Kafkas Univ Vet Fak Derg
16 (6): 995-1000, 2010
DOI:10.9775/kvfd.2010.2204

RESEARCH ARTICLE

Genetic Parameters and Correlations for Lactation Milk Yields According to Lactation Numbers in Jersey Cows [1]

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[1] *This study was supported by The Scientific and Technological Research Council of Turkey (TÜBİTAK) (Project no: TOVAG-107 O 338)*

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Makale Kodu (Article Code): KVFD-2010-2204

Summary

In this study, heritabilities, genetic and phenotypic correlations for lactation milk yields were estimated using 3630 305-day lactation milk yield records obtained from cows calved from 1984 to 2007 years in Jersey cattle herd of Karaköy Agricultural State Farm in Samsun. Calving year, calving month and lactation number were assumed as fixed effect factors in statistical analysis of data. Heritabilities, genetic and phenotypic correlations were estimated by derivative-free REML with the animal model. Analysis showed that the overall means of 305-day milk yield, lactation length, dry off period and calving interval were 3467 kg, 297 days, 70 days and 367 days, respectively. Variance analysis results showed that all of the fixed effect factors were statistically significant on lactation milk yields (P<0.001). REML estimates of heritability were 0.289, 0.319, 0.324, 0.331, 0.339, 0.357 and 0.379 for lactation milk yields (from the first to seventh lactation numbers, respectively). Genetic correlations among the first and sub-sequent lactation milk yields were 0.687, 0.676, 0.631, 0.601, 0.590 and 0.551, respectively. All genetic correlations were high and statistically significant (P<0.01). High genetic correlations among lactation numbers reflected that the first lactation milk yield of cows would be useful indicator for the sub-sequent lactations and selection of breeding stock.

Keywords: *Jersey, Milk yield, Parity, REML, Heritability, Correlation*

Jersey İneklerde Laktasyon Sıralarına Göre Laktasyon Süt Verimleri İçin Genetik Parametreler ve Korelasyonlar

Özet

Bu çalışmada, Karaköy Tarım İşletmesi Jersey sığır sürüsünde 1984-2007 yılları arasında doğum yapmış inekten elde edilen 3630 adet 305 günlük süt verim kayıtları kullanılmış ve süt verimlerine ait kalıtım dereceleri ile laktasyon sıraları arasındaki genetik ve fenotipik korelasyonlar tahmin edilmiştir. Verilerin istatistik analizinde, buzağılama yılı, buzağılama ayı ve laktasyon sırası sabit etkili faktörler olarak alınmıştır. Kalıtım dereceleri ile genetik ve fenotipik korelasyonlar hayvan modeli altında derivative-free REML yöntemi kullanılarak tahmin edilmiştir. Analizler, 305-günlük süt verimi, laktasyon süresi, kuruda kalma süresi ve buzağılama aralığı ortalamalarının sırasıyla 3476 kg, 297 gün, 70 gün ve 367 gün olduğunu göstermiştir. Varyans analizi sonuçları, ele alınan tüm sabit etkili faktörlerin süt verimleri üzerinde istatistiksel olarak önemli olduğunu göstermiştir (P<0.001). Laktasyon sıraları için (1. laktasyondan 7. laktasyona) süt verimlerine ait kalıtım derecelerinin REML tahminleri 0.289, 0.319, 0.324, 0.331, 0.339, 0.357 ve 0.379 olarak bulunmuştur. İlk laktasyon süt verimleri ile takip eden laktasyonlar arasındaki genetik korelasyonlar ise sırasıyla 0.687, 0.676, 0.631, 0.601, 0.590 ve 0.551 olarak bulunmuştur. Genetik korelasyonların tümü yüksek ve istatistiksel olarak önemli çıkmıştır (P<0.01). Laktasyon sıraları arasındaki yüksek genetik korelasyonlar, ineklerin ilk laktasyon süt verimlerinin sonraki laktasyon verimleri için önemli bir gösterge olduğunu, böylece damızlık seçiminde ilk laktasyon süt verimlerinin kullanılabileceğini göstermiştir.

