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PHENOTYPIC AND GENETIC PARAMETERS OF MILK PRODUCTION TRAITS OF A HOLSTEIN COMMERCIAL HERD IN EGYPT

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SUMMARY

A total number of 2245 lactation records of 867 cows sired by 288 bulls were used to study milk production characteristics at the Holstein herd of the International Company for Animal Wealth. Heritability estimates for milk yield traits were calculated and genetic and phenotypic correlations among these traits were also investigated. Statistical analyses were performed using SAS (1996) and DF-REML (Meyer, 1998).

Means of actual 305-day milk yield, annualized milk yield and Milk per day of cow age were 7128 kg, 6680 kg and 9.78 kg/day, respectively. Origin of the cow (imported or locally born) showed no significant effect on any of the milk production traits studied while year-season of calving affected all traits (P<0.0001). Also, parity influenced (P<0.0001) all traits. Milk production declined gradually after the second lactation.

It can be concluded that Holstein cows, raised under the intensive system applied at commercial farms, can maintain high milk production.

Keywords: *Holstein, genetic parameters, milk production traits, Egypt.*

INTRODUCTION

Introduction of exotic improved breeds into developing countries is one of the options for improving livestock production. Performance of these breeds depends largely on suitability of the new environment. In Egypt, as in most warm semi arid areas, exotic breeds are exposed to high climatic tempreture, limited feed resources and wide spread of endemic and epidemic diseases (Nigm,1990 and Nigm *et al.*, 1994) . High yielding animals are more sensitive and susceptible to diseases. However, intensive farming practices followed in large commercial farms provide relatively comfortable conditions for exotic animals. There exist in Egypt about 1000 large commercial dairy farms of more than 50 herds. These farms contain about 13% of the total dairy animals population and contribute about 25 % of the domestic milk production in Egypt (MALR, 1997).

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Holstein cattle have been introduced to Egypt in fairly large numbers during the last two decades. Most of these animals are maintained at large commercial farms.

Milk yield traits are the main economic traits for selection in dairy cattle. Accordingly, the main objective of the study was to characterize and evaluate milk production performance of Holstein cows kept under an intensive production system in a commercial farm. Genetic and phenotypic parameters for actual 305-day milk yield, annualized milk yield and milk produced per day of cow life are estimated.

MATERIALS AND METHODS

Animals

This study was carried out using milk production records of a Holstein herd belonging to the International Company for Animal Wealth, located at Abou-Rawash, Giza.

A total number of 425 pregnant heifers was imported in August, 1991. All heifers were pure American Holsteins and were officially registered in the American Holstein Association Herdbook. Semen from pure American Holstein proven bulls was used in A.I. Out of the 425 imported Holstein heifers (referred to as IH), normal lactation data of 404 cows were available for the present study. The locally born cows were 381 daughters and 82 granddaughters of the imported Holstein cows and were referred to as local Holstein (LH). All IH and LH cows were sired by 288 American and Canadian Holstein bulls.

Data

The data comprised 2245 lactation records of 404 IH and 463 LH cows collected over the period from August 1991 to May 1999. These records represented all available milk records of cows that dried off normally. The number of records available for determining annualized milk yield was 1681 records, due to loss of last lactation for calculation annualized milk yield.

Traits

The studied traits were: (1) Actual 305-day milk yield produced by the cow during the first 305 days of lactation (A305-d MY, kg), (2) Annualized milk yield (AMY, kg) calculated as: TMY (Total milk yield) divided by calving interval, in days x 365, and (3) Milk produced per day of cow age (M/dCA, kg/day) calculated as: cumulative milk produced up to the end of each lactation divided by cow age, in days, at the end of the corresponding lactation.

Statistical Analysis

Analyses of variance were calculated using the General Linear Model (GLM) procedure (SAS, 1996). Heritability and repeatability estimates, breeding values, genetic and phenotypic correlations were calculated using the Derivative-Free Restricted Maximum Likelihood (DF-REML) procedure (Meyer, 1998). Product moment correlation (r_{PM}) was used to study the relationships among breeding values of different traits and rank correlation (r_s) was used to determine the relationship among ranking order of breeding values for the studied traits (SAS, 1996).

