Genetic aspects of lactation curve traits and persistency indices in Friesian cows

H.G. El-Awady[1]

Animal Production Department, Faculty of agriculture, Kafrelsheikh University, PC: 33516, Kafrelsheikh, Egypt

SUMMARY

A total of 4769 lactation records of 995 Friesian cows mated by 109 sires during the period from 1988 to 2008 were used to estimate lactation curve and breeding values (BV) for 305day milk yield (305dMY), lactation period (LP), peak yield (PY) and persistency indices (P_1, P_2 and P_3). Data were analyzed using General Linear Model of SAS to determine the significant fixed effects. A Multi-trait animal model with Derivative-Free Restricted Maximum Likelihood procedures was used to estimate genetic and phenotypic parameters and breeding values for different traits studied. Month and year of calving, parity, and farm were considered as fixed effects in the analytical model, while animal, permanent environmental and residuals were included in the model as random effects. Means of 305-dMY, LP, PY, P_1, P_2 and P_3 were 3407 kg, 292 d, 440 kg, 1.17, 5.66 and 10.8, respectively. Heritability estimates for the same traits were 0.30, 0.24, 0.29, 0.55, 0.67 and 0.39, respectively. Genetic correlations between different traits studied were positive and ranged from 0.87 to 0.97 for production traits, from 0.98 to 1.00 for persistency indices and from 0.29 to 0.78 between production traits and persistency indices. Average breeding values were 1678.19 kg for 305-dMY, 146.24 days for LP, 121.40 kg for PY, 1.03 for P_1, 8.23 for P_2 and 14.15 for P_3, respectively. Product moment correlation between BV estimates of different traits studied was positive and ranged from 0.55 to 0.80 for production traits, from 0.33 to 0.71 for persistency indices and production traits and from 0.95 to 0.98 for persistency indices. According to the moderate heritability estimate for milk traits, the high product correlations between BV for persistency indices estimates, it could be concluded that genetic improvement in milk production can be achieved through a selective breeding program. Selecting cows for peak yield will improve persistency and lactation curve traits in Friesian cows.

Keywords: breeding value, dairy cattle, Friesian, lactation curve, peak yield, persistency indices

---

[1] Corresponding author: hassanelawady63@yahoo.com

INTRODUCTION

A graphical representation of the rate of milk secretion during a lactation of dairy animals is known as lactation curve. The shape of lactation curve is characterized by slope of lactation curve during the initial rise of the curve, peak yield, time required to attain the peak yield (peak period), slope of the curve after peak yield (persistency) and lactation length. All these characteristics in turn are responsible for total lactation milk yield. Peak yield and persistency are economic traits of dairy animals. The peak yield appears in the early stage of lactation and can be measured very easily but it is very difficult to measure persistency.

Persistency of lactation is the ability to maintain a relatively high level of production throughout the lactation period. This ability contributes greatly to the income from the operating producing herd. An animal with a high persistency index is indicative of a good producer. Persistency, peak yield and lactation length are main determinants of lactation yield. High persistent cows are expected to have higher lactation production, longer productive life and considered as efficient producers (Singh et al., 2002). On average, the ascending phase day does not extend for more than 10 weeks from the date of calving. Thereafter, there is a decline in production which may be very rapid in some cows (non-persistent) and slow in others (persistent cows). Additionally, genetic evaluations for persistency can be used to increase the average level persistency in the herd through selection (Dekkers et al., 1998). Some sire's superiority for production comes during ascending phase of lactation while for others, it shows up during descending phase of lactation and still others are consistent throughout the lactation (Jamkozik and Schaeffer, 2001). The selecting for animal persistency proofs will lead to balance between the selection of sires for greater persistency and greater production for 305-day milk yield, lactation period and peak yield traits.

Therefore, the purpose of this study was to estimate genetic parameters, breeding values (BV's) and product moment correlation between BV's for these traits to improve milk traits in Friesian cattle under Egyptian conditions.

MATERIALS AND METHODS

Source of data

Data utilized in this study was obtained from Sakha and El-Gammeza Experimental Stations, belonging to the Animal Production Research Institute (APRI), Ministry of Agriculture, Egypt. Data consisted of 4769 records of 995 Friesian cows mating by 109 sires during the period from 1988 to 2008. Abnormal records of cows and records without pedigree and breeding dates were excluded from the data.

Feeding and management

Animals in two farms were kept under the same system of feeding and management applied by APRI. Cows were fed according to their live body weight, milk production level and pregnancy status according to NRC (2001) recommendations. During winter and spring months (from December to May), animals were supplied with Egyptian clover (*Trifolium Alexandrenum*), while during summer and autumn months (from June to the end of November), animals were fed on dry ration, mainly either Berseem hay or green sorghum. Also, rice straw was available all the year round. Cows were machine milked twice a day at 7.00 am and 4.00 pm. Milk yield was recorded to the nearest 0.1 kg daily at each milking. Cows were usually milked until two or three months before the expected date of calving. Then if they did not go dry, they were dried off gradually by milking them once a day until complete drying off. Artificial insemination was used for Heifers and cows. Heifers were served for the first time when reached 18-20 months of age or 350 kg of weight which comes first. Cows were usually served two months after parturition. Pregnancy was detected by rectal palpation 60 days after the last mating.

