

PHENOTYPIC AND GENETIC PARAMETERS OF MILK PRODUCTION AND REPRODUCTIVE PERFORMANCE OF HOLSTEIN CATTLE UNDER THE INTENSIVE PRODUCTION SYSTEM IN EGYPT

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SUMMARY

Cow productivity in Holstein-Friesian cattle was analyzed in fourteen commercial private herds. All herds belong to members of the General Cooperative for Developing Animal Wealth and Products, Egypt. A total number of 4120 lactation records for 1085 cows sired by 290 bulls were used. The records covered the period from 1999 to 2003. Traits studied were 305 day milk yield (305d MY), total milk yield (TMY), lactation period (LP), dry period (DP), age at first calving (AFC) and calving interval (CI). Data were analyzed by Multiple Trait Derivative Free Restricted Maximum Likelihood (MTDFREML) procedure using repeatability multiple trait Animal Model analysis.

Means of 305d MY, TMY, LP, DP, AFC and CI were 9038 kg, 12054 kg, 407 days, 63.6 days, 29.2 months and 470 days, respectively. Heritability estimates for the same traits were 0.27, 0.22, 0.07, 0.05, 0.23 and 0.05, respectively. Also, repeatability and phenotypic and genetic correlations between traits were estimated.

The results indicated that raising high yielding Holsteins in commercial farms in Egypt is technically feasible. Additive genetic variance showed large contribution to total variation in milk yield traits indicating possibility of improving these traits by genetic selection. Selection based on first lactation could be used satisfactorily to improve milk yield traits.

Keywords: *Holstein, milk production, reproductive performance, genetic parameters, Animal Model, intensive system, Egypt*

INTRODUCTION

Recently in Egypt, many private dairy cattle farms were established through introducing Holstein Friesian cattle. Some genetic aspects of productive and reproductive performance of this breed under the semi-arid conditions in commercial herds were reviewed by Ahmed (1996), Salem (1998), Abdel-Salam *et al.* (2001), Afifi *et al.* (2002), El-Arian *et al.* (2003), Nigm *et al.* (2003), Zahed *et al.* (2003) and Alhammad (2005). Breeding values of cows and bulls as well as genetic parameters

are essential information in constructing the breeding policy and managerial decisions.

The objective of this study was to estimate phenotypic and genetic parameters of milk production and reproductive performance of Holstein cattle under the intensive production system in Egypt.

MATERIALS AND METHODS

This work was carried out using milk production and reproductive records of Holstein Friesian cows in fourteen commercial herds. These herds were located in Dammiatta (Dammiatta Governorate), EL-Sods (El-Sharkia Governorate), Benni-Ebaied and El-Dayrus (El-Dakhlia Governorate), Ghonim and Kafr Qushash (El-Behira Governorate), Shanshour (El-Menoufya Governorate), Abou El-Ghar, Deima, Ebiar, El-Kilani, Kalib Ebiar, Quttor, and Shobrareis (El-Gharbia Governorate). All herds belong to members of the General Cooperative for Developing Animal Wealth and Products, Egypt. Animals of the fourteen herds were imported as pregnant heifers from West Germany from the same source. Importation began in 1999 and continued to 2000.

Housing, feeding, breeding and management

In the fourteen studied herds, cows were mostly kept under similar systems of feeding and management. Animals were kept in open sheds. All year round, cows were fed on good quality concentrates and corn silage. During winter and spring (from December to May), animals were supplied with Egyptian clover (*Trifolium alexandrinum*) while during summer and autumn (from June to the end of November), maize, hay and green sorghum (*Sorghum vulgar var saccharatum*) were available. Also, rice straw was available all the year round. Feed was supplied to cows according to their live weight, production and pregnancy status. Free clean water was available all the time.

In most herds, heifers and cows were artificially bred using frozen semen imported from U.S.A, Canada and West Germany while, in few other herds, heifers and cows were naturally bred by Holstein bulls imported from West Germany. Heifers were bred when reached 350 - 375 kg of body weight and cows were served during the first heat after the 45th day post-partum. Cows were machine milked three times daily at eight hours intervals. Cows were usually milked until two months before the expected calving date.

