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Estimation of genetic and environmental parameters for milk traits in jersey cows

Jersey ineklerinde süt verim özelliklerine ait genetik ve çevresel parametrelerin tahmini

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ABSTRACT

The aim of this study was to estimate the genetic parameters and environmental factors for test day milk yield (TDMY), lactation milk yield (LMY), 305-day milk yield (305-DMY), milk fat percentage (FP) and milk protein percentage (PP) of Jersey cows raised on Karaköy Agricultural State Farm in Samsun province of Turkey. The data were obtained from 279 milk yield records of 170 heads cows calved from 2011 to 2013 years. Parity, calving season and calving year were considered as fixed effects. Heritability, additive genetic variance and phenotypic variance were estimated by multiple trait derivative free restricted maximum likelihood (MTDFREML) with the animal model. Variance analysis results showed that except for FP, the effects of parity and calving year on TDMY, LMY, 305-DMY and PP were significantly important ($P<0.05$). However, calving season did not affect TDMY, LMY, 305-DMY, FP and PP ($P>0.05$). Heritability estimates for TDMY, LMY, 305-DMY, FP and PP were 0.38, 0.30, 0.28, 0.19, and 0.36, respectively. Repeatability for TDMY, LMY, 305-DMY, FP and PP were ranged from 0.35 to 0.45. The results indicate that these traits can be used as a selection criteria in genetic improvement of Jersey cattle this herd.

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***Anahtar Kelimeler*:**

Süt verimi
Yağ oranı
Protein oranı
Kalıtım derecesi
Tekrarlama derecesi

ÖZ

Bu çalışmanın amacı, Türkiye'nin Samsun ilinde bulunan Karaköy Tarım İşletmesi'nde yetiştirilen Jersey ineklerinin test günü süt verimi (TGSV), laktasyon süt verimi (LSV), 305-gün süt verimi (305-GSV), süt yağ oranı (YO) ve süt protein oranı (PO) için genetik parametre ve çevresel faktörleri tahmin etmektir. Veriler, 2011 ve 2013 yılları arasında buzağılamış 170 baş ineğin 279 süt verim kaydından elde edilmiştir. Laktasyon sırası, buzağılama mevsimi ve buzağılama yılı sabit faktörler olarak dikkate alınmıştır. Kalıtım derecesi, eklemeli genetik varyans ve fenotipik varyans, bireysel hayvan modelinde MTDFREML ile tahmin edilmiştir. Varyans analiz sonuçları, YO hariç, TGSV, LSV, 305-GSV, YO ve PO üzerine laktasyon sırası ve buzağılama yılının etkilerinin istatistiksel olarak önemli olduğunu göstermiştir ($P<0.05$). Ancak, buzağılama mevsimi TGSV, LSV, 305-GSV, YO ve PO'nı etkilememiştir. TGSV, LSV, 305-GSV, YO ve PO için kalıtım dereceleri sırasıyla 0.38, 0.30, 0.28, 0.19 ve 0.36 olarak tahmin edilmiştir. TGSV, LSV, 305-GSV, YO ve PO için tekrarlama dereceleri ise 0.35 ile 0.45 arasındadır. Sonuçlar, bu özelliklerin bu sürüde Jersey sığırların genetik olarak iyileştirilmesinde bir seleksiyon kriterleri olarak kullanılabileceğini göstermektedir.

1. Introduction

Milk yield is the most important parameter for selection programs in dairy cattle (Sahin et al. 2012). In many countries, milk production records have been used for earlier selection decision and genetic evaluation of dairy cattle (Pelmus et al. 2017). Milk composition as well as milk yield are also very important quantitative traits for genetic selection (Erfani-Asl et al. 2015).

Under control of multiple genes, milk yield and milk composition traits are economically important traits affecting profitability in dairy cattle (Erfani-Asl et al. 2015) and these traits can be adopted as a selection criteria (Buttchereit et al. 2011). The availability of reliable genetic parameter estimates are very important for the genetic improvement according to future milk yield and milk quality through the selection of dairy cattle (Aspilcueta-Borquis et al. 2010). Therefore, it is necessary to improve the genetic quality to provide more permanent effect on productivity to increase animal productivity through selection.

Production differences are the functions of both genotypic and phenotypic differences between cows (Sargeant et al. 1998). Phenotypic and genetic parameters for production traits are essential population parameters required in animal husbandry (Erfani-Asl et al. 2015). Genetic parameters such as heritability and repeatability may change due to selection and management decisions, because estimate of those parameters are essential in design and application of practical animal breeding programs (Missanjo et al. 2013).