Studied traits

The studied traits were 305-day milk yield (305dMY, kg) as the milk produced by a cow averaged for 305-day, lactation period (LP), the period from the beginning after calving by 5 days to the normal end of lactation in days and peak yield (PY), the maximum monthly production of milk in the same lactation.

Persistency (P)

Three persistency indices were used in the present study, which were computed for each lactation as follows:

P_1 is the persistency index No. 1
= 2^{nd} 100 day milk yield / 1^{st} 100 day milk yield (Danell, 1982).
= milk yield (days 121-210) divided by milk yield (days 31-120).
P_2 is the persistency index No. 2
= lactation milk yield / peak yield (Rao and Sanderson 1982).
= lactation milk yield divided by the maximum milk yield (peak yield).
P_3 is the persistency index No. 3
= 5^{th} month milk yield / peak yield (Weller et al. 1987).
= lactation yield in five months postpartum divided by the peak yield postpartum.

Statistical analysis:

Preliminary statistical analysis was carried out by General Linear Model (GLM) procedure of SAS (2006) to determine the significant fixed effects to be included in the final model. The statistical model included month (1 to 12) and year (1988 to 2008) of calving, parity of the cow (1 to ≥5) and farm (1 = Sakha and 2 = El-Gammeza). The effects being significant (P<0.05 and/or P<0.01) for each trait were included in the final statistical model. Covariance components among all traits were obtained with Derivative-Free Restricted Maximum Likelihood (REML) procedures using the MTDFREML program of Boldman et al. (1995). The following statistical model was used:

$Y_{ijklmno} = \mu + a_i + C_j + M_k + Y_l + P_m + F_n + e_{ijklmno}$

where:

$Y_{ijklmno}$ = observation of productive traits,

μ = overall mean,

a_i = additive genetic random effect of the ith sire,

C_j = permanent environmental random effect of the jth cow,

M_k = fixed effect of month of calving k (k=1, 2,……12),

Y_l = fixed effect of lth year of calving (l=1988, 1989, to 2008),

P_m = fixed effect of mth parity (lactation order) (m=1, 2, to ≥ 5),

F_n = fixed effect of nth farm (l= 1= Sakha, 2 = El-Gammeza) and

$e_{ijklmno}$ = random error.

Convergence was reached when the simplex variance was less than $\mathbf{10^{-8}}$ and then several extra rounds of iterations were executed to ensure that a global maximum was reached. Best Linear Unbiased Prediction (BLUP) of estimated breeding value (EBV) was calculated by back-solution using the MTDFREML programme for all animals in the pedigree file for multi-traits analysis.

RESULTS AND DISCUSSION

Means, standard deviations, coefficients of variation (CV%) and test of significance for the different traits in the present study are presented in Table 1. Coefficients of variation ranged between 33.8 to 73.6% and were higher than those reported by El-Arian and Shalaby (2001b), working on 1161 first lactations, ranging from 8.2 to 36.6%. Abdel-Glil et al. (2004), working on Friesian cows, found that the coefficient of variation of LP was 22%, while 305 day milk yield (305dMY) was 40%. The relatively high coefficients of variability in this present study reflect high genetic and phenotypic variations between animals. The differences between the values in this study and those reported in the literature may also be due to the differences in the number of animals, years, herds and models used in the analysis.

Table 1: Summary of unadjusted means, standard deviations (SD), coefficients of variability (CV%) of the studied traits and test of significance of different factors affecting them (n = 4769).

Item	d. f	Trait†					
		305dMY	LP	PY	P_1	P_2	P_3
Test of significance							
Farm	1	**	**	**	**	**	**
Calving month	11	*	NS	**	NS	NS	NS
Calving year	20	**	**	NS	NS	NS	NS
Parity	4	**	**	**	NS	NS	**
Residual M.S	4732	723578	9301	12940	0.163	7.45	63.8
Mean		3407	292	440	1.17	5.66	10.8
SD		941.8	98.7	116	0.40	2.73	7.98
CV%		39.1	33.8	34.2	34.2	48.2	73.6

NS= not significant, * and **= significant at P< 0.05 and 0.01, respectively. †: 305dMY=305-day milk yield (kg), LP = lactation period (d), PY = peak yield (kg), P1, P2 and P3 = persistency indices.

