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GENETIC STUDY ON MILK PRODUCTIVE TRAITS USING FIRST LACTATION RECORDS

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SUMMARY

Totals of 1689 first lactation records of Friesian cows were used in the present study. Number of sires and the average number of daughters per sire (k) were 240 and 6.4, respectively. These data were used to estimate genetic and phenotypic parameters for total milk yield (TMY), 305-day milk yield (305-DMY), lactation period (LP) and productive efficiency (PE). The statistical model included the effect of sire as random effect, season and year of calving as fixed effects and both age at first calving (AFC) and weight at calving (WC) as covariate on milk production traits. The arethmatic means of TMY, 305-DMY, PE and LP were 3681, 3181, 2.79 kg and 338 d, respectively. Season of calving had significant ($P < 0.01$) effect on 305-DMY. Whereas it had non-significant effects on the other studied traits. Year of calving had a highly significant ($P < 0.001$) effect on the different studied traits except for LP the effect was not significant. Estimates of partial linear regression coefficients of TMY and 305-DMY on AFC and WC were highly significant ($P < 0.01$ or 0.001). Estimates of partial quadratic regression coefficients of all studied traits on AFC and/or WC were not significant. Sire of heifers had a highly significant ($P < 0.001$) effect on all traits studied except for LP. The sire variance component (σ^2_s) ranged between 3.32 to 12.7% of the total variance for all milk production studied traits. Heritability estimates (± S.E) for TMY, 305-DMY, PE and LP were 0.420 ± 0.083, 0.513 ± 0.088, 0.385 ± 0.082 and 0.133 ± 0.068, respectively. Highly positive and significant genetic and phenotypic correlations were found among the different studied traits.

Keywords: Friesian, milk traits, genetic parameters

INTRODUCTION

Friesian cattle are considered to be the main foreign dairy cattle breed that has been more distributed in Egypt. During the last two decades, the number of Friesian herds began to be increased either in governmental or commercial farms. Genetic evaluation of these herds from time to time is needed to identify the potentiality of these animals for production under Egyptian conditions in order to achieve maximum genetic improvement.

The genetic improvement of dairy cattle seldom involves only one economical trait. For a successful breeding program an understanding of the degree of genetic, phenotypic and environmental association among traits is essential. The high estimates of heritability for milk traits in the first parity give more accurate estimates for cow breeding value than using multiple lactations (Swalve and Van Vleck, 1986; Soliman *et al.*, 1990 and Soliman and Khalil, 1993). Therefore using first lactation records seems to be adequate for proving sires (Genena, 1998).

The objectives of this study were: 1) to study the effect of sire, season and year of calving, age at first calving and weight at first calving on total milk yield (TMY), 305-day milk yield (305-DMY), lactation period (LP) and productive efficiency (PE) expressed as milk yield (kg) per day of life from birth to the end of the first lactation period and 2) to estimate genetic, phenotypic and environmental parameters for these traits in governmental herd of Friesian cattle using first lactation records under the conditions of Nile-Delta region in Egypt.

MATERIALS AND METHODS

The data used in this study were derived from 1689 first lactation records collected during the period from 1971 to 1995. These animals were maintained at Sakha Research Station, Kafr El-Sheikh Governorate, belonging to Animal Production Research Institute, Ministry of Agriculture. The farm located at the northern middle part of the Delta, Egypt. The numbers of sires and daughters per sire (k) used in this study were 240 and 6.4, respectively.

The animals were kept in open shaded yards under the feeding and management system of Animal Production Research Institute. During winter and spring seasons (from December to the end of May), the animals were fed on Berseem (*Trifolium alexandrinum*) and supplemented with rice straw. During summer and autumn seasons (from June to the end of November), they were fed pellets of concentrates mixture, rice straw, and clover hay. Concentrate mixture was given twice a day to the milking cows according to their average daily milk yield and to dried cows (those in the last two months of pregnancy period) according to their body weight. The lactating cows were milked twice a day at 7.00 a.m. and 4.00 p.m. Cows were dried off about two months before the expected calving date.