Heritability explains the extent to which observed differences between individuals are associated with additive genetic variance (Unalan and Cankaya 2010). Repeatability explains how a production trait or parameter measured, keeps a constant value in following measurements in the future (Cilek and Sahin 2009). To increase profitability and production, it is important to select and use genetically superior animals. For this purpose, it is necessary to choose the best parental sire and dam according to the classical phenotypic and pedigree records. In selection studies, the effect of genetic factors on milk yield significantly increased with the help of quantitative genetic methods such as BLUP (Best Linear Unbiased Prediction) which were widely used in predicting breeding value (Roman et al. 2000; Javed et al. 2003; Unalan and Cankaya 2010; Sahin et al. 2012).

Jersey cows are the main pure dairy breed raised in the Black Sea region of Turkey. This region is quite suitable for Jersey cattle in terms of climatic characteristics and geographical structure (Erdem et al. 2010). To date, breeding studies were conducted on the characteristics of milk yield of Jersey cows (Lofgren et al. 1985; Roman et al. 2000; Sahin et al. 2012). A sufficient and comprehensive study on the milk characteristics of Jersey has not been established in Turkey. Therefore, how these efforts affected the productivity of Jersey has not been fully understood. The aim of this study was to identify the important causes of variation in milk production and milk composition and to estimate the genetic and pheno-typic parameters for test day milk yield (TDMY), lactation milk yield (LMY), 305-day milk yield (305-DMY), milk fat percentage (FP) and milk protein percentage (PP) of Jersey.

2. Materials and Methods

TDMY records and milk samples of Jersey cows were obtained by monthly during the period from 2011 to 2013 on Karaköy Agricultural State Farm located in Samsun province, Turkey. A total of 279 lactation records from 170 heads cows obtained from 157 dam and 33 sire were analyzed in the present study.

The studied traits were TDMY, 305-DMY, fat content, protein content, fat yield and protein yield. All cows were milked twice a day at 12 hours interval, housed in free stalls, and fed a TMR twice a day. TDMY from individual cows were collected and recorded monthly from fully automated computerized milking system by taking the mean of morning and evening milking. Milk yields were adjusted to 305-day lactation length by adjustment factors (Akman 1998). Calving interval less than 310 days and greater than 650 days were considered abnormal and deleted from the data set. Lactation length was between 150 and 400 days. Lactations with fewer than 5 test day records were discarded.

Milk samples for each cow were obtained monthly. The raw milk samples were immediately transported to the laboratory and stored at 4 ºC in freezer. During the study, the milk fat and protein content were determined with a LactoFlash (Funke Gerber) ultrasonic milk analyzer. The animals in the experiment were grouped according to the parity (1, 2, 3, 4 and ≥5), the year of calving (from 2011 to 2013) and calving season (spring, summer, autumn and winter).

Genetic parameters and breeding values for milk yield and components were estimated using an animal model. For this purpose, the data were analyzed by restricted error maximum likelihood (REML) fitting an animal model using the MTDFREML (multi trait derivative free restricted error maximum likelihood) program (Boldman et al. 1995). The model included random effects of animal, sire and dam and the permanent environmental effect of the animal. The model included three *fixed effects:* parity, calving year and calving season.

The model used to examine the effect of environmental factors is given below:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + b\left(X_{ijkl} - \bar{X}\right) + e_{ijkl}$$

where Y_{ijkl} is the observation value of the trait, μ is the population average, α_i is the effect of the ith parity (i: 1-≥5), βj is the effect of the jth calving year (j: 2011-2013), γ_k: is the effect of the kth calving season (k: autumn, winter, spring and summer), b is the constant regression coefficient for lactation length (except 305-DMY), X_{ijkl} is the lth record of the cow, ith parity, jth calving year and kth calving season, $\overline{X}$ is the lactation length and e_{ijkl} is the random error.

The model used for estimating the variance components and breeding values is given below:

$$Y_{ijklmn} = F_{ijkl} + a_m + p_n + e_{ijklmn}$$

where Y_{ijklmn} is the observed value for the trait, F_{ijkl} is the constant environmental factors, a_m is the additive gene effects of the mth animal, p_n is the permanent environmental effect of the nth animal and e_{ijklmn} is the error.

The estimates of heritability (h^2) were obtained by:

$$h^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_{pe}^2 + \sigma_e^2}$$

where h^2 is the heritability, σ_a^2 is the additive genetic variance, σ_{pe}^2 is the permanent environmental variance and σ_e^2 is the residual variance.

Repeatability (r) were calculated for lactation milk yield (LMY), test day milk yield, 305-DMY and milk components (fat and protein) using the following equation (Meyer et al. 1990):

$$r = \frac{\sigma_a^2 + \sigma_{pe}^2}{\sigma_a^2 + \sigma_{pe}^2 + \sigma_e^2}$$

where r is the repeatability, σ_a^2 is the additive genetic variance, σ_{pe}^2 is the permanent environmental variance and σ_e^2 is the residual variance.

