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RESEARCH ARTICLE

Estimation of Genetic Parameters and Variance Components of Milk Traits in Holstein-Friesian and British-Holstein Dairy Cows

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Summary

The objectives of this study were to estimate the genetic parameters of milk traits of dairy cows and to examine the associations among these traits in both Holstein-Friesian and British-Holstein. The data used in this study was obtained from (LSUK), an organisation for the recording of milk, health and service parameters of dairy cows in Scotland. The data consisted of information on total lactation milk, fat and protein yield. The final number of production records retained in the production database after all edits was 70931. Variance components and genetic parameters for milk, fat and protein yield were estimated using the ASREML program. Analysis for milk, fat and protein yield was conducted for each of the prepared data sets using a univariate animal model. Mean calving age ranged from 29-65 months. The mean lactation length ranged from 300-320 days. The heritabilities of these traits were ranging from 0.22 to 0.52. The heritabilities of milk, fat and protein yield were higher in Holstein-Friesian than British-Holstein. For most of the traits, phenotypic correlations were larger than the genetic correlations. The results showed that there were moderate-strong positive genetic and phenotypic correlations among the production traits. The genetic correlations ranged from 0.38 between milk and fat yield to 0.92 between milk and protein yield.

Keywords: *Genetic parameters, Milk traits, Variance components, Holstein*

Holştayn Frizyan ve İngiliz Holştayn Sütçü Sığırlarında Süt Özelliklerinin Varyans Unsurları ve Genetik Parametrelerinin Tahmini

Özet

Çalışmanın amacı Holştayn ve İngiliz Holştayn ineklerinin süt verim özelliklerinin genetik parametrelerini tahmin etmektir. Çalışmada kullanılan veriler İskoçya da süt ineklerinin süt, sağlık ve dölverimi kayıtlarını tutan bir şirketten (LSUK) temin edilmiştir. Bütün düzeltmelerden sonra laktasyon süt verimi, yağ ve proteinin bulunduğu 70931 adet veri kullanılmıştır. Süt, yağ ve proteinin varyans unsurlarının tahmininde ASREML programı kullanılmıştır. Bahsedilen özelliklerin tahmininde tek özellikli bireysel hayvan modeli kullanılmıştır. Ortalama buzağılama yaşı 26-65 ay, ortalama laktasyon uzunluğu da 300-320 gün olarak belirlenmiştir. Bahsedilen özelliklerin kalıtım dereceleri de 0.22 ile 0.52 arasındadır ve Holştaynların bu değerleri İngiliz Holştaynlarından büyüktür. Bir çok özellik için fenotipik korelasyonlar genetik korelasyonlardan daha kuvvetli bulunmuştur. Süt ve yağ arasındaki genetik korelasyon katsayısı 0.38 bulunurken, süt ve protein arasındaki 0.92 olarak belirlenmiştir.

Anahtar sözcükler: *Genetik parametreler, Süt özellikleri, Varyans unsurları, Holştayn*

INTRODUCTION

Both Holstein-Friesian and British-Holstein cow breeds are used in UK for dairy production and their pedigree and production traits are recorded in detail by Livestock Services UK (LSUK). Milk production is a major source of income in most dairy enterprises. After milk the other important yield traits are milk fat and protein contents. Most of the economic traits of livestock species are generally control of genetic factors [1] but environmental influences like herd, year, calving season, lactation number and calving age have significant effects on milk yield.

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Therefore these environmental effects have to be taken account to estimate the genetic part of the milk traits [2-5].

The aim of animal breeding is not only to produce superior individual animals but also to cause a general improvement in a herd by selecting genetically superior sires and dams as parents of future generations [1,6,7]. For the mentioned aims, estimating the genetic and phenotypic parameters, such as heritability-repeatability together with the variance components, is essential.