Anahtar sözcükler: *Jersey, Süt verimi, Laktasyon sırası, REML, Kalıtım derecesi, Korelasyon*

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INTRODUCTION

Knowledge of genetic parameters is required for planning efficient breeding programs in animal husbandry. One of the main genetic parameter is heritability. Heritability explains the extent to which observed differences between individuals are associated with additive genetic variance. Knowledge of heritability provides that a particular trait can be improved by selection, by improvements of management practise, or both [1].

Today, multi-trait analysis are generally used in animal breeding studies for the selection of stock. In addition, using such kind of analysis has a great deal of importance to provide reliable, unbiased and fast results concerning with estimation of genetic parameter, genetic and phenotypic correlations among the traits. The main utility of multi-trait analysis in the selection programs is to obtain some useful information for indirect selection [2]. The efficiency of indirect selection is related to the heritability of the trait and to the genetic correlation between traits. If genetic correlations between the traits are high enough, selection of the stock can be made easily and early measured trait using indirect selection. Therefore, both generation interval and financial cost in the herd can be reduced considerable [2,3].

Holstein cattle are commonly reared for the milk production in Turkey as many dairy cattle farms all over the world [4]. However some problems (management, nutrition and production etc.) related to keeping of this breed in non intensive farming systems, especially in high and mountainous regions which may be occurred. Therefore, the other cattle breeds are preferred by farmers in the different region of Turkey. For example, Jersey cattle have been reared especially in the middle and eastern of Black Sea region in Turkey since 1958. This breed is already used for the aim of both pure-breeding and crossbreeding, realized with the local breeds by the cattle farmers. Today, approximately 150.000 heads of pure-bred Jersey cattle and 750.000 heads of crossbred (Native x Jersey) cattle are avaliable in the region. This breed was well adopted to the climatical conditions and rural characterictics of the region. For this reason, most cattle breeders in this region prefer Jersey instead of the other dairy cattle breeds for milk production.

Jersey cattle have been also reared in Karaköy Agricultural State Farm in Samsun (Turkey). Besides, this is only farm which keeps on Jersey cattle herd among the State Farms of Turkey. For this reason, this herd can be assumed as a main source for the breeding stock of Jersey cattle breeders in the region.

Although Jersey cattle have been commonly reared for the milk production in the middle and eastern of Black Sea region of Turkey, the number of comprehensive studies on this breed in order to determine lactation parameters (actual and 305-day milk yield, calving age, calving interval, lactation length, dry off period, estimation of genetic parameters for and correlations among lactation numbers etc.) and the effects of some environmental factors on milk yield (calving year and season, lactation number etc.) are not adequate enough. For example, in the recent particular studies on Jersey cattle, some topics such as seasonal changes in milk yield and reproductive performance [5], estimation of variance components of milk yields [6], and relationships between udder traits and milk production [7] were investigated. But, especially genetic and phenotypic correlations among lactation numbers for milk yields were not reported in the previous studies. Therefore, the objectives of this study are to determine lactation parameters, effects of some environmental factors on milk yields, and to estimate heritability and genetic and phenotypic correlations among 305-day milk yields of cows calved from 1984 to 2007 years (over 24 years) according to lactation numbers in Jersey cattle herd of Karaköy Agricultural State Farm in Samsun.

MATERIAL and METHODS

The data used, obtained from Jersey cattle herd of Karaköy Agricultural State Farm in Samsun, located in the middle Black Sea region of Turkey. Data consisted of total 3630 305-day lactation milk yield records (911 first, 771 second, 637 third, 515 fourth, 397 fifth, 261 sixth and 138 seventh lactation records) of Jersey calved from 1984 to 2007 years (over 24 years).

