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Lifetime Production and Longevity of Holstein Friesian Cows in Relation to Their Sire Transmitting Ability

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Abstract
A total of 193 Holstein Friesian cows sired by 39 bulls at Dena farm in Egypt, during the period from 1987 to 1991 were used to estimate phenotypic and genetic parameters of lifetime production and longevity traits in Friesian cows in Egypt and to study relationship between sire transmitting ability (ETA's) of sires for first 305 day milk yield and each of lifetime production and longevity traits. Heritability and phenotypic and genetic correlations were estimated by paternal half sibs correlations. Heritability estimates were 0.18, 0.24, 0.04, 0.05 and 0.00 for first 305 day milk yield, total lifetime milk production, total lactation period, productive life and number of lactations completed. All phenotypic (0.14 - 0.97) and genetic 0.90 - 1.00) correlations among different traits studied were significant except the correlations between number of lactations completed and different traits studied. Sires with at least ten daughters were evaluated by best linear unbiased prediction procedures. Sires with positive expected (ETA's) for first 305 day milk production, have positive values for lifetime production and longevity traits. Product moment correlations of expected ETA's for first 305 day milk yield with lifetime production and longevity traits ranged from (0.09 to 0.96). Sire selection for higher milk yield in the first lactation would lead to a slight increase in longevity defined as length of productive life.

Introduction
Sire evaluation for milk traits are based on first lactations records, all lactation records or some combination of first and later lactations records. Sire evaluation on first lactation appears justified by the strong relationship between yield of first lactation and measures of lifetime performance (Hoque and Hodges, 1981; Khattab, 1992; Dutt *et al.*, 1996). Additionaly, many studied showed more additive genetic control in the first lactation than in later lactations (Rege, 1991).

Genetic relationship between first lactation production and lifetime production was found to be positively correlated in most studied (Bhatia, 1980; Hoque and Hodges, 1981; Solkner, 1989; Khattab, 1992).

The objectives of this study were: (1) to estimate the phenotypic and genetic parameters of lifetime production and longevity traits in Holstein Friesian cattle, (2) to estimate sire breeding values for daughters lifetime production and longevity traits and (3) to study relationship of breeding values for lifetime production and longevity traits with breeding value for milk yield in the first lactation.

Materials and Methods
Data: A total of 193 Holstein Friesian cows available were used for the present study. Data were collected from a commerical farm (Dena Farm) in Egypt. Records were taken during the period of 1987 to 1991, inclusive. Abnormal records affected by diseases or by disorders such as abortion were excluded. The number of sires and average of sires were 39 and 15.20, respectively. Sires with less than ten daughters were used. More information on the data, feeding system and management of that herd were described by Atil and Khattab (1999).

Measurements of lifetime production and longevity traits were:

M1, kg: 305 day milk yield in the first lactation,
TMY, kg: total lifetime milk yield, including production up to the natural end of each lactation,
TLP, d: days of the total lifetime lactation periods,
PL, d: length of productive life, including period from first calving to disposal and
NLC: number of lactations completed.

Cows sold for production reasons were excluded from the analysis.

Analysis: Data were analysed using Mixed Model Least Squares and Maximum Likelihood Computer program of Harvey (1987). 305 day milk yield were analysed using model (1) including year and month of calving as a fixed effects and sires as a random effect. TMY, TLP, PL and NLC were analysed using model (2) including year and month of birth as a fixed effects and M1 as a covariate and sire as a random effect. Khattab and Sultan (1991) working on 1317 normal lactation records of Friesian cows in Egypt, found that the genetic correlation between 305 day mik yield and age at first calving (AFC) - 0.01 and not significant. Therefore, the correction for AFC will not remove a part of the genetic variation among sires.

Estimates of sire and the remainder components of variances and covariances were estimates using program of Harvey (1987). Estimates of paternal half sib heritabilities and genetic correlations with standard errors and phenotypic correlations were estimated as a described in Harvey (1987).

