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Variances of direct and maternal genetic effects for milk yield and age at first calving in a herd of Friesian cattle in Egypt

Abstract

A total of 2095 lactation records of Holstein Friesian cattle kept at Dalla Farm in Egypt during the period from 1988 to 1992 were used in this study. Those data were used to estimate variances from direct and maternal genetic effects. The data was analyzed by using Multiple Traits Derivative Free Restricted Maximum Likelihood (MTDFREML) according to BOLDMAN et al. (1995) using repeatability Animal Model. Two models were used: Model 1 includes month of calving, year of calving, parity as fixed effects, days open and days dry as covariates and direct genetic, maternal genetic, covariance between direct and maternal genetic, permanent environmental and residual as random effects; Model 2 is similar to Model 1, but excluding additive maternal and covariance between additive direct and maternal effects.

Estimates of heritability for 305 day milk yield (305 dMY) were 0.22 and 0.23, for Model 1 and Model 2, respectively. Heritability estimates for age at first calving (AFC) were 0.77 and 0.82 for Model 1 and model 2, respectively. The removal of additive maternal genetic effects and covariance between direct and maternal genetic effects from the model increased estimates for heritability of additive genetic effects by 0.01 and 0.05 for 305 dMY and AFC, respectively. Then, the additive maternal genetic effect and covariance between direct and maternal genetic effects do not seem to make important contributions to the phenotypic variance for milk yield and age at first calving, and these effects are probably not important for genetic evaluations.

Key Words: variance, direct and maternal effects, Holstein Friesian cows, Egypt

Zusammenfassung

Titel der Arbeit: **Varianzen von direkten und maternalen genetischen Effekten für Milchleistung und Erstkalbealter einer Holstein-Friesian Herde in Ägypten**

Insgesamt 2095 Laktationsleistungen aus der 1. bis 5. Laktation von Holstein-Friesian Kühen der Dalla Farm in Ägypten aus den Jahren 1988 bis 1992 wurden für die Schätzung von Varianzen direkter und maternal genetischer Effekte genutzt. Die Analyse der Daten erfolgte mittels der Multiple Traits Derivative Free Restricted Maximum Likelihood (MTDFREML) Methode nach dem Wiederholbarkeitsmodell. Es wurden zwei Modelle genutzt. Modell 1 beinhaltet als fixe Effekte Abkalbemonat, Abkalbejahr und Laktationsnummer, als Kovariable die Güstzeit und Trockenzeit sowie direkt genetische, maternal genetische Effekte und die Kovarianz zwischen direkt und maternal genetischen Effekten, Umwelt- und dem zufälligen Effekt. Das Model 2 ist ähnlich aufgebaut, beinhaltet aber die additiv maternalen und die Kovarianz zwischen additiv direkten und maternalen Effekten nicht.

Heritabilitätsschätzungen für die 305-Tage Leistung ergaben für die Modelle 1 und 2 Werte von 0,22 bzw. 0,23. Die Schätzwerte für das Erstkalbealter lagen bei 0,77 bzw. 0,82. Die Nichtberücksichtigung von additiv maternalen genetischen Effekten und von Kovarianzen zwischen direkten und maternalen genetischen Effekten erhöhte die Schätzwerte der additiv genetischen Effekte für die Milchleistung bzw. das Erstkalbealter um 0,01 bzw. 0,05. Additiv maternale genetische Effekte und die Kovarianz zwischen direkten und maternalen genetischen Effekten haben nach diesen Ergebnissen keinen bedeutenden Einfluss auf die phänotypische Varianz bei der Milchleistung und dem Abkalbealter.

Schlüsselwörter: Varianz, direkte und maternale Effekte, Holstein-Friesian Kühe, Ägypten

Introduction

Animal models used to analyze maternally influenced traits of dairy cattle (e.g., milk yield and age at first calving) typically include direct and maternal effects and permanent environmental effects of the dam. Maternal effects include additive genetic maternal and environmental maternal effects. Additive maternal effects have been defined, as any influence from a dam on it is offspring, excluding the effects of directly transmitted genes that affect performance of the offspring (SCHUTZ et al., 1992).

In mammals, environmental variation in the offspring is partially due to genetic variation of some other traits from the dams, such that quantitative traits can be influenced by two genetic components, animal genotype (direct genetic effect) and dam genotype (maternal genetic effects). The maternal genetic effects are not important for yield traits of dairy cattle (SCHUTZ et al., 1992; ALBUQUERQUE et al., 1998). ALBUQUERQUE et al. (1998) analysis 138,869 lactation records from 68,063 Holstein cows, found that means estimates of the effects of maternal genetic variances and direct maternal covariances, as fractions of phenotypic variances, were 0.008 and 0.007 for milk yield. Also, the same authors concluded that removal of maternal genetic effect and covariance between maternal and direct effects from the model increased the fraction of direct genetic variance by 0.014.