Model

The following multitrait repeatability animal model was used to analyze milk production traits: actual 305-day milk yield, total milk yield, lactation period, annualized milk yield, milk per day of cow age:

$$Y_{ijklm} = A_i + E_i + B_j + S_k + P_l + e_{ijklm}$$

Where:

Y_{ijklm} = observation of milk production trait,
A_i = additive genetic random effect of the individual i,
E_i = permanent environmental random effect on the individual i,
B_j = fixed effect of origin j, j = 1 (imported) and 2 (locally born),
S_k = fixed effect of year-season of calving k (k = 14 levels), two seasons were defined; cool season from October to March and warm season from April to September and eight years of calving from 1991 to 1998,
P_l = fixed effect of parity l, (l = 6 parities) and
e_{ijklm} = random residual error.

RESULTS AND DISCUSSION

Milk yield traits

Table 1 shows arithmetic means, standard errors and coefficients of variation for actual 305-d milk yield (A305-d MY), annualized milk yield (AMY) and milk per day of cow age (M/dCA).

The A305-d MY obtained in the present study (7128 kg) is much higher than all corresponding estimates reported for Friesian (F), Holstein Friesian (HF) and pure Holstein (H) cows, in Egypt (Khattab and Ashmawy, 1990; Khattab, 1992; Salem, 1992; Khattab *et al.*, 1993; Mokhtar *et al.*, 1993; Khalil *et al.*, 1994; Salem and Omar, 1994; Mokhtar, 1995 and Ahmed, 1996). This could be regarded as a good performance for Holstein in Egypt when compared with the breed performance in temperate areas. However, the long lactation period (382 days) and consequently the long calving interval (with an average of 480 day) might impair the lifetime performance.

Table 1. Means, standard errors (SE) and coefficient of variation of milk production traits

Trait	Mean	SE	C.V.
Actual 305-d milk yield (A305-d MY, kg)	7128	40	26
Annualized milk yield (AMY, kg)	6680	42	26
Milk per day of cow age (M/dCA, kg/day)	9.78	0.04	20

Number of observations = 2245, except for annualized milk yield (N =1681).

Annualized milk yield was calculated to take into account milk production and regularity of reproduction. The AMY (6680 kg) was 450 kg (6.3%) less than the A305-d MY.

Milk per day of cow age (M/dCA) is a trait used to indicate the dairy animal profitability. It combines age at first calving, milk production and breeding efficiency in one indicative value. Mostageer *et al.* (1990) recommended the use of this index to visualize differences between genotypes since it takes into account the age at first calving and the length of lactation. The Canadian Record of Performance (ROP) system uses this parameter in genetic evaluation. Table 1 shows that the Holstein cow raised in commercial farms in Egypt produces on the average about 10 kg/day of her life in the herd (from birth till the end of the respective lactation). This value is much higher than the corresponding estimates reported for Friesian and Holstein Friesian in Egypt (Nigm, 1990); for Friesian in Libya (Morsy *et al.*, 1986). This results may due to the higher milk yield and shorter age at first calving in this study.

The ANOVA results for the studied traits are give in table 2. Origin showed no significant effect on all the studied traits. This finding is in agreement with the results obtained by Sadek (1994) working on a Friesian herd located at the U.A.E.. The least squares means of different traits for imported (IH) and locally born (LH) cows were estimated. Though all differences were non-significant.

Table 2. Analysis of variance of milk production traits

	Source of variation			
Traits	**Origin**	**Year-season**	**Parity**	**Remainder**
A305-d MY				
MS	1880097	31956207***	21497757***	3549105
P	.4668	.0001	.0001	
AMY				
MS	2815124	7348722**	7442494*	2916498
P	.3260	.0027	.0261	
M/dCA				
MS	.02	15.9***	623***	3.8
P	.9469	.0001	.0001	

$*P < 0.05$, $**P < 0.01$; $***P < 0.001$

A305-d MY= actual 305-d milk yield; AMY= annualized milk yield and M/dCA= milk per day of cow age.

Degrees of freedom (df) of origin, year-season, parity and remainder were 1, 13, 5 and 2225, except for AMY where df were 1, 12, 5 and 1662, respectively.

Table 2 shows that the effect of year-season of calving subclass was significant for all traits. Many investigators attributed the significant effect of year and season of calving on milk production traits to the varied climatic, nutritional and managerial conditions (Khattab and Sultan, 1990; Afifi *et al.*, 1992; Nigm *et al.*, 1994; Sadek, 1994 and Salem and Omar, 1994).

