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Genetic Analysis for Milk Traits in Different Herds of Holstein Friesian Cattle in Turkey

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Abstract: A total of 5093 lactation records of Holstein Friesian cows sired by 181 bulls kept at five herds in West of Turkey during the period from 1972 to 1987 were used to estimate phenotypic and genetic parameters for 305 day milk yield (305 dMY), lactation period (LP) and days open (DO). In addition, sire transmitting ability for these traits studied were also examined. Least squares analysis of variance showed significant effect of herds, season of calving, year of calving and parity on all traits studied, except the effect of season of calving on lactation period. Including age at calving as a polynomial regression of the second degree in the model yielded significant partial linear and quadratic regression of 305 dMY on age at calving, while the effect of age at calving on LP were not significant. In addition, days open had a significant effect on 305 dMY and LP. Sires within herds and cows within herds within sires were significant effect on most traits studied. Heritability estimates were 0.38 ± 0.06, 0.13 ± 0.03 and 0.007 ± 0.02 for 305 dMY, LP and DO, respectively. All phenotypic and genetic correlations among all traits studied were positive and significant ($P < 0.01$), while, the genetic correlation between 305 dMY and DO was negative. Sires with at least 10 daughters were evaluated by using best linear unbiased prediction (BLUP), sire transmitting ability ranged from -717 to 601 kg for 305 dMY, from -24 to 40 d for LP and from -5 to 6 d for DO. Sires give positive and higher BLUP values for 305 dMY give positive BLUP values for LP and negative BLUP values for DO.

Key words: Genetic, milk, holstein friesian cattle, Turkey

Introduction

Unbiased sire evaluations as well as estimation of the genetic parameters for milk yield require adjustments for the non−genetic factors.

Adjustment of milk records in sire evaluation for age at calving and / or days open has been suggested by (Smith and Legates, 1962; Schaeffer and Henderson, 1972; Khattab *et al.*, 1987; Khalil *et al.*, 1994; Atil, 1999 and Atil and Khattab, 1999).

The objectives of this study are to estimate phenotypic and genetic parameters for 305 day milk yield, lactation period and days open and sire transmitting abilities for these traits in five herds of Holstein Friesian cattle in West of Turkey.

Materials and Methods

Data: Productive and reproductive records of Holstein Friesian raised at five herds in West of Turkey (i.e., Tahirova, Dalaman, Türkgeldi, Sarmisakli and Menemen) were used. Records were begun between 1972 and 1987. A total 5093 lactation records representing 181 sires were used. All normal records of less than 305 day milk length along with those reaching 305 day were included. Cows with less than two records were excluded. Traits included 305 day milk yield, lactation period and days open.

Animals were fed on silage concentrates and Alfalfa all the year. Heifers were inseminated when they reached on an average of 305 kg body weight, while cows were inseminated during the last heat period after 60 days postpartum. Genetic analysis included the sires, which have at least 10 daughters. Artificial insemination (AI) was used.

Analysis: Data were analyzed using Harvey (1987)'s mixed model computer program. The model included the effects of herd, season and year of calving and parity as fixed effects, age of calving and days open are covariates and sire within herd and cow within herd by sire as random effects. Estimates of sires within herds ($\sigma^2_{s:h}$) and cows within herds by sires ($\sigma^2_{c:h*s}$) and reminder (σ^2_e) components of variance and covariance were estimated using the mixed model least squares and maximum likelihood computer program (Harvey, 1987).

Heritability (h^2) was estimated by the paternal half sib methods as

$$h^2 = 4\,\sigma^2_{s:h} / (\sigma^2_{s:h} + \sigma^2_{c:h*s} + \sigma_e^2)$$

Standard error of h^2 was calculated as formula described by Swiger *et al.* (1964). Genetic and phenotypic correlations were calculated as described in Harvey (1987).

Estimating of sire transmitting ability (STA): Sire transmitting abilities for first lactation were calculated using Best Linear Unbiased Prediction (BLUP).