Heritability estimates of milk yield in dairy cows range from 0.30 to 0.40 [1,6,8]. For fat yield and protein yield the heritability estimates are in the range 0.20 to 0.40 [9-12]. Repeatability estimates of yield traits are high and range from 0.50 to 0.55 [6,12]. Genetic correlations between milk and fat yields are in the range of 0.40 to 0.92, milk and protein 0.83 to 0.99 and fat and protein 0.69 to 0.77. The phenotypic correlations between milk and fat are in the range 0.69 to 0.81, between milk and protein 0.71 to 0.94 and between fat and protein are 0.81 to 0.84 [8,9,11].

The objectives of this study were to estimate the genetic parameters of milk traits of dairy cows and to examine the associations among these traits in both Holstein-Friesian and British-Holstein. Although several researches were conducted on the similar subject and breeds, to investigate these traits with a comprehensive data set obtained from LSUK, gives a specific importance to the study.

MATERIAL and METHODS

Data

The data used in this study was obtained from (LSUK), an organisation for the recording of milk, health and service parameters of dairy cows in Scotland. The data consisted of information on total lactation milk, fat and protein yield. A large number of records (88.4%) were available on the two major breeds i.e. Holstein-Friesian and British-Holstein, hence all observations except for these two breeds were eliminated from the database. Sire and dams for each cow were obtained from the pedigree file. All cows with pedigree problems were eliminated. Calving months were grouped into four seasons, January to March (Season 1), April to June (Season 2), July to September (Season 3) and October to December (Season 4). Herd, year and season codes were joined to create a fixed-effect code representing herd-year-season. All records with missing values for sire, dam, calving age, lactation length, fat or protein yield were eliminated. Records on cows in lactation number 6 and above were grouped into lactation number 6. Lactation length was restricted between 150 days and 450 days. The final number of production records retained in the production database after all edits was 70931.

Statistical Analysis

Variance components and genetic parameters for milk, fat and protein yield were estimated using the ASREML program [13]. Analysis for milk, fat and protein yield was conducted for each of the prepared data sets using a univariate animal model. The models used for each trait are presented in *Table 1*.

Two type of analyses were performed, one excluding a permanent environmental effect of animal (i.e. for data sets with first lactation records only) and the other including the permanent environmental effect of animal. Phenotypic variance (V_p), heritability (h^2), permanent environmental effect of animal as a proportion of the phenotypic variance (C^2) and repeatabilities were calculated. Bivariate analyses were performed to examine variance components and the relationship between traits.

RESULTS

After completing all the edits there were 70931 observations in the whole data set comprising of both breeds and all lactations.

The descriptive statistics for milk, fat and protein yield in all data sets are presented in *Table 2*. Milk yield, fat yield and protein yield increased in the order lactation 1<all lactation. Yields were greater for Holstein-Friesian than British-Holstein in lactation 1 but across all lactations yields were greater for British-Holstein than Holstein-Friesian. Mean calving age ranged from 29-65 months. Mean age at calving of Holstein-Friesian cows was slightly greater than the British

Table 1. *Models used for univariate analyses*

Tablo 1. *Tek değişkenli analizlerde kullanılan modeller*

Data Sets	Animal •	PEE	HYS	Breed	LN	LL (cov)	CA (cov)
Single Breed First Lactation	✓	°	✓	°	°	✓	✓
Single Breed All Lactation	✓	✓	✓	°	✓	✓	✓
Two Breeds First Lactation	✓	°	✓	✓	°	✓	✓
Two Breeds All Lactation	✓	✓	✓	✓	✓	✓	✓

Factors marked (✓) were fitted and factors marked (°) were not fitted in the model
PEE= *Permanent environmental effect of animal,* ***HYS***= *Herd-Year-Season,* ***LN***= *Lactation number,* ***LL***= *Lactation length,* ***CA***= *Calving age, Lactation, Factors marked (•) were random terms whereas all others were fixed effects or covariates (cov)*

-Holstein cows in the first lactation and in lactation >1, whereas age at calving was slightly greater in British-Holsteincows than Holstein-Friesian cows in all lactations. The mean lactation length ranged from 300-320 days.