The effect of farm was highly significant (P<0.01) for all the studied traits (Table 1). The present results show that cows at Sakha farm had higher 305-dMY, LP and PY than those at the El-Gammeza farm (Figure 1 and Figure 5). In this respect the significant effect of farm on 305-dMY and PY was also reported by Rekik et al. (2003), Ali et al., (2004) and Gamal El-Dien (2006). Month of calving had no effect on different traits studied except 305dMY and PY (P<0.05 and P<0.01). In addition, winter (December, January and February) and spring (March, April and May) calvers had the highest value in 305dMY, while summer (June, July and August) and autumn (September, October and November) calvers produced the low (Figure 3). Moreover, autumn and winter calvers had higher values in PY than summer and spring calvers (Figure 3).

The high yield in winter and spring calvers could be attributed to mild climatic conditions, resulting in abundant growth and availability of food quality fodder (Egyptian clovers), normally fed to the animals during the months from December to May. In this period of the year, animals receive a good management such as green fodder. This could be expected to respond well be expressing better production potential, while the decrease in their milk less offered and increase of temperature.

A non-significant effect of month of calving on persistency was reported in Table 1. The cows calving in summer and autumn (July to December) had higher persistency, than those calving in winter and spring (January to June). Year of calving had non-significant effect on different traits studied except on 305-dMY and PY, where the effect was significant (P<0.01) as shown in Table 1 and Figures 4 and 8). Changes in production from year to year could be attributed to changes in herd size, age of animals and improved managerial practices introduced from year to year. Parity had highly significant effect on 305dMY, PY and LP (Table 1, Figures 2 and 6). The results showed that 305-dMY and PY increase with parity till the fourth lactation (Figure 2), while LP decreased with advanced parities (Figure 6).

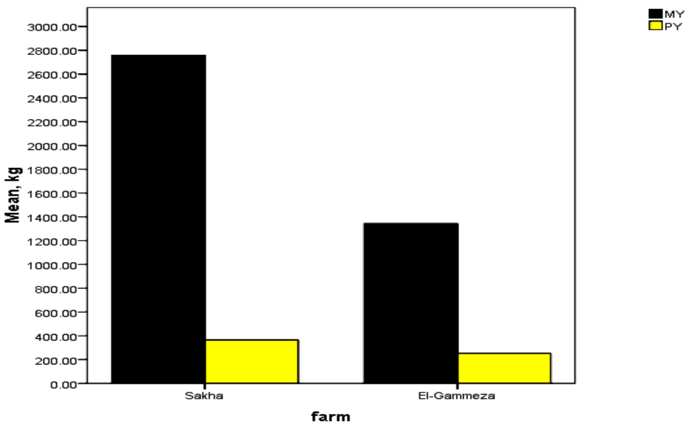

Figure 1: Effect of farm on 305dMY and PY.