In matrix notation, the mixed model used in the analysis can be written as:

$$Y = Xf + Zs + Wb + e$$

where Y was a vector of observation for each trait, X was a known fixed design matrix, f was an unknown vector of fixed effects representing the mean, herd, season and season of calving, Z was a known design matrix, s was an unobservable vector of random sire effects, W was a vector of covariate variable (independent variable i.e., age at first calving and days open), b was a vector of partial regression of Y on W and e was an unobservable random vector of errors with mean zero and variance-covariance matrix $I\sigma^2_e$.

The mixed model equations (Henderson, 1973) are

$$\begin{vmatrix} X'X & X'Z & X'W \\ Z'X & Z'Z+k & Z'W \\ W'X & W'Z & W'W \end{vmatrix} * \begin{vmatrix} f \\ s \\ b \end{vmatrix} = \begin{vmatrix} X'Y \\ Z'Y \\ W'Y \end{vmatrix}$$

where $k = (4 - h^2/h^2)$, for each trait was added to the diagonal of sire effects in the matrix.

Results and Discussion

Means: Least squares means for different traits studied are presented in Table 1. Means for 305 dMY and LP are 4606

± 175 kg and 301 ± 5 d, respectively. The present means of 305 dMY and LP are lower than those found by Yener *et al.* (1994), Atay *et al.* (1995) and Bakir and Sogut (1999) using another herds of Holstein Friesian cattle in Turkey, being 6777 kg, 5480 kg and 6955 kg for 305 dMY and 330, 333 and 321 d, for LP, respectively. While, the present means are higher than those reported by Khattab and Sultan (1990), Khalil *et al.* (1994) and Khattab and Atil (1999) working on Friesian cattle in Egypt, being 2484, 2384 and 3252 kg, for 305 dMY and 363, 322 and 367 d for LP, respectively. Least squares mean of DO is 262 ± 6. The present mean is higher than those reported by Schaeffer and Henderson (1972), Khattab and Ashmawy (1988), Kaya (1996) and Khattab and Atil (1999) working on Friesian cattle in different countries and ranged from 97 to 171 d. Khattab and Ashmawy (1988) suggested that DO length of 60 to 90 day was optimum length for attaining maximum production for Friesian cows in Egypt. The differences between our results and those of other workers could be due to differences in climatic and management conditions and / or genetic differences in herds.

Non-genetic effects: All main fixed effects included in the model were significant effects on different traits studied ($P < 0.01$, Table 2), except the effect of season of calving on LP. Menemen herd recorded the highest mean of 305 dMY and the shortest LP and DO relative to the other herds (Table 1). All herds are located in the West of Turkey, so the clear difference between them may be due to difference in management practices. Variations from one herd to another in days open have been attributed to differences in the practice of detection of estrus (Bozworth *et al.*, 1972). Therefore, an intensive program of heat detection and practice of insemination may significantly shorten open periods. Similar, significant effects of herds on milk traits are reported by (Gacula *et al.*, 1968; Khattab and Ashmawy, 1988, Khattab and Sultan, 1990; Rege, 1991; Salem, 1991; Khalil *et al.*, 1994; Kaya, 1996).

Winter was the season with the greatest occurrence of calving (1528) as compared to Spring (1475), Autumn (1064) and Summer (1026). The Winter calves are also the highest 305 dMY and the shortest LP and DO (4693 kg vs 4635, 4509 and 4588 kg for 305 dMY, 299 d vs 300, 300 and 304 d for LP and 254 d vs 266, 266 and 262 d for DO, respectively. Similar results are reported by Atay *et al.* (1995) Kaya (1996) and Ulutas *et al.* (1999) working on Holstein Friesian cattle in Turkey. The decrease in milk yield in Summer calving and longest of LP and DO may be due to decrease in feed intake and the hot humid weather. While, Kelm *et al.* (1997) found no significant effect of season of calving on milk yield and days open.

