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GENETIC AND PHENOTYPIC PARAMETERS OF SOME LONGEVITY AND LIFETIME PRODUCTION TRAITS IN HOLSTEIN-FRIESIAN COWS RAISED IN EGYPT

BY

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ABSTRACT

Heritability estimates of longevity traits [number of lactations completed during the cow's life (LNO), its herd life (HL), and its productive life (PL)], and lifetime production traits [total milk yield (LTMY) and lifetime lactation period (LLP)] were estimated using 5642 records for 887 cows, daughters of 94 Holstein bulls, using the mixed model and multi-trait animal model. Also, genetic and phenotypic correlation coefficients among all these traits were calculated.

Heritability estimates of longevity traits ranged from 0.04 to 0.06, while were 0.15 and 0.05 for LTMY and LLP, respectively. Longevity traits had high genetic correlation (≥0.98) and was 0.96 between LLP and LTMY. Genetic correlations between each of longevity traits and LTMY ranged from 0.85 to 0.90. Phenotypic correlations were less than the corresponding genetic correlations among most traits. These correlations ranged from 0.84 to 1.0 among longevity traits, from 0.53 to 0.62 among longevity traits and LTMY, from 0.48 to 0.68 between LLP and longevity traits while it was 0.90 between LLP and LTMY.

Product-moment correlation among longevity traits ranged from 0.983 to 0.999 and was 0.974 between lifetime total milk yield and lifetime lactation period. The product- moment correlations between lifetime lactation period and longevity traits ranged from 0.442 to 0.740. The same trend was observed for the corresponding rank correlations but with relatively lower estimates.

Key words: Genetic parameters, longevity, lifetime production, Holstein-Friesian, Egypt.

INTRODUCTION

A long productive life has a potentially large impact on profitability of dairy enterprises (Burnside *et al.*, 1984). The length of productive life will

influence the economic returns through its effect on the proportion of female offspring retained for replacements. Therefore, the proportion available for sale and the annual depreciation cost per cow will be affected. Moreover, longevity is one of the parameters affecting generation interval and thereby influences the rate of genetic change. Dairymen will choose highly producing cows to retain longer in their herds and select their daughters as replacers to maximize the farm income. This management practice, however, would decrease the rate of genetic progress for the production traits through the effect on the generation interval (Chauhan, *et al.*, 1993).

Estimation of genetic parameters is essential for any trait to be included in the breeding programmes. Lifetime production traits has been considered as important traits. Heritability estimates of such traits have been reported to be low and showed estimates of genetic correlations close to unity among longevity traits.

The present study was undertaken to estimate genetic parameters and predict the breeding values for number of lactations completed during the cows life, its herd life, productive life, lifetime total milk yield, and lifetime lactation period in Holstein-Friesian cows raised in Egypt using the mixed model and multi-trait animal model.

MATERIALS AND METHODS

Data and traits

Holstein-Friesian cows of the present study were imported from USA to Egypt since 1982 and raised in El-Salhia commercial herd, Ismailia Governorate (East to the south of Nile Delta). All the imported females reached Egypt as pregnant heifers. Cows were inseminated artificially during the first heat period following the 45th day post-partum, using frozen semen imported from the USA. Pregnancy was detected by rectal pulpation 60 days after the last service.

Cows were machine-milked twice daily. Cows were usually milked until 2 months before the expected next calving date. Then if they did not go dry, they were dried off gradually by milking them once a day until completely dried off. All cows were kept under similar feeding and management systems. All year round, all cows were fed concentrates and corn silage. During the winter and spring months the animals were supplied with Egyptian clover (*Trifolium alexandrium*) and during summer and autumn months, beets, maize and green sorghum (*Sorghum vulgar*) were available. In addition rice straw was available all the year round. Free clean water and mineral mixture were available at all times.

A total of 5642 complete lactation records for 887 cows, daughters of 94 bulls were used. These data covered 9 consecutive years (1983-1991). All records of Holstein cows sold for dairy purposes were excluded. Total milk yield and total lactation period up to disposal were regarded as lifetime production traits (LTMY and LLP), however the longevity traits studied were number of lactations completed (LNO), herd life (the interval between date of disposal and date of

birth, HL), and productive life (the interval between date of disposal and date of first calving, PL). Total lifetime production traits for an individual cow were obtained by summing up precorrected records of milk yields and lengths of all lactations given by the cow during its life using the additive correction factors for the fixed effects of year-season of calving and age at calving.