Cows were artificially inseminated using frozen semen at least 45 days after calving. Heifers were put for insemination for the first time when they reached about 350-kg body weight or 18 months of age, whichever comes first. Pregnancy was detected by rectal palpation 60 days after service and cows and heifers failed to conceive were artificially inseminated again in the next heat.

Statistical analysis

Data were analyzed using linear mixed model least squares and maximum likelihood (LSMLMW) computer program of Harvey (1990). The following mixed model was used to analyze total milk yield (TMY), 305-days milk yield (305-DMY) and lactation period (LP):

$$Y_{ijkm}=\mu+S_i+M_j+Y_k+bL_1(x_1-\bar{x}_1)+bQ_1(x_1-\bar{x}_1)^2+bL_2(x_2-\bar{x}_2)+bQ_2(x_2-\bar{x}_2)^2+e_{ijkm}$$

where :

Y_{ijkm} = the individual observation;

μ = the overall mean;

S_i = the random effect of the ith sire;

M_j = the fixed effect of the jth season of calving, j = 1, 2, 3, and 4 (winter from Jan. to March, spring from April to June, summer from July to September and autumn from October to December);

Y_k = the fixed effect of the kth year of calving, k = 1, 2, 3, ….., 25 (from 1971 to 1995);

bL_1&bQ_1= partial linear and quadratic regression coefficients for the studied traits on age at first calving;

bL_2&bQ_2= partial linear and quadratic regression coefficients for the studied traits on cows weight at calving (WC).

x_1 = months of age at first calving of cow (AFC), $\bar{x}_1$ averageAFC;

x_2 = kg of weight at calving (WC), $\bar{x}_2$ average WC and;

e_{ijkm} = residual term assumed to be randomly as a normaly distributed with mean zero and variance σ^2.

The same model was used also to analyze productive efficiency (PE) without including age at first calving as covariate. Productive efficiency (kg/day) was calculated as follows:

Productive efficiency (PE) = Total milk yield (kg) / age of cow from birth to the end of first lactation period (day).

Heritability estimates (h^2) were computed by the paternal half-sibs method according the formula:

$$h^2 = 4\sigma^2s / (\sigma^2s + \sigma^2e)$$

Estimates of heritability (h^2) and genetic, phenotypic and environmental correlation coefficients among different traits were computed by the LSMLMW program of Harvey (1990). All estimates were based on 1689 first lactation records.

RESULTS AND DISCUSSION

Actual means:

Arethmatic means, standard deviation (SD) and coefficient of variation (CV%) of TMY, 305-DMY, LP and PE are presented in Table 1. The present means of TMY, 305-DMY and LP (3681, 3181 kg and 338 days, respectively) generally fall within the range of those estimates reported in most studies carried out on the first lactation of Friesian cows in Egypt (El-Bayomi, 1986; Khattab and Ashmawy, 1988; Afifi *et al.*, 1992 a&b; Abdel Glil, 1996; Shalaby, 1996; El-Awady, 1998 and Salem and Kassab, 1999). Concerning PE, Morsey *et al.* (1986) reported that milk production per day of age at first calving was 3.62 kg. The differences between the present values of milk production traits and those reported in the literature may be due to the differences in genotype, management, weather, number of records used and years of the study.

Table 1. Arithmetic means, standard deviations (SD) and coefficients of variation (CV%) of milk production traits and productive efficiency in the first lactation (n = 1689)

Trait	Abbreviation	Mean	SD	CV %
Total milk yield (kg)	TMY	3681	1532	42.0
305-day milk yield (kg)	305-DMY	3181	1004	31.2
Lactation period (day)	LP	338	111	31.3
Production efficiency (kg/d)	PE	2.79	1.47	38.7

* Coefficient of variation computed as the percentage of the square root of the residual mean squares divided by the overall least squares means of a given trait according to Harvey (1990).

Non-genetic effects

Least squares means and mean squares for milk production traits and productive efficiency are presented in Tables 2 and 3, respectively.