Data were analyzed by SPSS statistical software program (SPSS, Version 13.0) to investigate the effects of some fixed factors on milk traits (SPSS 2004). The statistically significant factor averages were compared according to the Tukey Multiple Comparison Test (P<0.05).

3. Results and Discussion

As seen in Table 1, LMY (P= 0.011), TDMY (P= 0.009), 305-DMY (P= 0.001) and PP (P= 0.047) were affected by parity. Similar conclusions were reached by Erdem et al. (2010), who found that the effect of parity on milk yield was statistically important. The lowest TDMY was determined in the first parity in this study (P= 0.011). LMY was the highest in the third parity and decreased linearly with following lactations (P= 0.009). The highest 305-DMY was found in the second parity, and the lowest in the first parity (P= 0.001).

Increasing TDMY with later parity could be explained by advancing ages of the cows (Erdem et al. 2010). On the other hand, FP was not affected by parity. This finding is similar with the result of Gurmesa and Melaku (2012). PP was the highest in the first parity than other parities. Similar conclusions were displayed by Cinar et al. (2015). In general, the milk components decreased with increasing TDMY. In addition, the correction coefficients (b) were found to be important for all properties except 305-DMY.

In this study, LMY, TDMY, 305-DMY, FP and PP were not affected by calving seasons (Table 2). Differently, Yoon et al. (2004) revealed that cows calving in spring and winter produced more milk than cows calving in summer. El-Tahawy and El-Far (2010) reported that milk yield was the highest in autumn and winter compared to those of spring and summer. These findings for milk components were different from the reports of Pavel and Gaval (2011). They showed that the lowest FP and PP were obtained in summer. Gencurova and Hanu (1997) reported on the highest milk FP in winter that diminished in spring. Seasonal variation in milk yield and composition in different studies could be assumed as an expected case due to climatic and regional differences (Atasever and Stádník 2015).

Effects of calving year on TDMY (P=0.008), LMY (P= 0.021), 305-DMY, FP and PP (P<0.001) were statistically significant (Table 3). LMY and 305-DMY were the lowest in 2013, but the highest in 2011 and 2013. However, the highest TDMY was determined in 2012 and 2013 compared to that of 2011. FP and PP were found to be higher in 2011 compared to other calving years.

Genetic parameter estimates for LMY, 305-DMY, TDMY, FP and PP are given in Table 4. The heritability estimates obtained for DMY (0.38), LMY (0.30), and 305-DMY (0.28) in Jersey cows were in a good agreement with the results of Ulutas et al. (2008) and Missanjo et al. (2013). Research results were higher than the results reported by Cole and Null (2009) in Jersey cows. In contrast to present estimation, the heritability estimates were lower than the results showed in Holstein cows by various researchers (Şahin and Ulutaş 2010; Sahin et al. 2012). The obtained heritability value for FP (0.19) was approximately compatible with previous result of Cole and Null (2009), but was lower than the estimates from the literature (Maiwashe et al. 2008; Missanjo et al. 2013) in Jersey. The heritability for PP obtained in this study for Jersey was estimated to be 0.36, which was higher than results of Cole and Null (2009). However, this result was lower than the findings of Missanjo et al. (2013) and Maiwashe et al. (2008) who reported 0.53 and 0.44, respectively.

Repeatability for TDMY, LMY, 305-DMY, FP and PP were ranged from 0.35 to 0.45 (Table 4). The high heritability and repeatability indicated that these traits were largely affected by genetic factors (Cole and Null 2009) and lead to high selection accuracy (Rahayu et al. 2015). Rahayu et al. (2015) stressed that low heritable: <0.15, moderately heritable: 0.15 to 0.30 and highly heritable: >0.30. Except for FP, milk yield (DMY, LMY and 305-DMY) and PP in this study had high heritability and repeatability.

4. Conclusions

Effects of parity and calving year on milk yield and milk components were found to be generally significant (P<0.05). However, milk yield and milk components were not affected by calving seasons. High heritability and repeatability for milk traits were also determined. The results indicate that these traits can be used as a selection criteria in genetic improvement of Jersey cattle this herd.

Table 1. Descriptive statistics of test day milk yield, lactation milk yield, 305-day milk yield, fat percentage and protein percentage for different parities.