Statistical analysis

Data of lifetime production and longevity traits were analyzed by adopting the following linear mixed model to estimate sire and error components of varaicnes (σ^2_s and σ^2_e) using Henderson 3 method (Harvey, 1990) to be used as starting values for the animal model.

$$Y_{ijk} = \mu + S_i + YA_j + e_{ijk}$$

Where Y_{ijk} = observation of the ijkth cow, S_i = random effect of the ith sire, YA_j = fixed effect of the jth year-season of birth combination (j= 7 levels), e_{ijk} = random error paticular to the ijkth observation assumed to be normally independently distributed with zero mean and variance ~ NID(0, σ^2_e), with $E(Y_{ijk}) = YA_j$ and $V(Y_{ijk}) = \sigma^2_s + \sigma^2_e$ ($Cov_{se} = 0$).

Genetic and phenotypic parameters of lifetime produciton and longevity traits as well as breeding values of all animals with all available pedigree informaiton were estimated using the Derivative-Free Restricted Maximum Likelihood (DF-REML) given by Meyer (1998). The evaluated animals were 887 cows, daughters of 94 bulls and damed by 887 cows. The animal model (in matrix notation) used was:

$$Y = X\beta + Z_a a + e$$

Where: Y = the observation vector; β = the vector of fixed effects (year-season of birth combiantion), a = the vector of random animal effect (direct genetic effect); and e = the vector of random residual effects. The X and Z_a are the incidence matrices relating records to the fixed effects and random animal effects. Variance-covariance matrix of random effects was as follows:

$$Var\begin{bmatrix} a \\ e \end{bmatrix} = \begin{bmatrix} A\sigma^2_a & 0 \\ 0 & I_n\sigma^2_e \end{bmatrix}$$

Where: A= the numerator relationship matrix and I_n = the identity matrix. The mixed model equations were written as follows:

$$\begin{bmatrix} X'X & X'Z_a \\ Z_a'X & Z'Z_a + K_a A^{-1} \end{bmatrix}\begin{bmatrix} \beta \\ a \end{bmatrix} = \begin{bmatrix} X'y \\ Z_a'y \end{bmatrix}$$

Where $K_a = \sigma^2_e/\sigma^2_a$, σ^2_a = the variance of the animal and σ^2_e = the variance of the residual effects and A^{-1} = the inverse of numerator-relationship matrix of animal accounted for additive genetic relationships between them. Expectations of variances were $E(\sigma^2_a) = \sigma^2_G$, and $E(\sigma^2_e) = \sigma^2_e$, where σ^2_G is the genetic variance and σ^2_e is the variance of environmental effect on longevity and lifetime milk production traits. The product-moment correlation (r_{PM}) and Spearman rank correlation (r_S) between the predicted breeding values (PBVs) of different lifetime production with longevity traits were calculated (SAS, 1998).

RESULTS AND DISCUSSION

Actual means and standard deviations of lifetime traits depend on several factors, e.g. population, culling practices, nature of data editing, size of data set etc. Means and standard deviations of herd life (HL), production life (PL), lifetime total milk yield (LTMY) were much larger (Table 1) than those obtained by McAllister *et al.*, (1987) and Chauhan *et al.*, (1993) for the same breed. This may be because of the differences of the characteristics of data and the surrounding circumstances for each case. The coefficients of variability (CV) for lifetime production traits were considerably larger than longevity traits. The CV for LNO obtained in the present study (24.4%) was lower than the estimate of 47.1% obtained by Ashmawy (1985) using British records of Holstein-Friesian cows.

Table (2) contains heritability estimates of number of lactations completed during the cow life (LNO), herd life (HL), productive life (PL), lifetime total milk yield (LTMY) and lifetime lactation period (LLP), in addition to genetic and phenotypic correlations among these traits. Heritabilities of LNO, HL, PL and LLP ranged from 0.04 to 0.06, while that of LTMY was 0.15.

Heritability estimates of LNO in the literature cited were in the range from 0.04 to 0.07 (Klassen *et al.*, 1992; Jairath *et al.*, 1994; VanRaden and Klaaskate, 1993, and Vollema and Groen, 1996). Chauhan *et al.*, (1993) estimated a much lower estimate (0.005) for the same trait. Heirtability estimates of HL were lower than 0.10 (Hoque and Hodges, 1980; Smith and Quaas, 1983, Short and Lawlor, 1992 and Vollema and Groen, 1996).