Heritability and repeatability estimates for milk, fat and protein yield from univariate analyses together with their standard errors are shown in Table 3. The heritability of these traits was moderate and high, and ranging from 0.22 to 0.52. Heritabilities were higher in the first lactation data sets, starting from 0.38 up to 0.52. The heritabilities of milk, fat and protein yield were higher in Holstein-Friesian than British-Holstein.

Repeatabilities obtained from univariate analyses are also shown in Table 3. These results showed that the production traits were highly repeatable, with estimates ranging from 0.50 to 0.56. There was very little difference in repeatability estimates between the Holstein-Friesian and British-Holstein data sets. Standard errors for heritability and repeatability estimates for all the traits were generally small.

In addition to heritabilities and repeatbilities the genetic and phenotypic correlations between the production traits are also presented in Table 3. Therefore Table 3 gave an opportunity to evaluate the large amount of estimated

***Table 2.** Mean, minimum, maximum, standard deviation and coefficient of variation of milk, fat and protein yields (kg)*

***Tablo 2.** Süt, yağ ve protein verimlerinin ortalama, minimum, maksimum, standart hata ve varyasyon katsayıları (kg)*

Data Set	Trait	Mean	Min.	Max.	S.D	C.V
Holstein-Friesian First Lactation (HF.L1.) (n=9970)	MY	6816.3	698.8	16701.0	1857.3	27.2
	FY	268.3	34.1	665.9	72.8	27.1
	PY	223.2	23.9	514.6	61.3	27.5
Holstein-Friesian All Lactation (HF.LA.) (n=60163)	MY	7352.5	698.8	19693.2	2037.5	27.7
	FY	287.8	34.1	774.7	81.4	28.3
	PY	240.5	23.9	604.9	66.7	27.7
British-Holstein First Lactation (BH.L1) (n= 904)	MY	6182.3	1442.6	14114.6	1828.3	30.0
	FY	241.3	55.5	527.6	70.1	29.1
	PY	201.5	47.4	442.2	60.0	29.8
British-Holstein All Lactation (BH.LA) (n=10768)	MY	7743.9	1305.0	18919.0	2193.6	28.3
	FY	302.4	49.7	738.0	85.6	28.3
	PY	251.8	46.4	598.1	70.9	28.2
Holstein-Friesian & British-Holstein First Lactation (HF&BH.L1) (n=10876)	MY	6763.6	698.8	16701.0	1863.0	27.5
	FY	266.1	34.1	665.9	73.1	27.5
	PY	221.4	23.9	514.6	61.5	27.8
Holstein-Friesian & British-Holstein First Lactation (HF&BH.LA) (n=70931)	MY	7412.0	698.8	19693.2	2066.7	27.9
	FY	290.0	34.1	774.7	82.2	28.3
	PY	242.2	23.9	604.9	67.5	27.9

MY = Milk yield, FY= Fat yield, PY= Protein yield

***Table 3.** Heritabilities and genetic correlations (in bold print) with their respective (s.e) and repeatabilities and phenotypic correlations (in light print) with their respective (s.e) obtained from uni and bivariate analyses*

***Tablo 3.** Tek ve iki değişkenli analizlerden elde edilen kalıtım ve tekrarlama derecesi ile genetik ve fenotipik korelasyonlar ile standart hataları*