Parity affected significantly on A305-d MY and M/dCA and AMY. The A305-d MY was the highest in the second lactation (7255 kg)(Figure 1). A gradual decrease was observed from the second to the fourth with the highest decline, also, from the third to the fourth lactation (809 kg) (table 3). Similar trend can be seen for AMY. This trend was observed for both imported and locally born cows. In all yield traits there was an increase from the fourth to the fifth lactation.

The decline of milk production observed after the second lactation may be attributed to more sensitivity of the high yielding cows to the prevailing environmental conditions. High milk producing cows are more sensitive to adverse environments. Mostageer *et al.* (1987) found that Friesian cows with high milk yield leave the herd earlier than their herd mates with lower yield. This point needs more analysis of survival to the subsequent lactation for high against low yielders used in this study. It can be concluded that the environmental conditions were not appropriate enough to cope with the expected increased in milk production of these high yielding Holstein cows by advance of their lactation order.

Table 3. Least squares means ($\bar{x} \pm$ SE) of milk production traits as affected by parity

	Trait				
Parity	N	A 305-d MY	M/dCA	N	AMY
1	867	$7137^a \pm 96$	$7.25^a \pm 0.09$	694	$6910^a \pm 102$
2	601	$7255^a \pm 88$	$10.15^b \pm 0.09$	454	$6792^a \pm 96$
3	395	$7119^a \pm 118$	$11.71^c \pm 0.12$	302	$6747^a \pm 128$
4	235	$6310^b \pm 177$	$12.43^d \pm 0.18$	150	$6339^b \pm 208$
5	111	$6421^b \pm 246$	$13.22^e \pm 0.26$	62	$7042^a \pm 292$
6	36	$5927^b \pm 367$	$14.27^f \pm 0.38$	19	$5903^b \pm 452$

a, b, c, d, e, f Means in a column with different superscripts differ ($P < 0.05$).
A305-d MY= actual 305-d milk yield; AMY= annualized milk yield and M/dCA= milk per day of cow age.

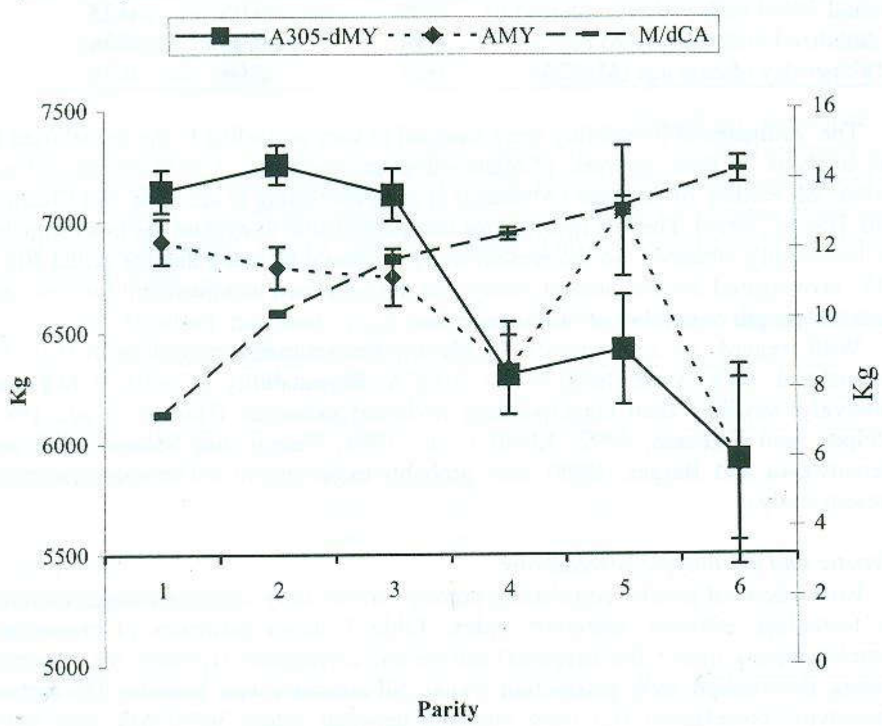

Figure 1. Effect of parity on milk production traits.

Milk per day of cow age increased drastically from the first to the second lactation (40%). The estimates increased gradually then after from the second to the sixth lactation with an increment rate of 15, 6, 6 and 8%, in respective order.