Table 2. Least squares means (±SE) for milk production traits and productive efficiency as affected by different factors

Classification	No. of obs.	Milk production traits TMY (kg)	305-DMY (kg)	LP (day)	PE (kg/d)
Overall mean	1689	3475 ± 91	2912 ± 62	354 ± 5	2.49 ± 0.05
Season of calving:					
Winter	566	3549 ± 111	2938 ± 73	353 ± 7	2.58 ± 0.06
Spring	415	3473 ± 115	2897 ± 75	360 ± 7	2.49 ± 0.07
Summer	324	3309 ± 123	2778 ± 80	347 ± 8	2.38 ± 0.07
Autumn	384	3568 ± 120	3034 ± 78	355 ± 8	2.52 ± 0.07
Year of calving:					
1971	130	4599 ± 634	4318 ± 395	323 ± 48	3.96 ± 0.41
1972	134	4491 ± 589	4214 ± 367	324 ± 45	3.78 ± 0.38
1973	109	4855 ± 488	4244 ± 305	316 ± 37	3.84 ± 0.31
1974	141	5302 ± 462	4637 ± 288	322 ± 35	4.20 ± 0.30
1975	81	4181 ± 473	3468 ± 295	312 ± 36	3.38 ± 0.30
1976	99	2814 ± 454	2687 ± 283	296 ± 34	2.92 ± 0.29
1977	82	3163 ± 444	2892 ± 277	329 ± 33	2.47 ± 0.29
1978	103	2941 ± 402	2521 ± 251	326 ± 30	2.18 ± 0.26
1979	73	3021 ± 452	2648 ± 282	297 ± 34	2.26 ± 0.30
1980	66	2835 ± 422	2505 ± 264	309 ± 32	2.07 ± 0.28
1981	24	2701 ± 562	2322 ± 350	320 ± 43	2.11 ± 0.37
1982	38	3764 ± 416	2950 ± 260	380 ± 31	2.71 ± 0.27
1983	44	4049 ± 446	3183 ± 278	409 ± 34	2.88 ± 0.29
1984	47	4058 ± 420	3139 ± 262	417 ± 32	2.77 ± 0.27
1985	34	4307 ± 423	3416 ± 264	425 ± 32	2.99 ± 0.28
1986	60	3523 ± 394	2729 ± 246	423 ± 30	2.37 ± 0.26
1987	53	2994 ± 396	2291 ± 248	385 ± 30	1.94 ± 0.26
1988	56	2743 ± 411	2118 ± 257	366 ± 31	1.77 ± 0.27
1989	65	2760 ± 409	2184 ± 256	378 ± 31	1.80 ± 0.27
1990	48	2583 ± 429	2001 ± 268	334 ± 32	1.68 ± 0.28
1991	41	2570 ± 474	1979 ± 296	344 ± 36	1.60 ± 0.31
1992	30	2597 ± 513	2085 ± 320	347 ± 39	1.48 ± 0.33
1993	31	3091 ± 548	2380 ± 342	388 ± 41	1.73 ± 0.34
1994	60	3587 ± 537	2975 ± 334	411 ± 41	2.15 ± 0.34
1995	40	3348 ± 600	2909 ± 374	360 ± 45	1.98 ± 0.34
Regression on:					
Age at first calving (Linear)		30.6 ± 11.7	26.5 ± 7.31	0.30 ± 0.89	--------
Age at first calving (Quad.)		– 2.54 ± 1.53	– 0.613±0.95	– 0.21± 0.12	--------
Weight at calving (linear)		4.11 ± 1.05	4.51 ± 0.65	0.07 ± 0.08	0.001±0.0
Weight at calving (quad.)		0.01±0.008	0.003±0.005	–0.0005±0.0	0.0 ± 0.0

Table 3. Least squares analysis of variance for factors affecting milk production traits and productive efficiency

Source of variation	d.f	Mean squares and significant			
		TMY	305-DMY	LP	PE
Sire	239	3721182 ***	1596907 ***	14992 *	1.56 ***
Season of calving	3	3875996 NS	3114470 **	8199 NS	1.99 NS
Year of calving	24	12273542 ***	8199888 ***	14287 NS	7.37 ***
Regression on:					
AFC (linear)	1	14490233 **	10811805 ***	1387 NS	-----
AFC (quadratic)	1	5882231 NS	342525 NS	40272 NS	-----
WC (linear)	1	32803937 ***	39467432 ***	8645 NS	2.64 NS
WC (quadratic)	1	3923357 NS	260610 NS	7732 NS	0.55 NS
Remainder	1418	2127057	823669	12294	0.93

NS = not significant. *, ** and *** = significant at $P < 0.05$, 0.01 and 0.001, respectively.