Data

A total number of 4120 lactation records for 1085 cows sired by 290 bulls was analyzed. A pool of sires was used in all the 14 herds. The records covered the period from 1999 to 2003, representing parities from 1 to 4. Productive traits studied were 305 day milk yield (305d MY, kg), total milk yield (TMY, kg), lactation period (LP, day) and dry period (DP, day). Reproductive traits studied were age at first calving (AFC, month) and calving interval (CI, day). Lactation records were grouped into age of cow classes of 3 months interval (21 classes), into days open classes of 30 days interval (7 classes) and into lactation length classes of 20 days interval (11 classes). Distribution of cows and lactation records according to herds are presented in table 1.

Table 1. Distribution of cows and lactation records in the fourteen herds of the study

Herds	No. of cows	No. of lactations
Dammiatta	78	311
El-Sods	68	272
El-Dayrus	283	1128
Kafr Qushash	77	308
Shanshour	69	273
Deima	45	160
Shobraris	72	283
El-Kilani	66	263
Quttor	48	171
Kalib Ebiar	105	352
Abou El-Ghar	28	101
Ghonim	56	189
Bani Ebaied	28	87
Ebiar	62	222
Total	1085	4120

Statistical analysis

Data were analyzed by Multiple Trait Derivative Free Restricted Maximum Likelihood (MTDFREML) procedure (Meyer, 1998), using repeatability multiple trait Animal Model analysis.

Traits were first analyzed by the Restricted Maximum Likelihood (REML) procedure of SAS, (1996) to obtain variance components for calculating genetic, permanent and residual covariances between each two traits as starting values. Then, the Multi Trait Animal Model was used to analyze reproductive traits (AFC and CI between first and second lactation) including individual and error effects as random effects, year and season of birth-combination and herd for AFC and year and season of calving, age of cow at calving and herd for CI as fixed effects. For all lactations, Animal Model was used to analyze 305d MY, TMY, LP and DP including individual, permanent environmental and error as random effects, year season of calving combination, age of cow at calving, days open, herd in addition to length of lactation period for TMY as fixed effects.

In matrix notation the Animal Model used for all lactations was:

$$\mathbf{Y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{Wp} + \mathbf{e}$$

Where:

\mathbf{Y} = observation vector of records, \mathbf{b} = fixed effects vector [e.g year-season of calving combination 20 classes from 1999-1 to 2003-4 (1= 1999-1, 2 = 1999-2,.., 20 = 2003-4), age of cow at calving 21 classes from 24 to 84 months (1 = 24- 26, 2 = 27 - 29, .., 21 = \geq 84 months), days open 7 classes from 100 - 280 days (1 = 100 - 129, 2 = 130 - 159, .., 7 = \geq 280 days), herd; 14 herds and lactation period 11 classes from 290 to 490 days (1= 290 - 309, 2 = 310 - 329, .. , 11 = \geq 490 days)], \mathbf{a} = animal direct genetic effect vector, \mathbf{p} = permanent environmental effect vector, and \mathbf{e} = residual effect vector. \mathbf{X} , \mathbf{Z} and \mathbf{W} are incidence matrices relating records to fixed, animal and permanent environmental effects, respectively.

Vector **a** only includes additive random animal effects; consequently, non-additive genetic effects are included in the **p** term. It is assumed that the permanent environmental effects and residual effects are independently distributed, with means of zero and variances σ_p^2 and σ_e^2 , respectively. Therefore,

$$\text{Var}(\mathbf{p}) = \mathbf{I}_p \sigma_p^2,$$

$$\text{Var}(\mathbf{e}) = \mathbf{I}_n \sigma_e^2 = \mathbf{R},$$

$$\text{Var}(\mathbf{a}) = \mathbf{A} \sigma_a^2 \text{ and}$$

$$\text{Var}(\mathbf{y}) = \mathbf{Z} \mathbf{A} \mathbf{I} \sigma_a^2 + \mathbf{W} \mathbf{I}_p \sigma_p^2 \mathbf{W}' + \mathbf{R}$$

Where:

A is the numerator relationship matrix, \mathbf{I}_p is an identity matrix with order equal to number of animals and \mathbf{I}_n is an identity matrix with order equal to number of records.