Heritability estimate in this study for PL is within the range from 0.04 to 0.08 (Hoque and Hodges, 1980; Jairath *et al.*, 1994; Short and Lawlor, 1992; Weigel *et al.*, 1995, and Vollema and Groen, 1996). The range for heritability estimates of LTMY being 0.11-0.13 reported in the literature (Hoque and Hodges, 1980; Jairath *et al.*, 1994, Klassen *et al.*, 1992, and Vollema and Groen, 1996) was slightly lower than the estimate of this study. However, Chauhan *et al.*, (1993) estimated a much lower heritability (0.017) for the same trait. Heritability estimate of LLP was slightly less than the range from 0.08 to 0.09 found by Jairath *et al.*, (1994), Klassen *et al.*, (1992) and Vollema and Groen (1996). In general, heritability estimates of longevity traits were low.

Genetic correlations among LNO, HL and PL were close to unity (Table 2). Genetic correlations between LTMY and longevity traits (LNO, HL and PL) were >0.84. Genetic correlations between LLP and HL, PL were 0.73, 0.74, however it was only 0.59 with LNO. Genetic correlation of LTMY with either HL or PL was the same (0.85). The present estimates of genetic correlation among longevity traits (LNO, HL, PL) were in close agreement with estimates of genetic correlation between HL and PL which between 0.94 and 0.99 reported by Pundir and Raheja (1995). Our estimates were higher than those of Chauhan *et al.*, (1993); Kaushik *et al.*, (1994) and Vollema and Groen, (1996) which ranged from 0.29 to 0.89 among HL, PL and LNO.

Table (1): Actual means, Standard deviations (SD), Coefficients of phenotypic variation (CV) for longevity and lifetime milk yield traits.

Trait[1]	Mean	SD	CV%
LNO	5.6	1.37	24.4
HL (mo.)	106.1	23.2	21.9
PL (mo.)	82.5	23.4	28.3
LTMY(kg)	36800.0	13972.9	37.9
LLP (mo.)	67.8	20.6	30.3

[1] Number of lactations completed during cow life (LNO), herd life (HL), productive life (PL), lifetime total milk yield (LTMY), lifetime lactation period (LLP).

Table (2): Habitability of (on diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations among longevity and lifetime production traits of Holstein cows[1].

Trait	LNO	HL	PL	LTMY	LLP
LNO	0.04	0.98	0.98	0.90	0.59
HL	0.84	0.05	1.00	0.85	0.73
PL	0.84	1.00	0.06	0.85	0.74
LTMY	0.53	0.62	0.62	0.15	0.96
LLP	0.48	0.68	0.66	0.90	0.05

[1] Standard errors were ≤ 0.001 for h^2, ≤ 0.06 for genetic correlations and ≤ 0.17 for phenotypic correlations. LNO=Number of lactations completed during the cow life, HL=herd life, PL=productive life, LTMY=lifetime total milk yield, LLP=lifetime lactation period.

The present estimates of genetic correlation between LTMY and each of LNO, HL, and PL were greater than the estimates of Chauhan *et al.*, (1993) which were in the range from 0.29 to 0.77. The present estimate of genetic correlation between LLP and PL (0.74) was lower than 0.98 which obtained by Vollema and Groen (1996). The high genetic correlations among lifetime and longevity traits estimated in this study may refer to that the performance of any of these traits would refer to the level of performance of any of the other traits.

Phenotypic correlations were usually lower than the corresponding genetic correlations (Table 2). Phenotypic correlations among longevity traits ranged from 0.84 to 1.0 (Table 2). The present estimates were similar to those obtained by Chauhan *et al.*, (1993) which ranged between 0.94 and 0.97 for the same traits.

Estimates of phenotypic correlation between longevity traits (LNO, HL, PL) and LTMY were within the range of 0.52-0.62, which was lower than the range of 0.88-0.97 obtained by Chauhan *et al.*, (1993) and Vollema and Groen (1996). Phenotypic correlations of the present study between LTMY and LLP was near 0.93-0.94 obtained by Kaushik *et al.*, (1994) and Vollema and Groen (1996).

Product-moment (r_{PM}) and rank correlations (r_S) are given in Table (3). All correlations were positive and significant (P<0.0001). The highest r_{PM} was found among PBV's of longevity traits (0.983-0.999) followed by the r_{PM} between LTMY and LLP (0.972), and r_{PM} between LTMY and either HL or PL (0.914-0.915). The lowest r_{PM} estimates were found between LLP and longevity traits (0.442-0.740). The same trend was observed for rank correlation with relatively lower estimates. The results of r_S indicate that ranking animals based on breeding values of LNO, HL or PL are nearly the same (0.977-0.999) followed by r_S between LTMY and LLP (0.966) and r_S between LTMY and each of HL and PL (0.905-0.908). Due to the relatively low r_S estimates between LLP and longevity traits (0.412 - 0.705) indicate that animals were re ranked for each of these traits (Table 3).