Estimation of sire transmitting abilities (ETA's):

In matrix notation, the models above can be written as:

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

where Y was a vector of observations for each trait, X was a known fixed design matrix, f was an unknown vector of fixed effects representing the mean and year and month of calving, Z was a known design matrix, s was an unobservable vector of random sire effect, W was a vector of covariate variable (independent variable), 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, 1953) are:

$$\begin{bmatrix} X'X & X'Z & X'W \\ Z'X & Z'Z+G & Z'W \\ W'X & W'X & W'W \end{bmatrix} . \begin{bmatrix} f \\ s \\ b \end{bmatrix} - \begin{bmatrix} X'Y \\ Z'Y \\ W'Y \end{bmatrix}$$

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

The above analysis was carried out to predict sire transmitting abilities for each trait. The estimates transmitting abililites (ETA's) of sires were sum of the sire solution.

To study the relationships of ETA's of sires for first 305 day milk yield with ETA's for lifetime production and longevity. Product moment correlations were employed.

Results and Discussion

Least squares means and their standard errors of different traits are presented in Table 1. Least squares means of first 305 day milk yield was 4843 kg, as estimated from model (1). This value is higher than those estimated by Khattab and Ashmawy (1988), Khattab and Sultan (1991) and Abdel Glil *et al.* (1995) (2254, 3045 and 2954 kg., respectively). In addition, Zarnecki *et al.* (1991) from ten strain crosses of Friesian cattle in Poland, reported that 305 day milk yield was 3464 kg.

The least squares means of TMY, TLP, PL, and NLC were 25423 kg, 1538 d, 65.64 mo, and 5.26, respectively, as estimated from model (2). The present means are higher than those reported by Sultan and Khattab (1989) working on another herd of Friesian cattle in Egypt (7723 kg, 1228 d, 42 mo, and 3.2, respectively). Also, the present mean of NLC is higher than that reported by Zarnecki *et al.* (1990) (3.9).

The differences between our results and those reported by other workers could be due to differences in climatic and managerial conditions and / or genetic differences in herds. Least squares analysis of variance of different traits studied are presented in Table 2. Effects of month of calving a birth on different traits studied were not significant. These results may be due to small number of cows. Effect of year of calving on different traits studied are significant except for NLC.

Estimates of partial linear and quadratic regression coefficient of different traits studied on M1 were not significant (Table 2).

Results obtained in the present study show that sire had a highly significant effect on different traits studied ($P<0.01$) except for NLC.

Table 1: Least squares means (LSM) and standard errors (SE) of different traits studied.

Traits*	LSM	S.E.
Ml, kg	4843.00	219.00
TMY, kg	25423.00	1771.00
TLP, d	1538.00	122.00
PL, mo	65.64	1.88
NLC	5.26	0.39

*M1 (305 day milk yield in the first lactation), TMY (total lifetime production), TLP (total lactation period), PL (productive life) and NLC (number of lactations completed).

Phenotypic and genetic parameters estimated for the different traits studied are presented in Table 3. Estimates of heritability of M1 is 0.18, which is in accordance with the estimate of Hoque and Hodges (1981) (0.22), and Yener *et al.* (1998) (0.17). The heritability estimates for TMY and TLP are 0.24 and 0.04, respectively, this values are similar to the estimate reported by Zarnecki *et al.* (1991) working on ten strains of Friesian in Poland; being 0.23 and 0.07 for TMY and TLP respectively. Also Khattab *et al.* (1994) found that heritability estimate for TMY was 0.22 on Egyptian buffoles, Khattab *et al.* (1992) and Singh and Yadav (1987) found that heritability estimates for TMY were 0.19 and 0.17, respectively for TLP were 0.16 and 0.13, respectively.