Data Set	Univariate Analyses (Heritabilities and Repeatabilities)			Bivariate Analyses (Genetic and Fenotipic Correlations)		
	MY	FY	PY	MY*FY	MY*PY	FY*PY
HF.L1	0.49 (0.050)	0.50 (0.050)	0.52 (0.051)	0.69 (0.039) 0.74 (0.006)	0.91 (0.012) 0.92 (0.002)	0.82 (0.026) 0.81 (0.004)
HF.LA.	(0.016) 0.53 (0.005)	(0.015) 0.51 (0.005)	(0.016) 0.55 (0.005)	0.52 (0.030) 0.73 (0.003)	0.86 (0.010) 0.92 (0.001)	0.69 (0.022) 0.79 (0.002)
BH.L1	0.44 (0.197)	0.39 (0.196)	0.38 (0.196)	0.46 (0.261) 0.75 (0.020)	0.09 (1.335) 0.37(0.889)	0.59 (0.226) 0.81 (0.015)
BH.LA	0.24 (0.038) 0.53 (0.013)	0.24 (0.036) 0.51 (0.013)	0.22 (0.036) 0.56 (0.012)	0.39 (0.084) 0.70 (0.007)	0.81 (0.034) 0.91 (0.002)	0.59 (0.067) 0.78 (0.005)
HF& BH. L1	0.48 (0.048)	0.51 (0.049)	0.52 (0.049)	0.69 (0.038) 0.74 (0.005)	0.92 (0.012) 0.92 (0.001)	0.82 (0.025) 0.81 (0.004)
HF& BH.LA	(0.015) 0.53 (0.005)	(0.014) 0.51 (0.004)	(0.015) 0.56 (0.005)	0.57 (0.025) 0.50 (0.002)	0.90 (0.020) 0.83 (0.001)	0.80 (0.011) 0.75 (0.001)

parameters in one place. For most of the traits, phenotypic correlations were larger than the genetic correlations. The results showed that there were moderate-strong positive genetic and phenotypic correlations among the production traits. The genetic correlations ranged from 0.38 between milk and fat yield to 0.92 between milk and protein yield. Phenotypic correlations ranged from 0.69 between milk and fat yield to 0.92 between milk and protein yield.

Estimates of additive genetic variance (V_A), error variance (V_E), phenotypic variance (V_P), permanent environmental variance due to the animals as a proportion of the phenotypic variance (C^2) of milk, fat and protein yield for the data sets analysed in lactation 1 and all lactations are presented in *Table 4*.

In all lactation yields of milk and protein of the corresponding study were close with the findings of Suzuki and Van Vleck [12] who reported milk yield of 7.369 kg and protein yield of 231 kg. Juga [16] reported a lower yield of milk (5.640 kg) from Finnish Ayrshire and Pryce et al.[8] also reported lower milk yield of 6.455 kg. These defined differences may be attributed to breed differences and different populations and environmental conditions. British-Holstein produced slightly more milk, fat and protein than Holstein-Friesian for all lactations. This could be expected because Holstein-Friesian contains genes from both Holstein and Friesian, whereas, Holsteins are pure breed and are expected to produce more.

For heifers heritability of production traits was found to be moderate to high, and ranged from 0.38 to 0.56 which agrees well with most of the estimates for heifers which ranged from 0.30 to 0.49. A moderate heritability (0.22-0.32) was noted across all lactations which agrees with the findings of Pryce et al.[8] and Suzuki and Van Vleck [12] who gave similar estimates (0.30-0.34) in dairy cows. In contrast, Dematawewa and Berger [17] reported slightly lower heritability of these traits (0.18-0.20) in Holstein cows and Juga [16] and Kadarmideen et al.[18] reported a slightly higher (0.40) heritability of these traits. The possible explanation for differences between the genetic parameters of this study with others may be attributed to the different populations and/or environments examined.

Table 4. *Estimates of variance components for milk traits from univariate analyses in first and all lactations*

Tablo 4. *Birinci ve tüm laktasyonlardaki tek değişkenli analizlerin süt özelliklerinin varyans komponentlerinin tahmini*

Data Sets	Trait	First Lactation			All Lactations			
		V_A	V_E	V_P	V_A	V_C	V_E	V_P
HF	MY	463406	482120	945526	359204	239281	529382	1127867
	FY	717.49	707.00	1424.49	599.43	354.31	916.39	1870.13
	PY	455.22	416.39	871.61	347.29	244.64	478.92	1070.85
BH	MY	335807	419914	755721	293471	348554	566912	1208937
	FY	517.26	806.37	1312.63	501.83	559.97	1013.48	2075.28
	PY	287.22	459.69	746.91	250.80	380.68	504.87	1136.35
HF&BH	MY	444565	484171	928736	364701	248878	537672	1151251
	FY	715.74	699.58	1415.32	594.59	381.66	936.42	1912.67
	PY	448.55	414.37	862.92	354.42	252.24	485.75	1092.41