Table (3): Product-moment (r_{PM}, below diagonal) and Spearman's rank (r_S, above diagonal) correlation coefficients among breeding values of longevity and lifetime production traits of Holstein animals[1].

Trait	LNO	HL	PL	LTMY	LLP
LNO		0.980	0.977	0.686	0.412
HL	0.985		0.999	0.908	0.628
PL	0.983	0.999		0.905	0.705
LTMY	0.700	0.914	0.915		0.966
LLP	0.442	0.666	0.740	0.974	

[1] all coefficients were significant at P≤ 0.0001. LNO=Number of lactations completed during the cow life, HL=herd life, PL=productive life, LTMY=lifetime total milk yield, LLP=lifetime lactation period

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المقاييس الوراثية والمظهرية لبعض صفات طول الحياة والكفاءة الإنتاجية لماشية الهولشتين-فريزيان المرباه فى مصر

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تـم تقدير المكافئ الوراثى لصفات طول الحياة للحيوان (عدد سجلات البقرة خـلال فـترة حياتها الإنتاجية (LNO)، طول حياتها فى القطيع (HL)، طول حياتها الإنتاجـية (PL)) ولصفات إنتاج اللبن خلال الحياة الإنتاجية (الإنتاج الكـــلى للبن (LTMY) وفـترة الحليب الكلية خلال الحياة الإنتاجية (LLP) - ومعاملات الإرتباط الوراثى والمظهرى بين هذه الصفات. كما تم تقدير القيم التربوية للحيوان لهذه الصفات وحسـاب معـامل الإرتباط الخطى البسيط (r_{PM}) بين تلك القيم وكذلك معامل ارتباط

الرتب (r_s) باستخدام ٥٦٤٢ سجل لعدد ٨٨٧ بقرة، بنات ٩٤ طلوقة من أحد القطعان التجارية لماشية الهولشتين فريزيان بالصالحية – محافظة الإسماعلية والتابع للجمعية التعاونية العامة لتطوير الثروة الحيوانية ومنتجاتها وباستخدام برنامج النموذج المختلط، وبرنامج نموذج الحيوان متعدد الصفات.

تراوحت قيم المكافئ الوراثى لصفات طول الحياة بين ٠,٠٤ – ٠,٠٦ موضحة قلة إمكانية التحسين الوراثى المباشر لهذه الصفات، بينما كانت ٠,١٥ و ٠,٠٥ لصفات كمية اللبن الكلى وفترة الحليب الكلية خلال فترة حياة البقرة، على التوالى. كانت معاملات الإرتباط الوراثى عالية بين صفات طول الحياة (٠,٩٩) يليها معاملات الإرتباط الوراثى بين طول فترة الحليب وكمية اللبن الكلى خلال طول الحياة الإنتاجية (٠,٩٦). تراوحت قيم معاملات الإرتباط الوراثى بين كمية اللبن الكلى وصفات طول الحياة بين ٠,٨٥ إلى ٠,٩٠. انخفضت قيم معاملات الإرتباط المظهرى عن مثيلاتها الوراثية لمعظم الصفات وتراوحت بين ٠,٨٤ إلى ١,٠ لصفات طول الحياة، وبين ٠,٥٣ إلى ٠,٦٢ بين صفات طول الحياة وكمية اللبن الكلى، وبين ٠,٤٨ إلى ٠,٦٨ بين صفات طول الحياة وطول فترة الحليب الكلية، بينما كانت ٠,٩٠ بين صفة طول فترة الحليب وكمية اللبن الكلى خلال حياة الحيوان.

تراوحت قيم معامل الإرتباط الخطى البسيط لصفات طول الحياة الإنتاجية بين ٠,٩٨ إلى ٠,٩٩ وكانت ٠,٩٧ بين كمية اللبن الكلى وطول فترة الحليب خلال الحياة الإنتاجية. انخفضت قيم معامل الإرتباط الخطى البسيط بين طول فترة الحليب الكلية وصفات طول الحياة حيث تراوحت بين ٠,٤٤ إلى ٠,٧٤. أخذت قيم معامل إرتباط الرتب نفس الإتجاه والقوة التى أظهرتها قيم معامل الإرتباط الخطى البسيط مع انخفاض القيم نسبيا.