To estimate heritability (h^2) and repeatability (t), the following equations were used:

$$h^2 = \sigma_a^2 / (\sigma_a^2 + \sigma_p^2 + \sigma_e^2), \text{ and}$$

$$t = (\sigma_a^2 + \sigma_p^2) / (\sigma_a^2 + \sigma_p^2 + \sigma_e^2)$$

Where:

σ_a^2 = additive genetic variance; σ_p^2 = permanent environmental variance and σ_e^2 = the random residual effect associated with each observation.

The mixed model equation (MME) for the best linear unbiased estimator (BLUE) of estimable functions of **b** and for the best linear unbiased prediction (BLUP) of **a** and **p** in matrix notation were as follows:

$$\begin{pmatrix} X'X & X'Z & X'W \\ Z'X & Z'Z + A^{-1}a_1 & Z'W \\ W'X & W'Z & W'W + I a_2 \end{pmatrix} \begin{pmatrix} a \\ b \\ p \end{pmatrix} = \begin{pmatrix} X'y \\ Z'y \\ W'y \end{pmatrix}$$

Where $a_1 = \sigma_e^2 / \sigma_a^2$ and $a_2 = \sigma_e^2 / \sigma_p^2$

RESULTS AND DISCUSSION

Means and variation

Actual means, minimum, maximum, standard deviations (SD), and coefficients of variation (CV%) for 305d MY, TMY, LP, DP, AFC and CI are given in table 2. Means of 305d MY and TMY obtained in this study (9038 kg and 12054 kg, respectively) are higher than most corresponding values reported for Holstein cattle raised in Egypt (Abdel-Salam, 2000; Attalla, 2003; Nigm et al., 2003; Gad, 2005). The estimates ranged between 5275 to 7184 kg for 305d MY and from 6496 to 8487 kg for TMY. On the other hand, the actual mean of 305d MY and TMY in this study are lower than those reported on Holstein Friesian cattle in Egypt by Alhammad (2005) (10847 kg and 13172 kg, respectively). The higher means obtained for yield traits in the present study could be due to high genetic quality of animals and/or, better management and feeding systems in the studied herds.

The mean of lactation period (LP) in the present study (407 days) is longer than the corresponding estimates on Holstein Friesian cattle raised in Egypt (Abdel-Salam, 2000; Afifi et al., 2002; Shitta et al., 2002; El-Arian et al., 2003; Nigm et al., 2003; Alhammad, 2005) which ranged between 263 to 382 day. However, high yielding cows usually have longer lactation period due probably to longer open days and consequently longer calving intervals. The average of dry period (DP) in the

present study was 63.6 days (table 2). This value is comparable to estimates reported by Alhammad (2005) on Holstein cows in Egypt. Also, the average DP in this work is less than those reported on Holstein Friesian cows in Egypt (Salem and Abdel-Raouf, 1999; Ahmed *et al.*, 2002; Shitta *et al.*, 2002 and El-Arian *et al.*, 2003) which ranged between 79 and 125 days.

The average age at first calving (AFC) was 29.2 month. Compared with the other corresponding values recorded in Egypt on Holstein Friesian cows, the present value is higher than the 27.8 and 23.7 month published by Salem (1998) and Afifi *et al.* (2004), respectively. The mean of CI (470 days) in the present study was close to the 472 days obtained by Ahmed *et al.* (2002) on Holstein cattle and higher than those reported in different Egyptian studies on Holstein Friesian cattle (Salem and Abdel-Raouf, 1999; Shitta *et al.*, 2002; Alhammad, 2005) which ranged from 394 to 434 days. The higher estimate obtained for calving interval in this work could be due to that high yielding cows usually have longer CI in commercial herds. It seems that this is a "planned" policy to get as much milk as possible but compromising calf production.

Table 2. Actual means, minimum (Min.), maximum (Max.), standard deviations (SD), and coefficients of variation (CV%) for some productive and reproductive traits of Holstein cows in intensive dairy production system

Trait	No. of records	Mean	Min.	Max.	SD	CV%
305d MY (kg)	4120	9038	6040	13200	1181	13.1
TMY (kg)	4120	12054	6605	18343	1755	14.5
LP (day)	4120	407	292	524	28	6.7
DP (day)	4120	63.6	30	96	7.5	11.6
AFC (month)	1085	29.2	22	36	2.6	9.0
CI (day)	1085	470	362	571	27	5.7