The objective of the present paper was to quantify the contribution of additive direct and maternal genetic effects to phenotypic variance of milk yield and age at first calving in a herd of Friesian cattle in Egypt.

Material and Methods

The data used in the present study was obtained from the history sheets of Friesian cows maintained at Dalla Farm, which is in Egypt. The nucleus of this herd was imported to Egypt from the United States of America (USA) as pregnant heifers in 1986. The data comprised 2095 normal lactation records (as a lactation period more than 150 days) spread over the period from 1988 to 1992. Abnormal records of cows affected by diseases (such as mastitis and udder troubles) or reproductive disorders were excluded.

Table 1
Number of records and 305 day milk yield in different parities (Anzahl Daten und 305-Tage Milchleistung nach Laktationsnummern)

Parity	Number of records	Milk yield Mean ± SE, kg
1	578	4320 ± 53
2	578	5349 ± 53
3	488	4984 ± 58
4	278	4868 ± 59
5	173	4389 + 85

Animals were kept loose under semi-open sheds all the year round. All cows were fed concentrate mixture with grazed Egyptian clover and rice straw during the year. The concentrate mixture used was composed of 45% cotton seed cake, 26% wheat bran, 17% yellow maize, 7% rice bran, 2% molasses, 1% sodium chloride and 2% calcium carbonate. Concentrates were offered twice daily before milking according to animals' body weight and its milk production. Cows were machines milked twice a day (at 7 a.m. and 4 p.m.). Milk yield was recorded weekly and to the nearest 0.20 kg, for each cow. Cows producing more than 10 kg a day and those in the last two months of pregnancy were supplemented with extra concentrate rations. Records included age at first calving and 305 day milk yield and cows with less than two records were excluded. The number of records and unadjusted 305 day milk yield in different parities are presented in Table 1. Heifers were attempted for service for the first time when they reached 24 month or 350 kg. Cows usually were served when seen in estrus two months after calving. Rectal palpation for pregnancy diagnosis was performed 60 days after the last service Artificial insemination (AI) was used by imported frozen semen from USA every year. Assignment of sires to cows was at random. The average number of daughters per sire ranged from 5 to 44.

Data was analyzed by Multiple Traits Derivative Free Restricted Maximum Likelihood (MTDFREML) according to BOLDMAN et al. (1995), using repeatability multiple trait animal model. Table 2 shows the data structure considered in the analysis as well as the means, standard deviations (SD) and coefficient of variability (CV%) for 305 day milk yield and age at first calving. The full animal model (Model 1) used in the analysis, included the fixed effects of month of calving (January,…,December), year of calving (1988, 1989,…,1992) and parity (1, 2,…, 5), days open and days dry as covariates and individual, maternal genetic, permanent environmental and residual as random effects.

The analysis was terminated when the MTDFREML program reached the attained and number of iterations (1318 rounds, Table 2). ALBUQUERQUE et al. (1995) indicated that some researches stopped the analysis after 300 rounds of iterations. EL-ARIAN et al. (2002) working on the same herd, using multi trait animal model (305 day milk yield, lactation period and dry period) concluded that the number of iterations recorded was 5787. In general, number of iterations required to reach convergence could be affected by the number of animals, the number of random factors in the model and even specific traits (AMER, 1999). Starting values for iteration for milk yield were obtained from ALBUQUERQUE et al. (1998) and for age at first calving were obtained from KHATTAB and ATIL (2003). Another model (Model 2) was fitted but excluded additive maternal effect and covariance between direct and maternal effect. More information about this model was written in detail by MRODE (1996).

Results

Unadjusted means of 305 day milk yield and age at first calving, standard deviation (SD) and coefficient of variability (CV%) are presented in Table 2. The mean of 305 day milk yield was 4746 kg.

Table 2
Data structure used in analysis, mean, standard deviation (SD) and coefficient of variability (CV%) for 305 day milk yield and age at first calving (Datenstruktur, Standardabweichungen und Variationskoeffizienten für die 305-Tage Milchleistung und Erstkalbealter)

Number	Mean	SD	CV %
305 day milk yield, kg	4746	1287	27.12
Age at first calving, mo.	27.73	2.63	09.50
Observations			
No. of records	2095		
No. of cows	586		
No. of sires	257		
No. of dams	423		
Animal in relationship matrix, No. A^{-1}	1266		
Mixed model equations, No. MME	6287		
No. of iterations	1318		

Variance components and means for variance and covariance components as rations of phenotypic variances from Model 1 and Model 2 are in Table 3. The variance for additive maternal genetic effects were 1% and 2% of phenotypic variance for 305 dMY and AFC, respectively, and the covariance between maternal and direct genetic effects were 2% and 6% for the two traits, respectively. Thus, these effects did not contribute importantly to phenotypic variance.