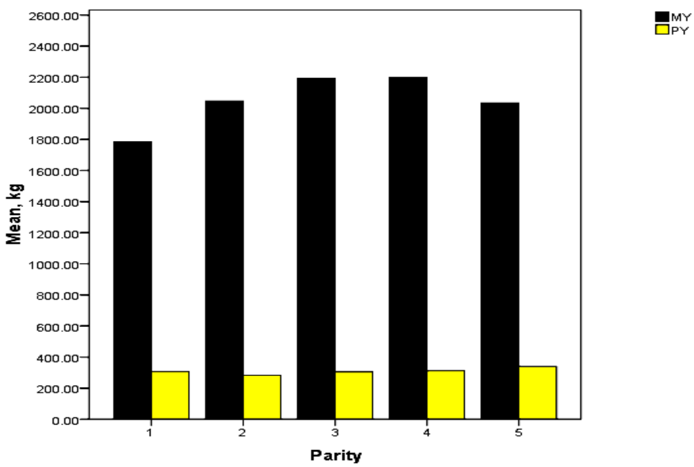

Figure 2: Effect of parity on 305dMY and PY

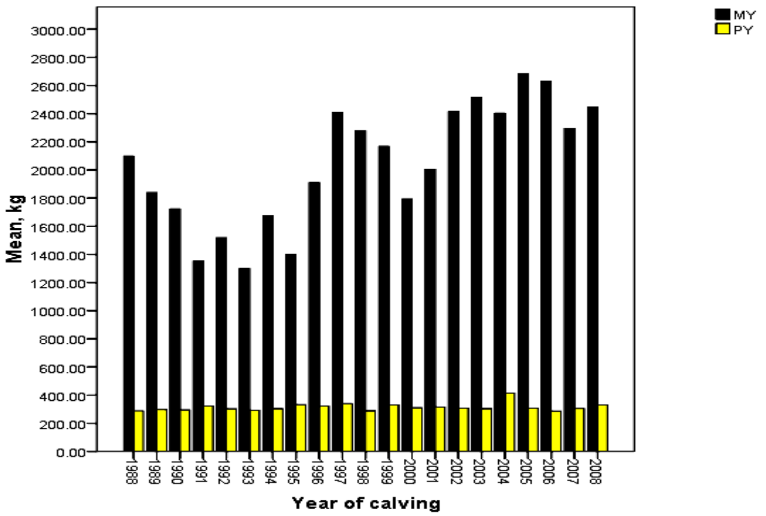

Figure 3: Effect of year of calving on 305dMY and PY

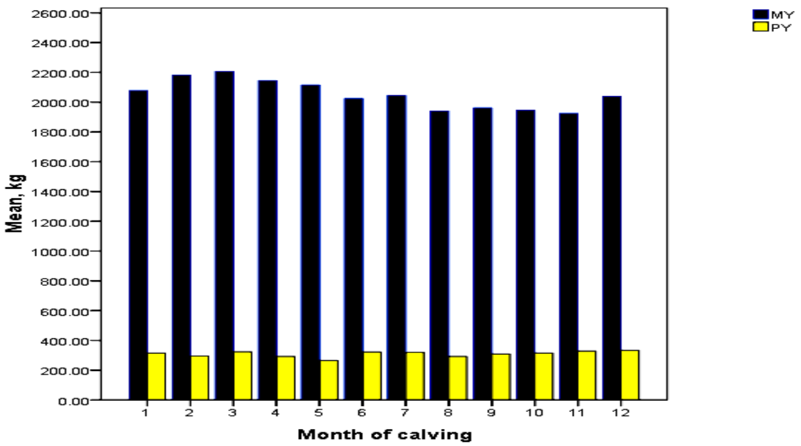

Figure 4: Effect of year of calving on 305dMY and PY

The present results showed that persistency values tended to decrease with advance of age (parity), until the fifth lactation. Older cows were less persistent than the young ones. This may be due to the fact that when the cow gets older it is expected to start its lactation at a higher level, but because the inhibiting effect of pregnancy occurs at about the same stage of lactation, the rate of decline becomes rapid in older cows. The significant effect of parity on persistency in cattle was reported previously by Singh (1995) and Fahim (2004). The present results are in agreement with those of Shah et al. (1983)

who found that persistency tended to be maximum in third and fourth lactations. Ibeawuchi (1984) found that persistency decreased from the first to the second lactation and started to increase in the third but declined again in the fourth lactation.