Season of calving had significant ($P < 0.01$) effect on 305-DMY. Whereas it had non-significant effects on the other studied traits. The present results indicated that cows calved in autumn and winter seasons (from October to March) cows produced the highest 305-DMY (3034 and 2938 kg, respectively). While cows calved in spring and summer seasons (from April to September) yielded the lowest 305-DMY (2897 and 2778 kg, respectively). The significant effect of season of calving on 305-DMY was reported by many authors working on different breeds of dairy cattle in Egypt or in other countries (e.g. Leroy *et al.*, 1979; Chew *et al.*, 1982; El-Bayomi, 1986; Juma and Jajo, 1986; Panneerselvam *et al.*, 1993 and Abdel-Glil, 1996). Such significant effect may be due to variations in atmosphere and feedstuffs available at different seasons of the year.

Year of calving had a highly significant ($P < 0.001$) effect on the different studied traits except for LP the effect was not significant (Table 3). These results are in close agreement with the findings on dairy cattle raised in Egypt or in other countries as reported by Ashmawy (1981); Chew *et al.* (1982); El-Bayomi (1986); Morsey *et al.* (1986) and Sallam *et al.* (1990); El-Barbary *et al.* (1992) Gad (1995); El-Nady (1996); Salem and Kassab (1999). The present results indicate that the changes in milk production from year to another may be due to the changes in number of animals of the herd, management and climatic conditions from year to year which consequently affect on the milk production.

Least squares analysis of variance (Table 3) shows that values of partial linear regression coefficients of TMY and 305-DMY on AFC and/or WC were highly significant ($P < 0.01$ or 0.001). Meanwhile, these regression coefficients were not significant in the case of LP and PE. On the other hand, values of partial quadratic regression coefficients of all studied traits (i.e. TMY, 305-DMY, LP and PE) on AFC and/or WC were not significant. All values of linear regression coefficients were positive. Meanwhile negative linear regression coefficients were observed in the case of quadratic regression coefficients except for quadratic regression coefficients of TMY and 305-DFY on weight at calving were positive (Table 2). Garcha *et al.* (1991) found significant effect of AFC on milk yield per day of age at first calving.

Estimates of regression coefficients given in Table 2 indicate that all milk production traits increased with the increase in AFC. However, the reduction in AFC is desirable for dairy cattle breeders to prolong the longevity of the herd and to reduce as possible as the cost of rearing the heifers (Mostafa *et al.*, 1999). The linear or curvilinear relationships of TMY, 305-DMY and/or LP traits on AFC reported here followed similar trend reported also by Sallam *et al.* (1990); Khattab and Sultan (1991); Khattab *et al.* (1994); Abdel Glil (1996); Mostafa *et al.* (1999) and Salem and Kassab (1999).

Sire variance components (σ^2_s)

Least squares analysis of variance for effect of sire (as random effect) on all milk production traits studied and PE is shown in Table 3. Sire variance components and proportions of variance are shown in Table 4. Results obtained in the present study show that the sire of heifers had a highly significant ($P<0.001$) effect on all traits studied except for LP which was only significant ($P < 0.05$). The present results indicate the possibility of genetic improvement in milk production traits through sire selection, which is well established by many investigators (e.g. Aboubakar *et al.* 1986; Afifi *et al.*, 1992a; El-Awady, 1998; Badawy and Oudah, 1999; Mostafa *et al.*, 1999; Salem and Abdel Raouf, 1999; and Salem and Kassab, 1999).