The present results indicate the possibility of genetic improvement for M1 and TMY through sire breeding. The two measurements of longevity, i.e., PL, and NLC have low heritability estimates, 0.05 and 0.00, respectively (Table 3). Ashmawy (1985) working on British Friesian cattle, reported that h^2 were 0.022, 0.021 and 0.012 for number of lactations completed, survival up to and lactation and survival up to 3rd lactation, respectively. Khattab *et al.* (1994) working on another herd of Friesian cattle in Egypt, found that heritability for PL and NLC were 0.23 and 0.06 respectively. Also, Khattab *et al.* (1992) working on Egyptian buffaloes found that h^2 estimates for age at disposal, productive life and number of lactations completed were 0.05, 0.04 and 0.04, respectively. The present estimates suggested that selection for longevity measured as PL and NLC could be in effective due to its low h^2. On the other hand, higher estimates of h^2 for longevity were reported by Asker *et al.* (1969) and Sharaby *et al*. (1983) for, being 0.38 and 0.36, respectively.

The phenotypic correlation between M1 and each of TMY and TLP were positive and highly significant, being 0.93

Table 2: Analysis of variance of factors affecting different traits studied.

		Model 1 F values		Model 2 F values		
Source of variation	df	M1	TMY	TLP	PL	NLC
Sire	38	1.23	1.00	1.27	1.09	0.49
Month of calving (birth)	11	0.79	0.47	0.50	0.86	0.40
Year of calving (birth)	4	5.43	2.21	2.71	19.75	1.88
Regressions						
M1, Linear	1		2.93	0.07	1.01	0.87
M1, quadratic	1		0.87	0.72	0.86	0.42
Remainder mean squares	137	1724739.00	105959782.00	378774.00	116.00	4.26

and 0.97, and higher than those estimates reported by Everett *et al.* (1976), Hoque and Hodges (1981), Sultan and Khattab (1989) and Khattab *et al.* (1994) which ranged from 0.26 to 0.37. The corresponding genetic correlations between M1 and each of TMY and TLP were unity. The present results are higher than those estimates reported by Tong *et al.* (1979), Weller *et al.* (1986), Zarnecki *et al.* (1990) and Khattab *et al.* (1994) which ranged from 0.78 to 0.89. Therefore, selection for high first lactation milk yield should lead to increased of lifetime milk production and total lactation period. Bhatia (1980) reported that selection for first lactation leads to an expected genetic response in total lifetime production of 32% more than when selection was applied directly to lifetime production. Gopal and Bhatnagar (1972) found that first 305 day milk yield was highly and positively correlated with the first five lactations (0.66), up to 6 years (0.47), 8 years (0.55) and 10 years (0.39). They concluded that the lifetime milk production increased with the increase of first lactation yield.

The phenotypic and genetic correlations between TMY and each of TLP and PL were positive and highly significant being 0.97 and 0.23, respectively for phenotypic correlations, and 1.00 for genetic correlations. The present results indicate that the high producing cows are genetically higher producers. Also the high producing cows in their first lactations remain in the herd longer than the lower producing ones. Hoque and Hodges (1981) came to the same conclusion.

The phenotypic correlations between NLC and each of TMY, TLP and PL were small, being 0.14, 0.033 and -0.09. Also, the genetic correlations between NLC and different traits studied are zero (Table 3).

Table 3: Heritability estimates (on diagonal), phenotypic correlations (above diagonal) and genetic correlations (below diagonal).

Traits	M1	TMY	TLP	PL	NLC
M1	0.18	0.93	0.97	0.28	-0.05
TMY	1.00	0.24	0.93	0.23	0.14
TLP	1.00	1.00	0.04	0.29	0.033
PL	1.00	1.00	0.90	0.05	-0.09
NLC	0.00	0.00	0.00	0.00	0.00

The ETA's showed large differences among sires in production and longevity traits. The ETA's for M1 ranged from -48 kg to 43 kg, from -618 kg to 451 kg for TMY, from -147 d to 136 d for TLP, from -0,52 mo to 0.99 mo for PL and from -0.18 to 0.12 for NLC. Similar findings are obtained by Khattab *et al.* (1994) working on another herd of Friesian cattle, found that the EBV's for M1 ranged from -447 to 1191 kg, from -1817 kg to 1672 kg for TMY, from -8.14 mo to 839 mo for PL and from -0.53 to -0.30 for NLC in addition, Zarnecki *et al.* (1991) found that the expected breeding values for 305 dMY ranged from -481 kg to 521 kg. Rogers *et al.* (1989) found that the expected breeding values for survival to 84 mo ranged from -8.90 to 7.60 mo, Metry *et al.* (1994) working on 316 buffoloes sired by 77 bulls found that the estimated breeding values of sires with 5 daughters lactations ranged from -424 kg to 247 kg. They concluded that potential genetic improvement of milk yield by mass selection is estimates as 2.2% per year.