Heritability estimates

Heritability estimates for productive and reproductive traits are presented in table 3. Estimate of h^2 for 305d MY (0.27) was moderately higher than those estimates reported on Holstein Friesian cattle in Egypt (i.e., Salem, 1998; Abdel-Salam, 2000; Abou-Bakr, 2003; Attalla, 2003; Zahed *et al.*, 2003; Alhammad, 2005) which ranged from 0.05 to 0.19. On the other hand, h^2 for 305d MY in this study was lower than those reported on Holstein-Friesian cattle in Egypt by El-Arian *et al.* (2001), Shitta *et al.* (2002) and El-Arian *et al.* (2003) which ranged from 0.31 to 0.33. Estimate of h^2 for TMY was 0.22 (table 3). Similarly, Salem (1998) reported corresponding estimate of 0.20 on Holstein cattle in Egypt. This estimate showed the highest value compared with the corresponding estimates obtained in Egypt, 0.09 and 0.06 by Abdel-Salam (2000) and Alhammad (2005), respectively. Moderately higher estimates for h^2 for milk yield (305d MY and TMY) in the present data indicate a relatively large contribution of additive genetic variance to the total phenotypic variance. Also, this could be due to the fact that these herds have not been subjected to selection.

Table 3 shows that estimate of h^2 for LP was 0.07. This value is generally similar to those obtained for Holstein cattle raised in Egypt (Salem, 1998; Abdel-Salam, 2000; El-Arian *et al.*, 2003; Alhammad, 2005) which ranged from 0.03 to 0.12. Estimate of h^2 for DP was 0.05 (table 3). This value is generally similar to obtained estimates by most workers on Holstein-Friesian in Egypt (i.e., Salem and Abdel-

Raouf, 1999; Shitta *et al.*, 2002; El-Arian *et al.*, 2003; Alhammad, 2005) which ranged from 0.0003 to 0.03. Low values for heritability of LP and DP mean that the great improvement in LP and DP should be possible by improving feeding and management system.

Table 3. Estimates of heritability (h^2), standard errors (SE) and repeatability (t) for productive traits in Holstein cows in intensive dairy production system

Trait	h^2	SE	T
305 day milk yield (305d MY)	0.27	0.014	0.61
Total milk yield (TMY)	0.22	0.008	0.50
Lactation period (LP)	0.07	0.002	0.31
Dry period (DP)	0.05	0.001	0.36
Age at first calving (AFC)	0.23	0.105	-
Calving interval (CI)	0.05	0.004	-

Estimate of h^2 for age at first calving (AFC; 0.23) was lower than 0.38 reported by Afifi *et al.* (2004) on Holstein cattle. However, estimate obtained for h^2 of AFC indicates that this trait could be improved by selection. The estimate of h^2 for CI was 0.05 (table 3). However, the estimates reviewed on Holstein cattle in different countries ranged from 0.0003 to 0.09. Since heritability estimates for CI were low, therefore, genetic selection for CI would be meaningless and improvement should depend mainly on managerial control.

Repeatability estimates

Estimates of repeatability (t) for productive traits (305d MY, TMY, LP, and DP) are given in the table 3. Most estimates of (t) for milk production traits in the present study were moderate or high and ranged from 0.31 to 0.61 (table 3). The high estimates of (t) in this work refer to that the proportion of phenotypic variation due to the permanent environmental effects was high. Consequently, culling of cows for lactation traits based on a single lactation record, as commonly practiced by commercial breeders of dairy cattle would be efficient from the genetic standpoint.

Phenotypic and genetic correlations

Estimates of phenotypic correlations (r_p) and genetic correlations (r_g) among productive traits and reproductive traits are given in Table 4. Phenotypic correlations and genetic correlations between 305d MY and TMY were positive and high being 0.85 and 0.88, respectively (table 4). These estimates generally fall within the range of those obtained for Friesian and Holstein-Friesian cattle by Abdel-Glil (1996), Abdel-Salam (2000) and Abdel-Glil *et al.* (2004). The present results indicate that milk yield in 305d MY could be a good indicators for production in the whole lactation.