No specific trend was noticed for the significant effect of the year of calving on 305 dMY, LP and DO (Table 1). Similarly the significant effect of year of calving on milk traits are reported by Khattab and Ashmawy (1988), Khattab and Sultan (1990), Rege (1991), Khalil *et al.* (1994), Yener *et al.* (1994), Atay *et al.* (1995), Kaya (1996), Khattab and Atil (1999) and Ulutas *et al.* (1999). Change in milk traits from one year to other can be attributed to change in herd, size, age of animals and improved management practiced introduced from year to another and phenotypic trend. Kaygisiz (1996) using another herd of Holstein Friesian in Turkey estimated environmental trend for milk yield as 200 kg / year. In addition, Ulutas *et al.* (1999) using another herd of Holstein Friesian cattle in Turkey, found that phenotypic trend per year was estimated as 136 kg / year.

As to the highly significant effects of parity on milk traits, the highest 305 dMY was attained during the third parity (Table 1). This is logically due to the increase in body weight combined with advancing age at the full development of the secretory tissue of the udder. Atay *et al.* (1995) and Kaygisiz (1996) reported that the highest 305 dMY was reached at 5th and 6th lactation respectively. In addition, Kaya (1996) using another herd of Holstein Friesian cattle in Turkey, found that the average 305 dMY was 4696 kg, 5352 kg, 5615 kg, 5739 kg and 5694 kg for first, 2nd, 3rd, 4th and 5th lactation, respectively. LP and DO increased with increased parity (Table 1). Hageman *et al.* (1996) estimated that DO increased 7 and 12.5 d for first and second lactation, respectively for each increase of 100 kg in 305 dMY, Salem (1991) indicated that DO increased with advance of lactation number from the first to the sixth lactation.

Estimates of partial linear and quadratic regression coefficients of 305 dMY on age at calving were significant being, 41.62 ± 6.16 kg/mo and -0.308 ± 0.05 kg/mo^2, respectively (Tables 1 and 2). Similar, curvilinear relationship between 305 dMY and age at calving were reported by Galal *et al.* (1974), Khattab and Ashmawy (1988), Khalil *et al.* (1994) and Atil and Khattab (1999). The prediction curve based on the second degree polynomial regression of 305 dMY with increasing in age at calving. The present results indicate that increase in 305 dMY with increase in age at calving up to 68 mo and then decline. At such age the cow is much mature when the body weight and size are fully developed followed by increase in the size and function of digestive and circulatory systems, mammary glands and other body systems. With advanced age, the physiological activities of all body systems start to decrease and the secretory tissue of the udder is partially degenerated leading to a gradual decrease in the amount of milk yield. Galal *et al.* (1974) and Atil and Khattab (1999) showed that peak yield was reached at approximately 84 and 56 mo of age, respectively.

Estimates of partial linear and quadratic regression coefficients of 305 dMY on DO were significant ($P<0.01$, Table 2), being 2.69 ± 0.29kg/d and -0.0072 ± 0.0014 kg/d^2, respectively. Khalil *et al.* (1994) with Friesian cattle in Egypt, estimated partial linear and quadratic regression coefficients of 305 dMY on DO were 0.52 ± 0.15 kg/d and -0.006 ± 0.00 kg/d^2. In addition, Atil (1999) working on Holstein Friesian in Egypt, estimated that the partial linear and quadratic regression coefficients of 305 dMY on DO were 7.50 ± 0.40 kg/d and -0.037 ± 0.00 kg/d^2, respectively. Smith and Legates (1962) attributed such curvilinear trend of the competition between milk production of the cow and nutrition of her fetus especially at the 5th month of pregnancy. They also added that it might be due to negative association between the milk secretion hormones and the stage of pregnancy. In addition, curvilinear relationship between milk yield and DO was also reported by Schaeffer and Henderson (1972), Khattab and Ashmawy (1988), Khalil *et al.* (1994) and Atil (1999). The prediction curve based on the second degree polynomial regression of 305 dMY with increasing in DO. The present results indicate that increase in 305 dMY with increase in DO up to 186 d and then decline. Therefore, from the economic standpoint, reduction of DO is a desirable goal of dairymen.