Table 4. Estimation of sire variance components (σ^2_s) and error variance components (σ^2_e) and proportion of variance (V%) due to random effect (sire) for different studied traits

Trait	Sire		Error	
	(σ^2_s)	(V%)	(σ^2_e)	(V%)
TMY	249563	10.5	2127058	89.5
305-DMY	121052	12.7	823669	87.2
LP	422	3.32	12294	96.7
PE	0.099	9.61	0.931	90.4

d.f of sires and error components were 239 and 1418, respectively.

The proportion of sire variance components (σ^2_s) adjusted for fixed effects of environmental factors ranged between 3.32 to 12.7% of the total variance for all milk production studied traits (Table 4). These estimates are in agreement with the findings of El-Awady (1998) on Friesian cattle (4.63 – 10.75%); Mostafa *et al.* (1999) working on Holstein-Friesian cattle (1.37 – 13.6%). Meanwhile, El-Nady (1996) working on Friesian cattle in Egypt found that the effect of sire of the cow on LP was not significant.

Heritability estimates and correlation coefficients:

Heritability estimates (±SE) based on paternal half-sibs for milk productive traits and productive efficiency of the first lactation as well as genetic, phenotypic and environmental correlation coefficients among milk production traits (i.e. TMY, 305-DMY and LP) are presented in Table 5.

Table 5. Heritability estimates ± SE (on diagonal) and genetic ± SE (below diagonal), phenotypic (above diagonal) and environmental (between parentheses) correlations among milk production traits

Trait	TMY	305-DMY	LP	PE
TMY	**0.420 ± 0.083**	0.797 (0.665)	0.748 (0.761)	
305-DMY	0.955 ± 0.031	**0.513 ± 0.088**	0.526 (0.578)	
LP	0.884 ± 0.105	0.578 ± 0.165	**0.133 ± 0.068**	
PE				**0.385 ± 0.082**

The estimates of heritability reported in the present study fall within the range of the estimates of heritabilities reported by different authors working on Friesian cattle in Egypt (e.g. Abdel Glil 1996; Shalaby, 1996; El-Awady, 1998; Badawy and Oudah, 1999; Salem and Abdel Raouf, 1999 and Salem and Kassab, 1999) which ranged from 0.12 to 0.52 . From the heritability estimates obtained in the present study for TMY, 305-DMY and PE, It could be concluded that the high hertitability estimates indicate that improvement of these traits could be achieved through selection. Badawy and Oudah (1999) and Mostafa *et al.* (1999) came to the same conclusion.

The genetic correlation coefficients between TMY and each of 305-DMY and LP were positive and highly significant (0.955 ± 0.031 and 0.884 ± 0.105, respectively). Similar results were found by Badawy (1994); Tag El-Dein (1997); El-Awady (1998) and Badawy and oudah (1999) who reported that genetic correlations between TMY and 305-DMY were 0.90, 0.96, 0.98 and 0.913, respectively. Also, the genetic correlation between TMY and LP was positive and highly significant, being 0.884 (Table 5). The present results are similar to those reported by Ragab *et al.*. (1973); Abubakar *et al.*. (1986); Khattab and Sultan (1990); Sallam *et al.*. (1990); Abdel Glil (1991); Tag El-Dein (1997) and El-Awady (1998) and Badawy and Oudah (1999) working on different sets of Friesian cows in Egypt. The high positive genetic correlation between lactation period and total milk yield (r_G = 0.884) indicate that genes associated with long lactation period are likely to be correlated with genes favorable for milk yield (Badawy and Oudah, 1999).

Estimates of phenotypic correlation between TMY and each of 305-DMY and LP were positive and highly significant (0.797 and 0.748, respectively) and between 305-DMY and LP being 0.526 as shown in Table 5. These results are in the agreement, in most cases, with those reported by Ragab *et al.*. (1973); Khattab and Sultan (1990); Abdel Glil (1991); Tag El-Dein (1997) and Badawy and Oudah (1999) on Friesian cattle in Egypt.

The environmental correlation coefficients among all traits were less than the values of genetic correlation coefficients (Table 5) except for the genetic and environmental correlation coefficients between 305-DMY and LP were equal (0.578) which may be due to more contribution of additive genetic deviation. Weller *et al.* (1986) and Mostafa *et al.* (1999) came to the same conclusion.

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