All cows were kept in semi open barn units and were fed total mixed ration (TMR) composed of concentrate feed, silage and hay according to their milk yields. Cows were milked two times a day (in morning and in evening) and test day milk yields were recorded monthly (in the last day of every month) in the herd. Paper based recording system (in charts) was used for lactation records of animals in the farm.

After the collection of data, all required lactation parameters (actual and 305-day milk yields, lactation lengths, dry off periods etc.) of milking cows were computed by HerdGuide-Turk software developed by Ünalan [8].

Computation of Lactations Parameters

Firstly, all test day milk yield records and the other related lactation records of milking cows were transferred

into the software. Then all of the lactation parameters for each cow (lactation number, actual milk yield, 305 -day milk yield, lactation length, calving year and month etc.) were computed by the software. The software was developed to compute the milk yields of cows according to the milk yield calculation method given by ICAR (International Committee for Animal Recording). After the evaluation of data, cows had below 150 day lactation lengths which were discarded from data set and then 305-day milk yield records were used in the analysis.

Statistical Analysis

The data was analyzed with the following linear model in SPSS 12.0 statistical program. General Linear Model (GLM) procedure was performed for the least squares analysis of variance. Calving year, calving month and lactation number were considered as main fixed effect factors in the model.

$$Y_{ijkl} = \mu + CY_i + CM_j + LN_k + e_{ijkl}$$

where:

Y_{ijkl} 305-day milk yield of l^{th} cow,
μ the overall mean,
CY_i i^{th} calving year effect (i = 1, ..., 24),
CM_j j^{th} calving month effect (j = 1,...,12),
LN_k k^{th} lactation number effect (k = 1,...,7),
e_{ijkl} random error

Estimation of Genetic Parameters and Correlations

Heritabilities, genetic and phenotypic correlations for 305-day lactation milk yields were estimated using DXMUX sub-program that was developed in order to perform multi-trait analysis in DFREML Ver. 3.0 β program [9]. Animal model (AM) given below was used for the estimation of heritabilities, genetic and phenotypic correlations.

$$Y_{tijkl} = \mu_t + CY_{it} + CM_{jt} + a_{kt} + e_{ijkl}$$

where:

Y_{tijkl} 305-day milk yield of k^{th} cow for t^{th} lactation number,
μ_t the overall mean for t^{th} lactation number,
CY_{it} i^{th} calving year effect for t^{th} lactation number (i = 1, ..., 24),
CM_{jt} j^{th} calving month effect for t^{th} lactation number (j = 1,...,12),
a_{kt} additive genetic effect of k^{th} cow for t^{th} lactation number
e_{ijkl} random error

RESULTS

Some descriptive statistics related to calving age, lactation length and dry off period according to lactation numbers are given in *Table 1*.

Table 1 showed that the overall means of calving interval, lactation length and dry off period of milking cows were almost 12 months (367 days), 297 days and 70 days, respectively.

The least square means of 305-day milk yields for each lactation number are given in *Table 2*. This table showed that mean 305-day milk yields of cows were increased continuously with subsequent lactation numbers (from 3254 kg in the first lactation to 3739 kg in seventh lactation) and differences were also statistically significant (P<0.001). In this study, overall means for milk yield was found about 3467 kg.

The trend of mean 305-day milk yields for each calving year is given in *Fig. 1*. This figure indicated that although mean 305-day milk yields fluctuated in some years in the herd, but in general it increased from 2519 kg to 4024 kg between 1984 and 2007 years. In other words, total amount of increase and rate over 24 years were 1505 kg and 60%, respectively; and the mean increase per year was about 65.4 kg. In addition, simple linear regression model for calving

Table 1. *Calving ages, lactation lengths and dry off periods for lactation numbers*
Tablo 1. *Laktasyon sıraları için buzağılama yaşı, laktasyon süresi ve kuruda kalma süreleri*