V_A*= Direct additive genetic variance,* ***V_E****= Error variance,* ***V_P****= Phenotypic variance,* ***V_C****= Permanent environmental variance*

DISCUSSION

Holstein-Friesian was the main breed representing 85% of the total production records analysed. The large number of records available on Holstein-Friesian suggests that either this was the main breed in this population or possibly the record keeping was better at farms where this breed was kept. In any case records from Holstein-Friesian and British Holsteins gave an opportunity to make a comparison between two breeds in terms of milk traits.

In this study, yields of milk (6182-6816 kg), fat (241-268 kg) and protein (201-223 kg) found in first lactation heifers agrees well with the findings of Campos et al.[11], Suzuki and Van Vleck [12] and Hoekstra et al.[14] who reported 6197-6939 kg milk yield, 238-277 kg fat yield and 204-216 kg protein yield in first lactation Holsteins. In contrast, yields of these traits given by Van Vleck and Van Dong [10] and by Van Dorp et al.[15] were higher than this study. An analysis of Van Vleck and Dong [10] was based on selected herds having higher than average yields. Results of Van Dorp et al.[15] were based on herds selected on the basis of availability of health records and the data set was small having 4368 records.

Similar heritability estimates for production traits has also been reported by Van Vleck and Van Dong [10]. For both breeds, heritability estimates were higher in heifers than in lactations >1 *(Table 3)*. Butcher and Freeman [19], suggested possible explanations for the higher heritability in first lactation than in later lactations that included larger effects of genes in lactation 1, larger environmental effects in later lactations and presence of genetic maternal effects.

The repeatability of the traits was high and ranged from 0.51 to 0.56 which is in close agreement with most of the estimates (0.52 to 0.59) as reported by Suzuki and Van Vleck [12] and Kadarmideen et al.[18]. However, Dematawewa and Berger [17] reported comparatively low (0.41 to 0.42) repeatability for milk, fat and protein yields in Holstein cows and Pryce et al.[8] reported a slightly higher (0.64) repeatability of milk yield in dairy cows in the UK.

Genetic correlations among production traits were moderate to very high and ranged from 0.38 to 0.92 except for the very low correlation (0.09) between milk and protein yield in BH.L1. This result must be interpreted with caution because of the characteristics of records. A high correlation among milk yield traits could be expected because these are interrelated, since an increase in milk yield is likely to cause an increase in fat yield and protein yield. Genetic correlations obtained in this study are comparable in magnitude and sign to the findings of various workers who reported genetic correlations from 0.35 to 0.99 [8,15]. Phenotypic correlations were high and positive and ranged from 0.69 to 0.92 except for the low phenotypic correlation (0.37) between milk and protein yield in BH.L1. Low genetic and phenotypic correlation between milk and protein yield in BH.L1 can be result of any disorder of the data set and should be taken the consideration cautiously. Estimates of phenotypic correlations obtained here are in close agreement with estimates of Van Drop et al.[15] and Dematawewa and Berger [17] ranged between 0.58 and 0.95.

Although there were no dramatically differences between the two breeds in terms of studied traits, genetic parameters were higher in Holstein-Friesian. Phenotypic milk, fat and protein yield were more in British Holsteins for all lactations. Apart from these outcomes this study gave an opportunity to compare the genetic parameters of milk traits in Holstein-Friesian and British-Holstein breeds with a considerably large dataset. Calculated heritabilities and repeatabilities brought a chance to assess the breeds in both genetic and phenotypic part; so the result may easily be evaluated by scientist and cattle breeders.

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