F - ratios presented in Table 2 indicate that herd, season of calving, year of calving, parity, age at calving and days open are considered the major factors influences 305 dMY and LP. Khalil *et al.* (1994), Salem (1991) and Khattab and Atil (1999) came to the same results. This leads to

Table 1: **Least squares constants for factors affecting 305 day milk yield (305 dMY), lactation period (LP) and days open (DO) in Holstein Friesian Cattle in Turkey**

Classification	N	305 DMY Const. ± S.E.	LP Const. ± S.E.	DO Const. ± S.E.
Overall mean	5093	4606±175	301±5	262±6
Herds				
Tahirova	717	158.0±71.0	21.0±2.0	9.24±2.0
Dalaman	1173	-899.0±9.0	20.0±2.0	-2.41±2.0
Türkgeldi	266	-829.0±105.0	-6.0±3.0	-12.73±4.0
Sarmisakli	1285	409.0±77.0	-2.0±2.0	14.08±2.0
Menemen	1652	1161.0±75.0	-32.0±2.0	-8.17±2.0
Season of calving				
Winter	1528	87.0±25.0	-1.61±1.0	-8.0±2.0
Spring	1475	29.0±26.0	-0.60±1.0	4.0±2.0
Summer	1026	-97.0±28.0	-096.0±1.0	4.0±2.0
Autumn	1064	-18.0±29.0	3.20±1.0	-0.40±2.0
Year of calving				
72	41	543.0±213.0	-21.0±10.0	15.0±17.0
73	55	657.0±167.0	-3.0±7.0	-23.0±13.0
74	110	301.0±134.0	2.0±6.0	-17.0±10
75	166	202.0±110.0	-8.0±5.0	10.0±9.0
76	223	426.0±92.0	-7.0±4.0	14.0±7.0
77	269	323.0±76.0	2.0±3.0	13.0±6.0
78	399	72.0±62.0	2.0±2.0	11.0±5.0
79	524	-83.0±55.0	8.0±2.0	4.0±4.0
80	757	-405.0±57.0	6.0±2.0	0.61±4.0
81	449	-378.0±65.0	7.0±3.0	-1.0±5.0
82	408	-243.0±77.0	4.0±3.0	7.0±6.0
83	458	-342.0±92.0	2.0±4.0	2.0±7.0
84	519	24.0±107.0	0.64±5.0	-3.0±8.0
85	509	-154.0±126.0	2.0±5.0	0.86±9.0
86	189	-359.0±156.0	-0.70±7.0	-0.40±12.0
87	17	-584.0±525.0	4.0±5.0	-33.0±42.0
Parity				
1	1778	156.0±216.0	-6.0±10.0	-52.0±16.0
2	1259	177.0±68.0	-8.0±6.0	-21.0±10.0
3	856	241.0±133.0	-4.0±3.0	-17.0±5.0
4	544	8.0±46.0	1.0±2.0	16.0±3.0
5	343	-161.0±85.0	2.0±4.0	25.0±6.0
6	208	-234.0±137.0	7.0±6.0	21.0±9
7	105	-187.0±203.0	8.0±9.0	28.0±9.0
Regressions				
Age, linear		41.62±6.16	-0.139±0.29	-107.0±0.47
Age, quadratic		-0.308±0.05	-0.002±0.002	0.03±0.0003
Days open, linear		2.69±0.29	0.38±0.0135	
Days open, quadratic		-0.0072±0.0014	-0.0006±0.00007	

Table 2: **Least squares analysis of variance for factors affecting 305 day milk yield (305 dMY), lactation period (LP) and days open (DO) in Holstein Friesian Cattle in Turkey**