The results in table 4 show that the genetic correlations between LP and each of 305d MY and TMY were positive being 0.43 and 0.62, respectively. The present results are in the desirable direction indicating that high yielding cows are also having longer LP, whereas, the genetic correlations between DP and each of 305d MY and TMY were -0.06 and 0.01, respectively (table 4). The present results were quite expected since the high yielding cows usually have longer LP and shorter DP. Similar results were obtained by Salem and Abdel-Raouf (1999), Shitta *et al.* (2002)

and El-Arian *et al.* (2003) on Friesian and Holstein cattle. Similarly, the phenotypic correlation and genetic correlation between LP and DP were negative and high (-0.89 and -0.57, respectively). The results fall within the range of those obtained for Friesian and Holstein cattle by Salem and Abdel-Raouf (1999), Shitta *et al.* (2002) and El-Arian *et al.* (2003).

Phenotypic correlations (r_p) and genetic correlations (r_g) between AFC and CI were negative being -0.18 and -0.64, respectively (table 4). The present results indicate that selection for younger AFC might result in shorter CI. Similar result was obtained by Hussein (2004) on Friesian cattle raised in Egypt who found that phenotypic correlation and genetic correlation between AFC and CI was -0.04 and -0.09, respectively.

Table 4. Estimates of phenotypic correlations (r_p , above the diagonal) and genetic correlations (r_g , below the diagonal) among productive traits and reproductive traits in Holstein cows in the intensive dairy production system

Trait	305d MY	TMY	LP	DP	AFC	CI
305d MY		0.85	-0.21	0.11	-	-
TMY	0.88 ± 0.069		0.31	-0.12	-	-
LP	0.43 ± 0.216	0.62 ± 0.185		-0.89	-	-
DP	-0.06 ± 0.019	0.01 ± 0.007	-0.57 ± 0.392		-	-
AFC	-	-	-	-		-0.18
CI	-	-	-	-	-0.64 ± 0.211	

CONCLUSIONS

The most important conclusions derived from the present study could be summarized as follows:

- 1- Lactation performance of Holstein-Friesian cattle in private farms in Egypt is comparable to its corresponding performance in temperate region.
- 2- High genetic quality, intensive feeding and management systems followed in private commercial farms are successful in maintaining high production of Holstein in Egypt.
- 3- Additive genetic variation has considerable contribution to the total variation in milk yield traits.
- 4- Improving milk yield traits and age at first calving could be based on selection while improving lactation period and calving interval is controlled primarily by environmental factors.
- 5- Early selection of yield traits, based on first lactation performance, could be used satisfactorily to improve milk yield traits.

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المعايير المظهرية و الوراثة لإنتاج اللبن والأداء التناسلي لأبقار الهولستين تحت نظام الإنتاج المكثف فى مصر

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تم تحليل إنتاج أبقار الهولستين فى 14 قطيع تجارى خاص أعضاء فى الجمعية العامة لتنمية الثروة الحيوانية فى مصر. وكان العدد الكلى 4120 سجل لبن من 1085 بقرة بنات 290 طلوقة خلال الفترة من 1999 وحتى 2003. وكانت صفات إنتاج اللبن خلال الدراسة هى ناتج لبن 305 يوم وناتج اللبن الكلى وطول موسم الحليب وطول فترة الجفاف، بينما الصفات التناسلية كانت العمر عند أول ولادة والفترة بين ولادتين. وتم تحليل البيانات المتاحة بواسطة برنامج Animal Model باستخدام MTDFREML . كانت متوسطات إنتاج لبن 305 يوم وناتج اللبن الكلى وطول موسم الحليب وطول فترة الجفاف والعمر عند أول ولادة والفترة بين ولادتين 9038 كجم و 12054 كجم و 407 يوم و 63.6 يوم و 29.2 شهر و 470 يوم على الترتيب. وكانت قيم المكافئ الوراثى لنفس الصفات 0.27 ، 0.22 ، 0.07 ، 0.05 ، 0.23 ، 0.05 على الترتيب. وأيضاً تم تقدير المعامل التكرارى والإرتباطات المظهرية والوراثية بين الصفات. أشارت النتائج إلى الإمكانية الفنية لتربية أبقار الهولستين فى المزارع التجارية فى مصر بنجاح. أظهر التباين الوراثى التجمعى مساهمة معتبرة فى التباين الكلى مشيراً إلى إمكانية تحسين صفات إنتاج اللبن بالانتخاب الوراثى. أظهرت النتائج أيضاً إمكانية الاعتماد على بيانات الموسم الأول للتحسين الوراثى لصفات إنتاج اللبن.