Table 3
Phenotypic and genetic variance and covariance for milk yield and age at first calving using two models (Phänotypische und genetische Varianz und Kovarianz für Milchleistung und Erstkalbealter nach den zwei verwendeten Modellen)+

Model	g^2	m^2	gm	pe^2	e^2	Total
Model 1						
305 dMY	255735 (0.22)	14470 (0.01)	-27428 (0.02)	156683 (0.13)	761492 (0.66)	1160952
AFC	6.45 (0.77)	0.17 (0.02)	0.52 (0.06)	0.78 (0.09)	0.494 (0.06)	8.42
Model 2						
305 dMY	243686 (0.23)			62292 (0.06)	733725 (0.71)	1039704
AFC	6.99 (0.82)			0.90 (0.11)	0.67 (0.078)	8.56

+g^2=additive direct genetic effect, m^2=additive maternal genetic effect, gm=covariance between direct and maternal genetic effects, pe^2=permanent environmental effect, e^2=residual error effect and figures in parenthesis are equal fraction of phenotypic variance.

Table 3 shows, that the values of temporary environmental fractions of variance were high for 305 dMY (66% and 71% for Model 1 and Model 2, respectively), while it were small for AFC (6% and 7.8% for Model 1 and Model 2, respectively, it indicates the important of improving the environmental conditions for improving such as important economic traits.
Estimates of heritability for 305 day milk yield are 0.22 and 0.23 and for AFC are 0.77 and 0.82, estimated from Model 1 (full model) and Model 2, respectively (Table 4). The removal of additive genetic maternal effects and covariance between direct and maternal effects from the model (Model 2) increased estimates of heritability of direct genetic effects by 0.01 and 0.05 for 305 dMY and AFC, respectively. In general, direct heritability estimates for 305 dMY was shown in Table 4.
The genetic correlation between 305 dMY and AFC was positive and significant (Table 4).

Table 4
Estimates of heritability (direct and maternal) and genetic correlations among 305 day milk yield (305 dMY) and age at first calving (AFC) as estimated from Model 1 (Heritabilitätschätzungen (direkt und maternal) und genetische Korrelationen zwisshen 305 Tage Milchleistung (305 dMY) und Erstkalbealter (AFC) geschätzt nach dem Modell 1)

	g^1	g^2	m^1	m^2
g^1	0.22			
g^2	0.31	0.77		
m^1	-0.45	-0.71	0.01	
m^2	-0.67	-0.50	-0.96	0.02

g^1 and g^2 are direct heritability for 305 dMY and AFC, respectively, m^1 and m^2 are maternal heritability for 305 dMY and AFC, respectively, heritability on diagonal and genetic correlation below diagonal.

Discussion

The mean of 305 day milk yield (4746 kg, Table 2) was higher than those estimated on other sets of Holstein Friesian cattle in commercial farms in Egypt (e.g. AFIFI et al., 1992 (3838 kg) and EL–ARIAN et al., 2001 (4544 kg)). While, the present mean was lower than those reported by DIMOV et al. (1995) working on two herds of Holstein Friesian in California and New York (9478 and 8060 kg, respectively), KALM (2002) (6050 kg) on Holstein Friesian in Germany. The mean of age at first calving was 27.73 mo. The present mean was lower than the estimate reported by KHATTAB and SULTAN (1991) (31.30 mo.) working on another herd of Friesian cattle in Egypt. The coefficient of variability for 305 dMY and AFC were lower than those reported by KHATTAB and ATIL (2003) working on Holstein Friesian in Turkey being 29.77% and 12.53%, respectively. The differences between the present mean and those of other researchers could be due to differences in climatic and management. Herds could be possibly the genetically different or be caused by different models used.

When the phenotypic and genetic variance and covariance for milk yield and age at first calving using two models (Table 3) were examined, similar trend found by ALBUQUERQUE et al. (1998) analysis milk traits (milk yield, fat yield and fat percentage) found that the variance of additive maternal genetic effects varied from 0.8% to 1.0% of phenotypic variance, and the covariance between maternal and direct genetic effects varied from 0.7% to 2.5%. Also, SCHUTZ et al. (1992) using an animal model estimated small values for ratios of variances for maternal genetic effects to phenotypic variances for milk yield (2.58%) and fat percentage (6.5%) and for covariances between maternal and direct effects for milk yield (5.99%).