Source of Variation	D.F.	F Values. 305 dMY	LP	DO
Herds	4.0	231.46**	71.19**	13.15**
Sire: herds	197.0	2.78**	1.76**	1.15
Cow: herds x sires	1647.0	2.34**	1.72**	1.97**
Season of calving	3.0	5.58**	1.74	5.05**
Year of Calving	15.0	15.64**	2.56**	2.78**
Parity	6.0	6.36**	1.50	80.54**
Regressions				
Age, linear	1.0	45.68**	0.230	425.81**
Age, quadratic	1.0	35.84**	0.649	52.95**
Days open, linear	1.0	87.67**	767.97**	
Days open, quadratic	1.0	26.09**	89.91**	
Reminder	3216.0			
Reminder, M.S.		494360.0	1103.0	3295.0

** ($P < 0.01$)

conclude that adjusting of lactation records for these factors are very necessary for sire evaluation.

Table 3: **Estimates of heritability, genetic and phenotypic correlations between milk traits**

Traits	305 dMY	LP	DO
305dMY	0.38±0.06	0.43	0.16
LP	0.57±0.09	0.13±0.03	0.49
DO	-0.05±0.67	0.75±0.81	0.007±0.02

Table 4: **Minimum and maximum values for sire transmitting abilities estimated by best linear unbiased prediction for milk traits**

Traits	Min.	Max.	Differences
305dMY(kg)	-717	601	1318
LP (d)	-24	40	64
DO (d)	-6	5	11

Random effects: Sires within herds had significant effect on 305 dMY and LP ($P < 0.01$, Table 2). The present results are in agreement with those obtained by Khattab and Sultan (1990), Rege (1991), Salem (1991), Khalil *et al.* (1994), Kaya (1996), Atil (1999) and Khattab and Atil (1999) working on different breeds of dairy cattle.

Table 5: Ten most frequently used sires and their proofs for milk traits

Proofs Sire [+]	N	305 dMY, kg	LP, d	DO, d
43	156	483	-0.91	-3.54
110	132	-3	0.57	-3.30
118	103	-9	-12.00	-3.30
123	136	-162	-3.00	2.90
134	167	-41	3.00	-0.83
135	94	601	4.00	-1.78
242	84	110	5.00	0.04
263	99	38	-2.00	-4.73
414	121	76	-0.06	-4.00
516	207	-343	-7.02	-5.00

[+] Number of halb sib daughters.

The present results indicated that the possibility of genetic improvement of 305 d MY and LP through selection. While, DO can be improved by better management. Effect of cows within herds within sires for different traits studied is significant (P<0.01, Table 2). Variances in genetic potentiality of cow affect along with some changes in the herd management. Similar, results are obtained by Khalil *et al.* (1994) and Khattab and Atil (1999). In addition, cow evaluation and selection are important in herd improvement scheme. The ultimate aim of an evaluation is to enable breeders to compare their animals by estimating producing ability.

Heritability estimates: Estimates of heritability genetic and phenotypic correlations between different traits studied were calculated from the analysis records of sets of paternal half sibs. The estimates were based on 5093 normal lactation records. Heritability estimates for 305 dMY was 0.38 ± 0.06 (Table 3). Similarly, Atay *et al.* (1995) and Tuzemen *et al.* (1999) working on Holstein Friesian cattle in Turkey found that h^2 estimates for 305 dMY were 0.26 and 0.29, respectively. In addition, Kaya (1996) working on four herds of Holstein Friesian cattle in Turkey found that h^2 estimates for 305 dMY ranged from 0.19 to 0.31. According to the moderate h^2 estimates for 305 dMY, it can be concluded that the genetic improvement in milk yield can be achieved through selective breeding program.

The heritability estimate of LP was 0.13 ± 0.03 (Table 3). The present estimate is similar to that values 0.09 and 0.17 reported by Tuzemen *et al.* (1999) and Khattab and Sultan (1990), while higher h^2 estimates for LP were reported by Atay *et al.* (1995), Kaygisiz and Vanli (1997) using another herd of Holstein Friesian in Turkey and ranged from 0.22 to 0.48. The major part of the variation in this character is due to non-genetic factors.