The present results show also sire positive value for M1 gives a positive values for TMY, TLP and PL. Selection of this sires for breeding purposes could be lead to rapid genetic improvement for lifetime production and productive life in the next generation. Van Vleck (1964) reported that progeny groups ranked higher for first lactation performance also ranked high in later lactation. Also, Hoque and Hodges (1981) with Canadian Holstein Friesian cows found that higher survival rate of daughters of sires with positive milk proof compared to sires with negative milk proof.

Product moment correlations between the ETA's for production and longevity traits are given in Table 3. The product moment correlations between M1 and each of TMY and TLP are 0.96 and 0.98. The present estimate are higher than those of Hoque and Hodges (1981), Weller *et al.* (1986), Rogers *et al.* (1989), Zarnecki *et al.* (1990) and Khattab *et al.* (1994) ranged from 0.76 to 0.80. The present results indicate that selection of sires according to first lactation increase TMY and TLP also, it is useful to depend on the first lactation in sire evaluation rather than on lifetime production. In addition, the use of lifetime production increases generation interval, increase in generation interval in the sire to son and dam to son paths can be avoided of initial screening is done on first lactation. Nicholson *et al*. (1978) reported that the first lactation proofs was an accurate prediction of proofs based on to succeeding lactations.

In addition, Dutt *et al.* (1996) working on 561 daughters sired by 37, they used three measures of lifetime production i.e., number of lactations completed, herd life and lifetime milk yield. They found that the rank correlations between first lactation milk yield and lifetime production traits ranged from -0.84 to 0.83. Sires ranking different between first lactation milk yield and lifetime traits. Selection of bulls on dam, milk production would not lead to genetic improvement. Therefore, selection of bulls should be on bases of the first lactation milk yield their daughters.

On the other hand, Syrstad (1973) concluded that sire evaluation on second lactation records was 10 to 12 % more accurate than yield of first lactation alone. Also, Weller *et al*. (1986) working on Israeli Holstein cows, found that selection for multiparity resulted 9% more genetic gain than selection for first lactation alone.

Product moment correlations of PL with MI, TMY and TLP studied are significant ($P<0.01$, Table 3) and ranged from 0.22 to 0.29. The present estimates are similar to the reported by Everett *et al.* (1976), Blanchard *et al.* (1983), Rogers *et al.* (1989) and Khattab *et al.* (1994) which ranged from 0.25 to 0.46. Schaeffer and Burnside (1974) suggested that stayability could be improved by using bulls that ranked high for proofs on milk. Everett *et al.* (1976) concluded that sire selected for high first lactation milk yield have daughters which last longer and screening bulls on 48 mo stayability would be the most desirable because bulls can be evaluated at a younger age. In addition Leroy (1988) suggested that lower production should be culled more often than high production.

Product moment correlations of ETA's of NLC with M1, TMY and TLP were positive and but small and ranged from 0.09 to 0.13 (Table 3). This maybe due to zero of heritability of NLC and also the low genetic correlations between NLC with different traits studied. Ashmawy (1985) working on 480 British Friesian Holstein sires found that selection for stayability defined as number of lactations completed would not be effective.

Table 4: Product moment correlations between expected breeding values (EBV's) of sires for lifetime production and longevity traits.

	EBV's			
Traits	M1	TMY	TLP	PL
TMY	0.96			
TLP	0.98	0.95		
PL	0.28	0.22	0.29	
NLC	0.09	0.22	0.13	0.00

The differences between product moment correlations of ETA's for different traits studied and genetic correlations (Table 3 and 4) could be due to small number of observations on each sire.

The present results suggested that evaluation of artificial insemination (AI) sires on their daughters in the first lactation milk production would lead to increase lifetime milk production, and also longer stayability of cow in the herd.

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