Maternal genetic effects have been described in domestic mammals such as swine (SOUTHWOOD and KENNEDY, 1990) and beef cattle (DODENHOFF et al., 1999) and represent an environmental effect on the growth of offspring from birth to weaning. However, dairy calves are separated from their dams at birth so that the influence of the dam would be only through intrauterine environmental (ALBUQUERQUE et al., 1998). In addition, uterine environmental and the maternal colostrum may also contribute to the maternal genetic effects.

Also when Table 4 was investigated, a similar trend was reported by ALBUQUERQUE et al. (1998) which found that heritability estimates of direct genetic effects increased by 0.014, 0.021 and 0.046 for milk yield, fat yield and fat %, respectively, when additive genetic maternal effects and covariance between direct and maternal genetic effects are removed from the analysis. The same authors also concluded that, some confounding between direct and maternal genetic effects should be expected because the dam that contributes the maternal genetic effect also transmits half of her genetic value for direct effects in her daughter. Some cows do not have lactating daughters, and many sires do not have any lactating granddaughters. Also, SCHUTZ et al. (1992) arrived at the same conclusion; found that maternal genetic effects are not important for yield traits of dairy cattle.

In addition, ROUGHSEDGE et al. (2000) working on 55230 Holstein Cows in UK, using two animal models with and without maternal effects, found that heritability for 305 day milk yield were 0.436 (0.017) and 0.436 (0.015) with and without maternal effects, respectively. The same authors reported that no significant components of variance attribute to maternal effect.

About heritability estimates of Holstein Friesian in warm climate areas reported some authors (TAWFIK et al., 2000, (0.22); ATIL, 2000, (0.13); ATIL and KHATTAB, 2000, (0.27); ULUTAS et al., 1999, (0.22); WOLLNY et al., 1998, (0.24); AMIN et al., 1996, (0.25)). While, the present estimate is lower than those reported by EL-

ARIAN et al. (2002) working on Holstein Friesian cattle in Japan and Egypt. In addition, ALBUQUERQUE et al. (1995) working on first lactation yields of milk, fat and protein from Holstein cows in New York and California, using multi trait animal model, found that heritability for milk yield were 0.30 and 0.33 for New York and California, respectively. The same authors concluded that heritability estimates with animal model vary, but most are higher than those obtained with sire model. In this respect, CUE et al. (1987) using sire model with Canadian data, reported that heritability estimates of 0.36 for milk yield. Direct heritability estimates for AFC (0.77, Table 4) was similar to the value (0.75) obtained by KHATTAB and ATIL (2003) working on Holstein Friesian cattle in Turkey and using multi trait animal model. While, the present estimate was higher that that reported by KHATTAB and SULTAN (1991) (0.38).

Also genetic correlations are investigated in this study similarly with our results, TONHATI et al. (2000) found that the genetic correlation between milk yield and AFC was 0.63 while, negative genetic correlation between 305 dMY and AFC was reported by KHATTAB and SULTAN (1991) (-0.01) and KHATTAB and ATIL (2003) (-0.22). All genetic correlations between direct and maternal genetic effects for both traits are negative and ranged from -0.45 to -0.96 (Table 4).

According to moderate direct heritability for 305 dMY and high heritability for AFC, it could be concluded that the genetic improvement in milk yield and age at first calving can be achieved through selective breeding programs and genetic progress can be achieved if the farms adopt tests for the genetic evaluation of sires. Also, the higher estimates of direct heritability for AFC reported by KHATTAB and SULTAN (1991), they concluded that the large sire variance in AFC is due to confounding of sire with management. In addition TONHATI et al. (2000) on Murrah buffaloes, in Brazil, concluded that the genetic change for milk yield and AFC is possible by selecting the most productive animals.

Due to small amount of additive maternal genetic effects for 305 dMY and AFC, it could be concluded that the additive maternal genetic effects and the covariance between additive maternal and direct genetic effects do not seem to make important contributions to the phenotypic variance of milk yield and age at first calving, probably because the important environmental influence of the dams on their calves is from conception to birth.

The positive genetic correlation between 305 dMY and AFC (0.31), suggested that when milk yield is the selected variable there could be an increase of AFC. From these results it is reasonable to conclude that milk yield and AFC should be considered independently in the creation of cow selection programs. Negative genetic correlations among direct and maternal effects for both traits ranged from -0.45 to 0.96. LEE and POLLAK (1997) suggested that negative estimates of direct-maternal genetic correlations were inflated when the effects of sireXyear interaction were not included in the model. In addition, LEE et al. (2000) concluded that a reason for why the estimate is so large and negative is not apparent although one reason may be that the pedigree structure might not be adequate for obtaining estimates of both direct and maternal heritabilities and the direct-maternal genetic correlations. Therefore, more research work, in this respect, is needed by using a large date sets and including other milk traits (i.e. fat and protein yield as well a somatic cell score).

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