Lactation Number	n	Calving Age (mth)		Lactation Length (day)		Dry off Period (day)	
		Mean	SE	Mean*	SE	Mean	SE
1	911	28.15	0.20	301.28 ^{a}	1.90	66.22	1.40
2	771	40.23	0.23	296.52 ^{ab}	2.04	71.98	1.88
3	637	52.19	0.27	290.67 ^{b}	2.56	72.65	2.06
4	515	64.60	0.33	300.08 ^{ab}	2.73	69.68	1.84
5	397	76.50	0.42	293.26 ^{ab}	3.27	69.35	2.32
6	261	88.32	0.59	292.72 ^{ab}	3.87	67.48	2.49
7	138	100.56	0.46	299.52 ^{ab}	6.72	-	-
Overall	3630	52.72	0.37	296.68	1.02	69.65	0.80
Probability		-		0.017		0.070	

** Means with different letters within column are significant (P<0.05)*

year (X) on mean 305-day milk yield (Y) was also estimated as Y = 2693.1 + 51.36X (P<0.001)(R^2 = 0.738). This equation showed that phenotypic trend for mean 305-day milk yield was nearly 51.4 kg/year in the herd. Residual distributions of the regression model was given in *Fig. 2*.

Table 2. *The least square means of 305-day milk yields for lactation numbers*

Tablo 2. *Laktasyon sıraları için 305-günlük süt verimleri ortalaması*

Lactation Number	n	305-Day Milk Yield (kg)				
		Min.	Max.	CV (%)	Mean*	SE
1	911	1158	5882	22.2	3253.58 ^{c}	23.95
2	771	793	5760	24.9	3344.84 ^{c}	30.04
3	637	1024	6571	27.2	3530.15 ^{b}	38.10
4	515	1102	6988	26.1	3617.80 ^{ab}	41.61
5	397	867	6021	27.8	3662.40 ^{a}	51.03
6	261	1212	6152	26.4	3678.30 ^{a}	60.01
7	138	1126	6260	27.8	3739.41 ^{a}	88.47
Overall	3630	793	6988	26.1	3466.89	14.10
Probability			-		P<0.001	

** Means with different letters within column are significant*

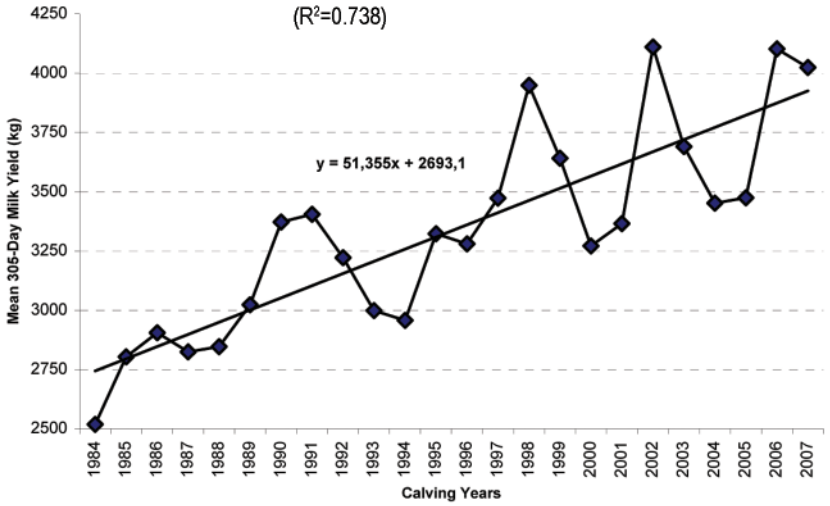

Fig 1. Mean 305-day milk yields of Jersey cows for calving years

Şekil 1. Buzağılama yılları için Jersey ineklerin 305-günlük süt verimleri ortalaması