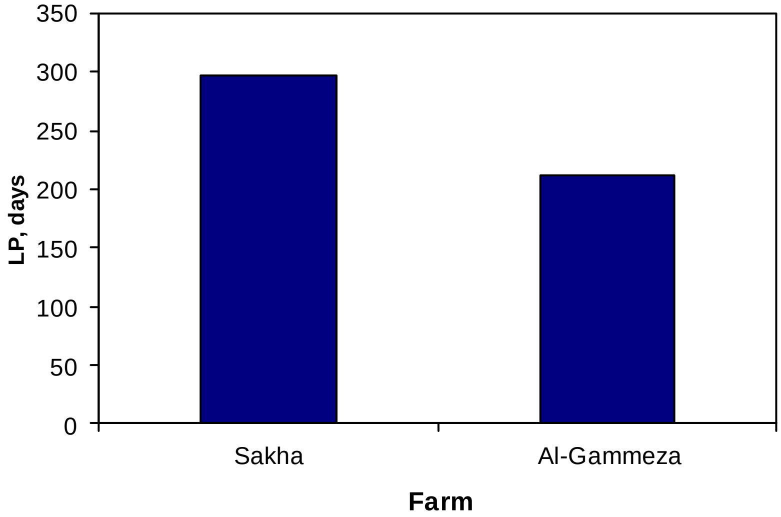

Figure 5: Effect of farm on LP

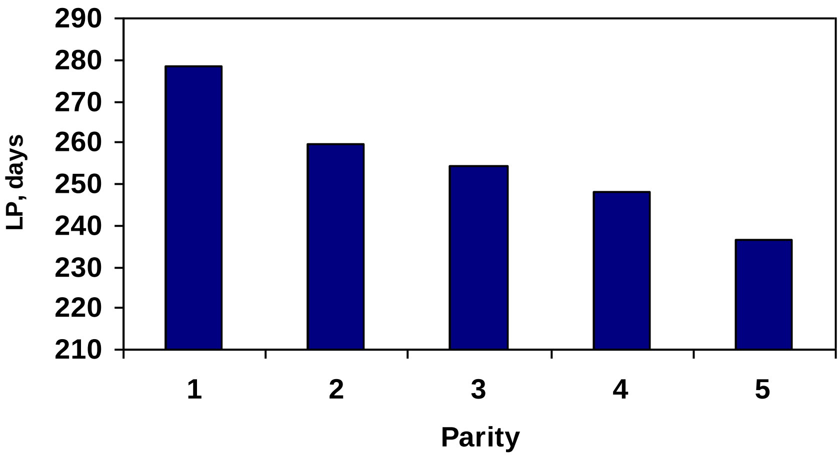

Figure 6: Effect of parity of calving on LP

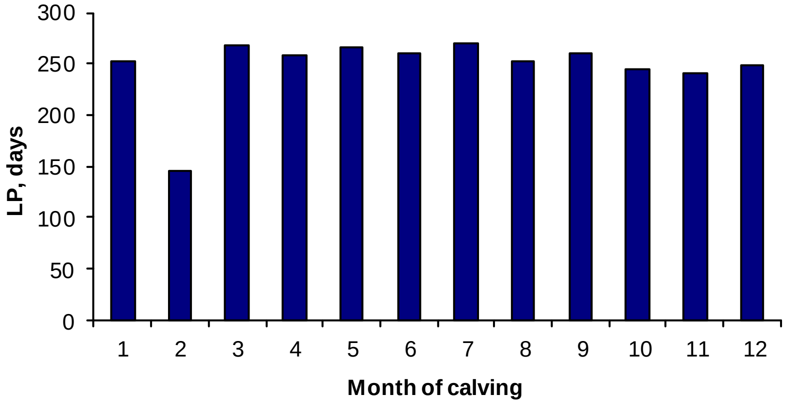

Figure 7: Effect of month of calving on LP

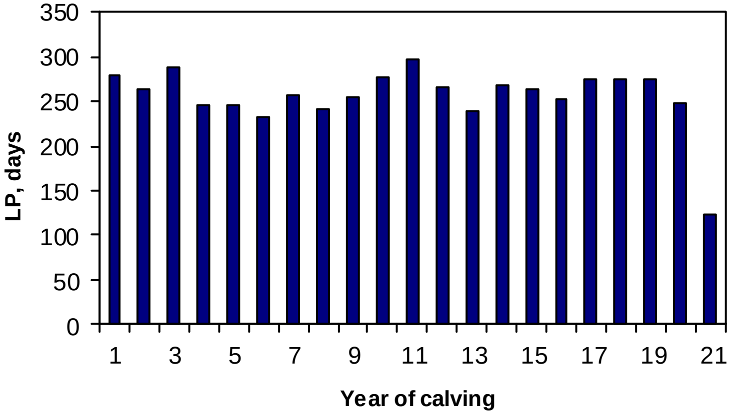

Figure 8: Effect of year of calving on LP

Genetic parameters

Heritability estimates of 305-dMY, LP, PY and P indices were 0.30, 0.24, 0.29, 0.55, 0.67 and 0.39, respectively (Table 2). The estimate of heritability for 305-dMY in the present work correspond with the estimates obtained by Visscher and Goddard (1995) with Jersey cows, Shitta et al. (2002) with Holstein cows, El-Awady, (2002) with German Friesian cows and El-Arian et al. (2003) with Friesian cows, ranging from 0.27 to 0.33. The heritability estimate for LP is in agreement with those reported by Kaygisiz and Vanli (1997) and Shitta et al. (2002) which ranged from 0.19 to 0.30 in dairy cattle. Lower estimates of h^2 of LP were reported by Visscher and Goddard, (1995), Mostafa, (2001), El-Arian et al., (2003), and Abdel-Glil et al. (2004) ranging from 0.01 to 0.17 for different breeds of dairy cattle. On the other hand, higher estimates of h^2 for LP were reported by Sallam et al. (1990) (0.48) for Friesian cattle. The estimate of h^2 for peak yield is in close agreement with that reported by Maarof and Tahir, (1988) (0.28) for Friesian cattle. The highest estimate of h^2 for peak yield was reported by Shrinivaset et al. (1997), being 0.67 with Friesian cows. Fahim, (2004) based on 1923 milk records of Holstein cows, reported that the heritability of persistency of lactation period ranged from 0.01 to 0.06. The heritability estimates of persistency indices raged from 0.39 to 0.67. The heritability of persistency indices was 0.32 with Jersey and Holstein cows (Singh, 1995) and 0.62 for Friesian cows (Kassab, 1995). The lowest h^2 for this trait was reported by Ferris et al. (1985) (0.04), Kaya, (1996) (0.09), Dekkers et al. (1998) (0.13) and Rekaya et al. (2000) (0.14), who used various indices in different breeds of dairy cows in many countries. According to the moderate estimates of h^2 for 305-dMY, LP, PY and persistency indices in the present study, it could be concluded that the genetic improvement in milk traits can be achieved through a selection program.

Genetic correlations between different traits studied were positive and ranged from 0.29 to 1.00 (Table 2). The genetic correlation between milk yield traits were positive and nearest the unity. This agrees with the results reported by Mostafa, (2001) and Abdel-Glil (2004) with Friesian cattle, ranging from 0.97 to 1.00.