Parity	n	TDMY (kg)	LMY (kg)	305-DMY (kg)	FP (%)	PP (%)
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
1	31	13.6±2.70b	5065.3±1441.51a	4661.3±1285.23c	5.28±0.748	3.48±0.176a
2	54	16.1±2.80a	5204.3±1166.99a	5540.5±1282.74a	5.09±0.583	3.41±0.179b
3	45	16.2±3.17a	5221.7±1573.01a	5227.5±145.68ab	5.06±0.619	3.39±0.174bc
4	52	16.3±3.29a	4847.7±1650.53ab	4887.3±974.65bc	4.89±0.546	3.33±0.147c
≥5	97	15.7±3.41a	4397.3±1733.88b	4832.2±173.58bc	4.94±0.634	3.37±0.158bc
P		0.011	0.009	0.001	0.353	0.047
b		-0.005 (P= 0.023)	13.967 (P<0.001)	-	0.001 (P= 0.045)	<0.001 (P= 0.045)

a, b, c: Different letters on the same column indicate statistically significant differences (P<0.05).
b: Correction coefficients, P: Significance.
TDMY: test day milk yield, LMY: lactation milk yield, 305-DMY: 305-day milk yield, FP: fat percentage, PP: protein percentage.

Table 2. Descriptive statistics of test day milk yield, lactation milk yield, 305-day milk yield, fat percentage and protein percentage for different calving seasons.

Calving season	n	TDMY (kg)	LMY (kg)	305-DMY (kg)	FP (%)	PP (%)
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Autumn	31	15.9±4.62	4863.5±2129.90	4970.4±1371.43	4.87±0.517	3.40±0.168
Winter	53	15.9±2.75	5351.4±1534.98	5183.2±1079.49	4.89±0.562	3.38±0.162
Spring	87	16.0±2.99	4874.4±1543.36	5023.8±1053.08	5.03±0.610	3.39±0.189
Summer	108	15.5±3.22	4566.5±1433.13	4962.2±1317.77	5.11±0.688	3.38±0.158
P		0.714	0.714	0.668	0.668	0.696
b		-0.005 (P= 0.023)	-0.005 (P= 0.023)	-	-	<0.001 (P= 0.045)

b: Correction coefficients, P: Significance.
TDMY: test day milk yield, LMY: lactation milk yield, 305-DMY: 305-day milk yield, FP: fat percentage, PP: protein percentage.

Table 3. Descriptive statistics of test day milk yield, lactation milk yield, 305-day milk yield, fat percentage and protein percentage for different calving years.

Calving year	n	TDMY (kg)	LMY (kg)	305-DMY (kg)	FP (%)	PP (%)
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
2011	94	14.5±2.96b	5197.4±1367.73a	5038.6±1295.64a	5.35±0.689a	3.45±0.203a
2012	106	16.2±3.13a	5196.3±1770.94a	5328.1±1184.14a	4.92±0.577b	3.33±0.164c
2013	79	16.7±3.29a	3953.0±1210.12b	4599.6±965.04b	4.74±0.406c	3.40±0.089b
P		0.008	0.021	<0.001	<0.001	<0.001
b		-0.005 (P= 0.023)	13.967 (P<0.001)	-	0.001 (P= 0.045)	<0.001 (P=0.045)

a, b, c: Different letters on the same column indicate statistically significant differences (P<0.05).
b: Correction coefficients, P: Significance.
TDMY: test day milk yield, LMY: lactation milk yield, 305-DMY: 305-day milk yield, FP: fat percentage, PP: protein percentage.

Table 4. Estimates of genetic parameters for milk yield and milk components.

Variance Components	TDMY (kg)	LMY (kg)	305-DMY (kg)	FP (%)	PP (%)
Additive Genetic Variance (σ^2_a)	3.603	294001	427660	0.063	0.0095
Permanent Environmental Variance (σ^2_c)	0.730	97125	116397	0.081	0.001
Residual Variance (σ^2_e)	5.268	578771	1007702	0.181	0.0158
Phenotypic Variance (σ^2_p)	9.601	969897	1551759	0.325	0.0263
Heritability (h^2)	0.38 (0.189)	0.30 (<0.001)	0.28 (<0.001)	0.19 (0.187)	0.36 (<0.001)
Uncorrelated random effect (c^2)	0.07 (0.018)	0.10 (<0.001)	0.07 (<0.001)	0.25 (0.191)	0.04 (<0.001)
Repeatability (*r*)	0.45 (0.059)	0.40 (0.063)	0.35 (0.066)	0.44 (0.060)	0.40 (0.063)
Residual Error (e^2)	0.55 (0.081)	0.60 (<0.001)	0.65 (<0.001)	0.56 (0.079)	0.60 (<0.001)

TDMY: test day milk yield, LMY: lactation milk yield, 305-DMY: 305-day milk yield, FP: fat percentage, PP: protein percentage, In parentheses: Standart Error.

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