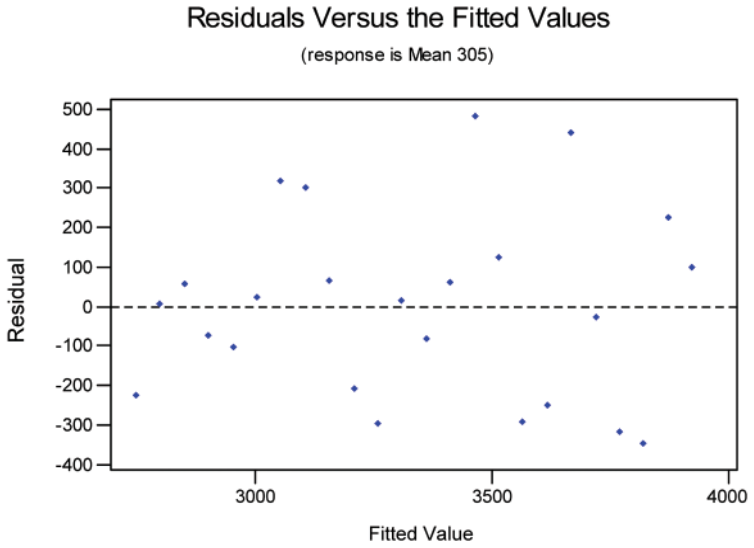

Fig 2. Residual distributions of the simple linear regression model

Şekil 2. Basit doğrusal regresyon modeline ait hata dağılışları

The means of 305-day milk yields according to calving months are given in *Table 3*. It was shown that there were statistically significant differences among mean 305-day milk yields according to calving months (P<0.001). While the highest mean milk yield was recorded in January, the lowest mean milk yield was obtained in July. These results showed once again that cows calved in winter and spring season yielded higher milk amount than cows calved in summer season.

Heritabilities, genetic and phenotypic correlations for lactation numbers are given in *Table 4*. Heritability estimates were found as 0.289, 0.319, 0.324 0.331, 0.339, 0.357 and 0.379 for lactation milk yields (from the first to seventh lactation numbers, respectively).

In this study, genetic correlations among the lactation numbers varied from 0.554 to 0.995. Genetic correlations between the first and subsequent lactation milk yields were 0.687, 0.676, 0.631, 0.601, 0.590 and 0.551, respectively. All genetic correlations were high and statistically significant (P<0.01). Also, the highest genetic correlation was between sixth and seventh lactation milk yields with 0.995.

DISCUSSION

In this study the means of calving interval, lactation length and dry off period of Jersey cows were found as 367 days, 297 days and 70 days, respectively. These results were very closed to the ideal values for the profitable dairy cattle breeding. In some previous studies on Jersey cattle, the means of calving intervals were informed as 369 days [6], as 387-411 days [10], as 411-425 days [11] and as 410 days [12]. While only one of the previously reported result [6] was similar to the result obtained from this study, the other reported results were also larger. However, the mean lactation length (297 days) was also similar to the informed previously as 302 days [6] and as 299 days [11], but it was lower than reported as 320 days [7].

Table 3. *The least square means of 305-day milk yields for calving months*
Tablo 3. *Buzağılama ayları için 305-günlük süt verimleri ortalaması*

Calving Months	n	305-Day Milk Yield (kg)				
		Min.	Max.	CV (%)	Mean*	SE
Jan.	362	1300	6571	22.5	3595.98 ^{ab}	42.48
Feb.	325	1163	6167	24.6	3689.65 ^{a}	50.25
Mar.	331	835	6020	23.0	3558.79 ^{abc}	44.89
Apr.	323	867	6152	28.0	3448.04 ^{cd}	53.73
May	315	1442	5956	24.5	3491.42 ^{bcd}	48.18
June	284	1238	5721	25.1	3425.18 ^{cd}	50.99
July	291	1138	6076	27.5	3193.50 ^{f}	51.55
Aug.	265	1102	6224	27.9	3258.62 ^{ef}	55.94
Sept.	207	793	5905	28.1	3367.83 ^{de}	65.76
Oct.	251	1218	6056	27.2	3384.39 ^{de}	58.21
Nov.	309	1126	6242	26.9	3351.61 ^{de}	51.38
Dec.	367	811	6988	25.9	3663.72 ^{a}	49.59
Overall	3630	793	6988	26.1	3466.89	15.00
Probability			-		P<0.001	