Table 2: Estimates of heritability (±SE) on diagonal and genetic correlations (±SE) below diagonal of lactation curve traits and persistency indices.

Trait†	305-d	LP	PY	P_1	P_2	P_3
305dMY	0.30±0.07					
LP	0.89±0.04	0.24±0.05				
PY	0.87±0.06	0.97±0.08	0.29±0.07			
P_1	0.35±0.09	0.52±0.09	0.70±0.08	0.55±0.08		
P_2	0.44±0.09	0.63±0.08	0.78±0.07	0.99±0.01	0.67±0.09	
P_3	0.29±0.10	0.50±0.11	0.73±0.08	1.00±0.01	0.98±0.01	0.39±0.07

†: 305dMY=305 day milk yield (kg), LP = lactation period (d), PY = peak yield (kg), P1, P2 and P3 = persistency indices.

The genetic correlation between 305-dMY and LP (0.89) were positive (Table 2). The estimate is closest to the value obtained by Kassab et al. (2001), El-Arian et al. (2003) and Tag El-Dein and Hussein, (2005) with the Friesian cattle, ranging from 0.80 to 0.97. Ashmawy, (1981) indicated that genes producing animals with long LP are correlated with those genes favourable for milk production and therefore selection against short LP is also expected to be guided against low production. 305-dMY was positively genetically correlated with PY (0.87), similarly Ferris et al. (1985) with Holstein cows, and El-Arian and Shalaby, (2001) with Friesian cows, reported positive genetic association between 305-dMY and peak yield being 0.91 and 0.83, respectively. The genetic correlation coefficients between 305-dMY and persistency indices were positive being from 0.29 to 0.44. The perfect genetic correlation was obtained between 305-dMY and P_2. Ferris et al. (1985) with Holstein cows, found that the genetic correlation between 305-dMY and persistency indices were the highest (0.52). Also, El-Arian and Shalaby, (2001) with Friesian cows, reported that the genetic correlation between 305-dMY and persistency indices was positive and high ranging from 0.21 to 0.79. Shalaby, (2005) with Holstein Friesian cows, found genetic correlation between 305-dMY with persistency was 0.44. The genetic correlation between LP and PY was 0.97 (Table 2). In addition, genetic correlation between LP and persistency indices had positive value. A highly positive genetic correlation of (0.63) was obtained between LP and P_2. Shalaby (2005) reported higher positive genetic correlation between LP and persistency (0.96). The positive genetic correlation between persistency of lactation and PY ranged from 0.70 to 0.78. Fahim (2004) found high genetic correlation between PY and persistency using Holstein cows, (0.82). Ferris et al. (1985) observed the lowest estimates with Holstein cows, (0.20). El-Arian and Shalaby (2001) with Friesian cows, reported the genetic correlation between PY and persistency ranged from 0.003 to 0.80. The genetic correlations between persistency indices in this study were positive and ranged from 0.98 to 1.00 (Table 2).

Sire SBV's for 305-dMY, LP, PY and persistency indices (P_1, P_2 and P_3) are presented in Tables 3. Estimates of SBV's as deviation from the mean ranged from -769.52 to 908.67 kg for 305-dMY, from -98.03 to 48.21d for LP, from -75.55 to 45.85 kg for peak yield, from -0.643 to 0.385 for P_1, from -5.080 to 3.152 for P_2 and from -7.723 to 6.429 for P_3, (Table 3). The present results showed large genetic differences between sires for different traits studied. Similarly, El-Chafie (1981) working on Friesian X Native cattle in Egypt, found that the range of breeding values ranged from -56 to 88 kg for 100-dMY, from -802 to 344 kg for 305-dMY and from -37 to 47 d for LP. EL-Awady (1998) reported that predicted sire value ranged from -336 to 529 kg for 305-dMY, and from -8 to 66 d for LP for Friesian cows in Egypt, from -863.21 to 842.75 kg, from -1.31 to 1.31 d for 305-dMY and LP, respectively for Friesian cows in Germany.

Table 3: Minimum, maximum and range of sire breeding values for different traits.

Trait†	Minimum	Maximum	Range
305dMY, kg	-769.52	908.67	1678.19
LP, d	-98.03	48.21	146.24
PY, kg	-75.55	45.85	121.40
P_1	-0.643	0.385	1.03
P_2	-5.080	3.152	8.23
P_3	-7.723	6.429	14.15

†: 305dMY=305-day milk yield (kg), LP = lactation period (d), PY = peak yield (kg), P1, P2 and P3 = persistency indices.

