean). Statistical characterizations of production levels in the first three lactations reported at table 1.

Table 1. Statistical characterization of production levels in the first three lactations

	Production levels	No. of records	Mean (Kg)	Standard Deviation	Standard Error	Coefficient of Variation	Skewness
First lactation	Low	36436	4955.38	1071.47	5.61	21.62	-0.072
	Medium	86792	6250.93	1140.65	3.87	18.25	-0.270
	High	38100	7292.37	1189.07	6.09	16.31	-0.426
Second lactation	Low	24692	5366.34	1226.20	7.80	22.85	0.019
	Medium	72165	6798.7	1365.74	5.08	20.09	-0.019
	High	26512	8067.02	1463.59	8.99	18.14	-0.346
Third lactation	Low	14764	5558.27	1252.24	10.31	22.53	0.047
	Medium	49024	7028.74	1463.42	6.61	20.82	-0.215
	High	17225	8344.22	1563.75	11.91	18.74	-0.399

Data analysis

Bartlett test performed as a pre-test for studying the heterogeneity of variances between mentioned groups. Genetic parameters for three level of milk production were separately estimated by using MATVEC Microsoft and animal model at in each lactation. The model equation was:

$$Y_{ijkl} = \mu + HYS_i + Age_j + a_k + e_{ijkl}$$

Y_{ijkl}*: is* the milk yield; μ: population mean; HYS_i: the effect of ith Herd-Year-Season; Age_j: the effect of jth the age; a_k: effect of kth animal and e_{ijkl} is the residual effect.

Multivariate analysis was performed by this model:

$$\begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \\ e_3 \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix} + \begin{bmatrix} z_1 & 0 & 0 \\ 0 & z_2 & 0 \\ 0 & 0 & z_3 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} x_1 & 0 & 0 \\ 0 & x_2 & 0 \\ 0 & 0 & x_3 \end{bmatrix}$$

y_1, y_2, y_3, are milk yield record in three lactations; x_1, x_2, x_3 , design matrices of fixed effect for each subgroup; z_1, z_2, z_3 , design matrices of random effect; b_1, b_2, b_3, fixed effect

vector for each subgroup; u_1, u_2, u_3, random effect vector for each subgroup and e_1, e_2, e_3, are the residual effect vector for each subgroup.

Results and Discussion

a) Univariate and Multivariate analysis

Variance components and heritability at different milk production levels in the first three lactations were estimated using MATVEC Microsoft by univariate and multivariate animal model. Milk yield at three production levels were assumed as three different traits. The results of three- traits analyses reported at table 2.

Table2. Variance components estimations with univariate (multivariate in parentheses) at the three production levels

	Production levels	σ_a^2	σ_e^2	σ_p^2	h^2 (SE)
First lactation	Low	$289199_{(290555)}$	$864444_{(859224)}$	$1153643_{(1149779)}$	$0.25_{(0.25)}$
	Medium	$314690_{(316845)}$	$854020_{(853005)}$	$1168710_{(1169850)}$	$0.269_{(0.27)}$
	High	$304924_{(305628)}$	$999596_{(999834)}$	$1304520_{(1305462)}$	$0.233_{(0.23)}$
Second lactation	Low	$270487_{(271692)}$	$1120394_{(1100125)}$	$1390881_{(1371817)}$	$0.194_{(0.2)}$
	Medium	$335139_{(340675)}$	$1296880_{(1391749)}$	$1632019_{(1632424)}$	$0.205_{(0.21)}$
	High	$401356_{(399112)}$	$1513367_{(154813)}$	$1914723_{(1957725)}$	$0.194_{(0.20)}$
Third lactation	Low	$275737_{(277015)}$	$1597430_{(1578592)}$	$1873167_{(1855607)}$	$0.147_{(0.15)}$
	Medium	$282175_{(289978)}$	$1608330_{(1601945)}$	$1890505_{(1891923)}$	$0.149_{(0.15)}$
	High	$350381_{(349745)}$	$1906430_{(1907756)}$	$2256811_{(2257501)}$	$0.147_{(0.15)}$

Results showed that the additive variance is the largest in medium production level and residual variance is the largest in high production level but all variance components are the largest in high production level, indicating that there is the heterogeneity of variance in the first lactation. Heritability is the lowest in high production level and is the highest in medium production level but in the second and third lactations, is the highest in high production level which the derived results of the first lactation are consistent with the results of Sadeghi et al (2004). Also, heritability estimates are the highest in the first lactation and the heritability estimate of the second lactation is higher than of the third lactation. Most of the study shows the positive relationship between mean production with heritability and variance components and some researchers reported the low relationship between them. In current study, there is a positive relationship between mean production with variance components and heritability in the second and third lactations, heritability estimates and variance components of high production level are the highest in the second and third lactations. Also, mean production at high production level is higher in the first lactation which has a positive relationship with residual and phenotypic variances and has any relationship with heritability and additive variance. Also, herd management is an effective factor on milk yield and mean production is high in the herds with better management. Nikolaou et al (2004) reported that the heritability estimates increase in higher level of milk production which is consistent with the results of Carriedo (1995).

Comparison between results of univariate and multivariate analyses showed that the heritability estimate in three traits analysis is slightly higher than univariate analysis due to increase in the used information but there was

not a significant difference between the variance components of univariate and multivariate analyses.

b) Genetic and phenotypic correlation

Genetic and phenotypic correlations between different level of production have been shown at the figures 3, 4 and 5. The result showed that genetic and phenotypic correlations between the subsequent lactation periods (first- second and second- third) are higher than those of unsubsequent periods (first- third) due to the similarity of physiological conditions of animal in the near lactation period. The higher genetic correlations between lactation periods are due to the use of complete pedigree and familial relationship.

Table 3. Phenotypic and genetic correlation of milk yield at high production level

	First lactation	Second lactation	Third lactation
First lactation	0.23	0.55	0.42
Second lactation	0.44	0.21	0.53
Third lactation	0.33	0.94	0.16

Genetic correlations (under diagonal), phenotypic correlations (above diagonal), heritability estimates (on diagonal)

Table 4. Phenotypic and genetic correlation of milk yield at medium production level

	First lactation	Second lactation	Third lactation
First lactation	0.27	0.52	0.40
Second lactation	0.42	0.21	0.49
Third lactation	0.30	0.93	0.15

Genetic correlations (under diagonal), phenotypic correlations (above diagonal), heritability estimates (on diagonal)

Table 5. Phenotypic and genetic correlation of milk yield at low production level

	First lactation	Second lactation	Third lactation
First lactation	0.25	0.66	0.55
Second lactation	0.53	0.19	0.63
Third lactation	0.41	0.96	0.15

Genetic correlations (under diagonal), phenotypic correlations (above diagonal), heritability estimates (on diagonal)

Bartlett test performed as a pre-test for studying the heterogeneity of variances between mentioned groups. Result of this test reported at table 6.

Table 6. Heterogeneity test of variance components of different production levels in the first three lactations

Category	df	Chi-square value	Level of significant (p<0.00001)
Lactation 1	2	406.2	0.0001
Lactation 2	2	797.6	0.0001
Lactation 3	2	792.2	0.0001

Bartlett test was significant among all groups ($p<0.0001$) and indicating the heterogeneity of variance components between three production levels in the first three lactations.

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