** Means with different letters within column are significant*

Table 4. *Heritabilities, genetic and phenotypic correlations for lactation numbers*
Tablo 4. *Laktasyon sıraları için kalıtım dereceleri, genetik ve fenotipik korelasyonlar*

Lac. No	1	2	3	4	5	6	7
1	0.289±0.05	0.687**	0.676**	0.631**	0.601**	0.590**	0.551**
2	0.548**	0.319±0.06	0.752**	0.739**	0.677**	0.645**	0.550**
3	0.525**	0.730**	0.324±0.04	0.770**	0.601**	0.577**	0.544**
4	0.422**	0.548**	0.553**	0.331±0.02	0.886**	0.759**	0.665**
5	0.365**	0.527**	0.544**	0.667**	0.339±0.03	0.906**	0.706**
6	0.224*	0.447**	0.471**	0.508**	0.817**	0.357±0.03	0.995**
7	0.221*	0.403**	0.381**	0.458**	0.620**	0.604**	0.379±0.03

*Heritabilities (± SE) on main diagonal, genetic correlations above diagonal and phenotypic correlations below diagonal * P<0.05 ** P<0.01*

In this study, 305-day lactation milk yields for lactation numbers (from the first to seventh) were found between 3253-3739 kg and the differences were significant (P<0.001). These results were highly lower than the mean milk yields (4800-6211 kg) by parities (from the first to sixth) informed by the previous study [10]. But these differences could depended on genetic and environmental herd differences. The overall mean of 305-day milk yield (3467 kg) in this study was larger than previously reported results as 3096 kg [6] and as 2553 kg [11], but it was similar to the informed result as 3492 kg [7].

In the earlier studies, it was reported that both of Jersey and Holstein breeds, milk yields were highest following calving in the first quarter (Jan. to Mar.) of the year and the lowest following calving in the third quarter (Jul. to Sep.) [10]. In addition, the other previous studies conducted on Jersey cattle, cows calved in December, January and February months they showed higher milk production than cows calved in the other months [5,7,11,13]. The reason of this trend was explained by heat stress depending on high temperature on especially high yielded dairy cows [5] and lack of pasture sources in summer season [14]. On the other hand, some researchers also indicated that excessive temperature and humidity could be reasoned to decrease of milk yield of Jersey cows [5,7,11,13].

It was stated that heritability estimates for lactation milk yields for previous studies on Jersey cattle were 0.26[1], and were between 0.25 and 0.33 [15]. Beside, it was informed that heritability estimates for the first and second lactation milk yield of Jersey cattle were 0.35 and 0.29, respectively [16]. In the other previous study, heritability estimates for the first lactation milk yield of Jersey cattle were reported between 0.38 and 0.48 for four different data set [17]. All of those previously reported results were similar to the heritability estimates (between 0.29 and 0.38 for lactation numbers) obtained from this study.

In conclusion, some non-genetic factors such as calving year, calving month and lactation number were statistically significant on 305-day milk yields of Jersey cows in accord with the results informed previously by many studies. Heritability estimates for milk yields were similar to previously reported results for Jersey cows. In the other side, exclusively for this study, heritability estimates for milk yields related to lactation numbers were increased too with increasing number of parity in Jersey cows. This result could be explained that influences of environmental sources of variation on milk yields of subsequent lactations (from the first to seventh lactation) were decreased relatively.

All genetic correlations among the lactation numbers were also high and statistically significant for milk yields of Jersey cows. High genetic correlations among lactation numbers showed that the first lactation milk yield of cows would provide useful information for the subsequent lactations and selection of cows to breeding stock.

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