El-Arian and Shalaby (2001), who analysed 1161 normal first lactation records, reported that the accuracy (R^2) of the breeding values of sires was increased as the number of daughters increased, which indicates the importance of increasing the number of daughters per sire to increase the reliability of sire evaluation, and the BV’s ranged from -529 to 447 for 305-dMY and from -1.41 to 1.07 for peak yield. The presents estimates showed large genetic differences between sires for 305-dMY, which indicate the higher potential for rapid improvement in milk production of Friesian cattle in Egypt through selection. Product moment correlations between BV estimates of different traits studied are positive and high (Table 4). This may be due to the fact that the BV's for sires were based on a limited number of progeny. Hoque and Hodges (1980) came to the same results. Product moment correlations ranged from 0.32 and 0.98 for production traits, between 0.33 to 0.71 for persistency indices and production traits and from 0.95 to 0.98 for persistency indices. High correlations between peaked and persistency indices indicated that the animal peaked are most persistent. The present high product correlations between different persistency indices, indicated that the methods used in the present study were on the degree of importance. Also, these results suggest that selecting for higher PY will lead to improvement in persistency and lactation curve traits, in Friesian cows under Egyptian conditions.

Table 4: Product moment correlations between BLUP estimates of different traits studied.

Traits†	305dMY	LP	PY	P_1	P_2
LP	0.797				
PY	0.550	0.703			
P_1	0.404	0.547	0.710		
P_2	0.435	0.547	0.697	0.977	
P_3	0.325	0.547	0.657	0.945	0.950

†: 305dMY=305 day milk yield (kg), LP = lactation period (d), PY = peak yield (kg), P1, P2 and P3 = persistency indices.

ACKNOWLEDGEMENT

The author would like to thank the Animal Production Research Institute, Ministry of Agriculture, Egypt for making the data available for analysis.

REFERENCES

Abdel-Glil, M.F., Hussein, K. and Tag El-Dein, M.A., 2004. Sire evaluation for milk production traits of Friesian cattle in Egypt. J Agric Sci Mansoura Univ, 29 (10), 5539.

Ali, A.K. A., Alessa, A.A., Alshaikh, M.A., Aljumaah, R.S., Al-Haidarey, A.A. and Alkraidees, M.S., 2004. Response surface and fixed effects models of non-genetic factors for dairy cows in Saudi Arabia. Vet Med J, Giza. 52 (2), 231.

Ashmawy, A.A., 1981. A selection index for the improvement of some economic traits under Egyptian conditions. Ph.D. Thesis, Ain Shams Univ, Cairo, Egypt.

Boldman, K. G., L. A. Kriese, L. D. Van Vleck, C. P. Van Tassell and Kachman, S.D., 1995. A Manual for use of MTDFREML. A Set of programs to Obtain Estimates of Variances and Covariances (Draft). U.S. Department of Agriculture, Agricultural Research Service, Clay Canter NE.

Campos, M.S., Wilcox, C.J., Becerril, C.M. and Diz, A., 1994. Genetic parameters for milk yield and reproductive traits of Holstein and Jersey cattle in Florida. J Dairy Sci, 77, 867.

Danell, B., 1982. Studies on lactation yield and individual test-day yields of Swedish dairy cows. Acta Agric Scand, 32, 83.

Dekkers, J.C., TenHag, J.H. and Werrsink, A., 1998. Economic aspects of persistency of lactation in dairy cattle. Livest Prod Sci, 53, 237.

El-Arian, M.N., El-Ayek, M.Y., Khattab, A.S and Abo Gamoes, R.H., 2001a. Estimation of genetic parameters and genetic trends of some milk production traits in a commercial herd of Holstein Friesian cows in Egypt. J Agric Sci, Mansoura Univ, 26(4), 1975.

El-Arian, M.N. and Shalaby, N.A., 2001a. Genetic analysis for lactation curve traits and persistency indices of Friesian cattle in Egypt. J Agric Sci Mansoura Univ, 26(4), 1957.

El-Arian, M.N., El-Awady, H.G. and Khattab, A.S., 2003. Genetic analysis for some productive traits of Holstein Friesian cows in Egypt through MTDFREML program. Egypt. J Anim Prod 40, 99.

El-Awady, H.G., 1998. Genetical analysis of reproductive and productive performance of Friesian herds. Ph.D. Thesis, Fac. Agric., Kafr El-Sheikh, Tanta Univ., Egypt.

El-Awady, H.G., El-Arian, M.N. and Khattab, A.S., 2002. Genetic improvement for milk traits of German Holstein through selection indices. J Agric Sci Mansoura Univ, 27, 8205.

El-Chafie, O.M., 1981. Studies on cattle (cows and Buffaloes) sire evaluation, genetic parameters of partial lactation, dry period and service period. M.Sc. Thesis, Faculty of agriculture, Alexandria, University, Egypt.

Fahim, N.H., 2004. A study on milk yield and persistency of a Holstein herd in Egypt. M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.

Ferris, T.A., Mao, I.L. and Anderson. C.R., 1985. Selecting for lactation curve and milk yield in dairy cattle. J Dairy Sci, 68, 1468.