Heritability estimate for DO was 0.007 ± 0.02 (Table 3). Lobo *et al.* (1984) found h^2 estimates for DO derived from the sire components of variance were 0.01, 0.05 and 0.09 in first, second or later and all lactations respectively. They also, found that the regression of daughter on dam for 449 daughters damp airs were 0.02 ± 0.00. In addition, lower h^2 estimates for DO were also reported by Schaeffer and Henderson (1972) (0.00 to 0.04), Khattab *et al.* (1987) (0.05), Kaygisiz and Vanli (1997) (0.06) and Atil (1999) (0.00). The present results suggested that the most variation in DO is due to non-genetic additive genetic factors. Therefore, improving the managerial techniques should lead to a considerable decrease in length of DO. Makuza and McDaniel (1996) suggested that the low h^2 for DO indicated that temporary environmental influences were much greater than genetic influences or permanent environmental effects. Khalil *et al.* (1994) concluded that due to low h^2 for lactation intervals (i.e. LP and DO) relative to yield traits (305 dMY) selection index based on paternal half sister groups did not allow lactation intervals to play a major role in selection programs.

Phenotypic and genetic correlations: Phenotypic correlation between 305 dMY and DO was 0.16 (Table 3). Olds *et al.* (1979) estimated that each additional days open resulted in 4.5 kg more 305 dMY. Also, Khattab and Ashmawy (1988) reported that the regression coefficient of 305 dMY on DO was 2.2 kg/day. In addition Atil (1999) using another herd of Holstein Friesian cattle found that the phenotypic correlation between 305 dMY and DO was 0.24. The present results indicate that the average 305 dMY increases as number of days open increases. Negative genetic correlation between 305 dMY and DO (-0.05 ± 0.67, Table 3) concluded that selection against days open would increase milk yield. Therefore, a reduction of DO is the desirable goal of dairymen. Khattab *et al.* (1987), Atil (1999) and Khattab and Atil (1999) came to the same conclusion.

Sire values for 305 dMY, LP and DO were estimated by using the procedure of best linear unbiased prediction (BLUP). Estimates of sire transmitting abilities as deviations from the mean for 305 dMY ranged from -717 to 601 kg, from -24 to 40 d for LP and from -5 to 6 d for DO, with the range being 1318 kg, 64 d and 11 d, respectively (Table 4). The present estimates showed large genetic differences between sires for different traits for milk yield and lactation period, which indicate the high potential for rapid genetic improvement in milk traits of Holstein Friesian cattle in Egypt through selection. While, there is a small differences for BLUP values for DO. Similarly, Yener *et al.* (1998) working on two herds (h's) of Holstein Friesian cattle in Turkey (h_1) and Egypt (h_2) concluded that BLUP values for h_1, ranged from -322 to 349 kg for 305 dMY, from -2.46 to 1.7 d for LP and from -8.200 to 8.90 d for DO and for h^2 ranged from -349 to 567 kg for 305 dMY and from -0.45 to 0.94 d for LP and from -5.42 to 11.38 for DO. Ulutas *et al.* (1999) working on Holstein Friesian cattle in Turkey concluded that involving of BLUP procedure to herd management with increasing number of records and selection based on breeding values of each animal might help to improve genetic gain for herd. Also, Atil and Khattab, (1999) working on Holstein Friesian cattle in Egypt, found that BLUP values ranged from -519 to 481 kg for 305 dMY and from -16 to 19 d for LP.

Table 5 presents proof for different traits studied of 10 sires with the largest number of daughters. Sires give positive and higher BLUP values for 305 dMY gives positive and higher values for LP and negative values for DO. The present results indicate that selection of these sires for breeding purposes could lead to rapid genetic improvement for milk yield in the next generation and will decrease DO. Yener *et al.* (1998) came to the same conclusion.

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