Gamal El-Dien, Y.M.S., 2006. Studies on genetic improvement in Farm animals. M.Sc. Thesis, Fac. Agric., Mansoura Univ., Egypt.

Hoque, M. and Hodges, J., 1980. Genetic and phenotypic parameters of lifetime production traits in Holstein cows. J Dairy Sci, 63, 1900.

Ibeawuchi, J.A., 1989. Persistency of milk production in F1 Friesian x White Fulaui cattle in a tropical environment. Bulletin of animal health and production in Africa. 36, 215. Cited Dairy Sci Abst (1989), 51, 3743.

Jamkozik, J. and Schaeffer, L. R., 2001. Persistency proofs for dairy bulls. http://cqil.uoqulph. ca. / pub/dairy/persist.html.

Kassab, M.S., 1995. Factors affecting some performance traits in Friesian cattle. Alex J Agric Res, 40, 65.

Kassab, M.S., Salem, A.Y., Kassab, S.A. and Swylem, G.H.A., 2001. Selection indices of some economic traits on Friesian cows. J Agric Sci Mansoura Univ, 26(4), 1889.

Kaya, I., 1996. Parameters estimates of persistency of lactation and relationship of persistency with milk yield in Holstein cattle. Ph.D. Thesis Egr Univ, Izmir, Turkey.

Kaygisiz, A. and Vanli, Y.C., 1997. Genetic analysis of the Brown Swiss cattle, herd of Van Agriculture Vocational high school. Tarim Bilimleri Degisi, 3, 23.

Maarof, N.N., and Tahir. K.N., 1988. Studies on the performances of Friesian cattle in Iraq. II. Persistency of lactation and peak yield. ZANCO., 6: 4, 29, 22 ref. (CAB Abstr.)

Mostafa, M. A., 2001. Relationships between milk production and postpartum reproduction performance in Friesian cows. J Agric Sci Mansoura Univ, 26(4), 1909.

National Research Council (NRC), 2001. Nutrient Requirements of Dairy Cattle, National Research ouncil. 7th Rev Ed, National Academy Press, Washington, DC., USA, pp: 184.

Rao, M.K. and Sunsdaresan, D., 1979. Influence of environment and heredity on the shape of lactation curves in Sahiwal crossbred cows. J Agric Sci Cambridge, 92, 293.

Rekaya, R., Carabano, M.J. and Toro. M.A., 2000. Bayesian analysis of lactation curves of Holstein -Friesian cattle using a nonlinear model. J Dairy Sci 83, 2691.

Rekik, B., Gara, A.B., Hamouda, M.B. and Hammami, H., 2003. Fitting lactation curves of dairy cattle in different types of herds in Tunisia. Livest Prod Sci 83, 309, 15 ref.

Sallam, M.T., El-Feel, F.M. and Khattab, A.S., (1990). Effect of genetic and non-genetic factors on productive and reproductive traits in Friesian cows in Egypt. Minia. J Agric, 12, 521.

SAS Procedures Guide, Version 10.05, 2006. SAS Inst., Inc., Cary, NC.

Shah, S.M., Singh, C.S.P. and Shrivastava, A.K. (1983). Studies on persistency of milk yield in cross-bred Friesian cows. Indian Vet J 60, 740.

Shalaby, N.A., 2005. Genetic evaluation for milk production, reproduction traits and two-trait animal model analysis for Friesian cows in commercial herds in Egypt. J Agric Sci, Mansoura Univ, 30, 3637.

Shitta, A.A., Tag El-Dien M.A. and Awad. Set El-Habaeib S., 2002. A study on production and reproduction traits of Friesian cattle in Egypt. J Agric Sci Mansoura Univ, 27(11), 7281.

Shrinivaset, J., Govindaiah, M.G. and Jahageerdar, S., 1997. First lactation performance of Holstein Friesian s in a private herd. Indian J Dairy and Biosci, 8, 33.

Singh, S.R., 1995. Variation in persistency of lactation yield in Jersey X Hariana cows. Indian J Dairy Sci, 48, 10.

Singh, K., Kanaujia, A.S. and Khanna, A.S., 2002. Prediction functions for persistent lactation yield in crossbred cattle. Indian J Anim Sci, 72 (5), 414.

Tag El-Dien, M. A. and Hussein, K., 2005. Genetic and phenotypic studies on milk production traits of Friesian cows in Egypt. J Agric Sci, Mansoura Univ, 30(10), 5849.

Visscher, P.M. and Goddard, M.E., 1995. Genetic analysis of profit for Australian dairy cattle. Animal Science, 61, 9.

Weller, J.I., Ron, M. and Bar-Anan, R., 1987. Effects of persistency and production on the genetic parameters of milk and fat yield in Israeli-Holsteins. J Dairy Sci, 70, 672.