The markedly high milk yield produced by the Holstein in the first lactation (about 7000 kg in 305 days) may refer to that improving environmental and managerial conditions would increase cow production in the following lactations.

Genetic parameters

Heritability

Table 4 presents estimates of heritability (h^2) and repeatability (t) for milk yield traits. Heritability estimates obtained in the present study were generally low indicating relatively high environmental variability in these traits. The lowest heritability was that of annualized milk yield (0.04) followed by actual 305-day milk yield (0.05). The standard error was markedly large and similar (0.05) for the three traits. The M/dCA scored the highest estimate (0.24). This high heritability estimate of M/dCA may refer to the usefulness of incorporating the trait in breeding programs.

Table 4. Estimates of heritability (h^2) and their standard errors (SE) and repeatability (t) for milk production traits

Trait	h^2	SE	T
Actual 305-d milk yield (A305-d MY)	0.05	0.05	0.35
Annualized milk yield (AMY)	0.04	0.05	0.26
Milk per day of cow age (M/dCA)	0.24	0.08	0.76

The estimates of heritability were reported to vary according to the model used in the analysis of data, sources of relationships accounted for, size of the data set and nature of editing of the data (Abubakar *et al.*, 1986; Dong *et al.*, 1988 and Chauhan and Hayes, 1991). The last two reasons seem applicable to explain the low estimates of heritability obtained in the present study. It should be noted that the actual 305-d MY investigated in the present study was not subjected to adjustment for cow age, lactation length or number of milkings/day.

With regard to repeatability (table 4), the estimates ranged from 0.26 for Annualized milk yield to 0.76 for M/dCA. Repeatability of A305-d MY was relatively smaller than corresponding reviewed estimates (Hansen *et al.*, 1983; Welper and Freeman, 1992; Khalil *et al.*, 1994; Vargas and Solano, 1995 and Dematwewa and Berger, 1998) due probably to the unadjusted records used in the present study.

Genetic and phenotypic correlations

Estimation of genetic correlations among various dairy characteristics is required to formulate efficient selection index. Table 5 shows estimates of phenotypic correlations (r_p above the diagonal) and genetic correlations (r_g below the diagonal) among the studied milk production traits. All estimates were positive. The highest phenotypic correlations (r_p) were obtained between actual 305-d MY and AMY (0.82). The milk per day of cow age (M/dCA) showed fairly high estimates of phenotypic correlations with actual 305-d MY (r_p=0.74).

Table 5. Phenotypic correlation (r_p, above the diagonal) and genetic correlation (r_g, below the diagonal) among milk production traits

Trait	A305-d MY	AMY	M/dCA
A 305-d MY		0.82	0.74
AMY	0.85		0.63
M/dCA	0.85	0.54	

A305-d MY= actual 305-d milk yield; AMY= annualized milk yield and M/dCA= milk per day of cow age.

The estimates obtained for genetic correlations (r_g) were all positive and mostly higher than their corresponding phenotypic correlations. The estimate (0.85) was obtained for r_g between actual 305-d MY and both of AMY and M/dCA. It is noteworthy that M/dCA showed high positive genetic relationship with A305-d MY (r_g = 0.85). This finding means that selection for A305-d MY would improve M/dCA and consequently dairy farm profitability.

Table 6 shows maximum and minimum breeding values for Actual 305-day milk yield, annualized milk yield and Milk/d of cow age.

Table 6. Maximum and minimum breeding values for all studied traits

	Sires		Cows	
Traits	**Max.**	**Min.**	**Max.**	**Min.**
Actual 305-day milk yield (kg)	259	-398	447	-409
Annualized milk yield (kg)	216	-319	337	-382
Milk/d of cow life (kg/day)	0.9	-0.9	1.4	-1.4

The product moment correlation (r_{PM}) was calculated to determine the relationships among breeding values for various milk yield traits. Rank correlation coefficients (r_s) were determined to describe the relationships among ranking order of breeding values for different milk production traits. Table 7 shows product moment and rank correlations among breeding values of all animals, sirs and cows for milk production traits.

Table 7. Product moment (r_{PM}) and rank (r_s) correlations among breeding values of milk production traits

Trait	AMY		M/dCA	
	r_{PM}	r_s	r_{PM}	r_s
A305-d MY				
All animals	0.85	0.81	0.82	0.79
Sires	0.87	0.82	0.82	0.79
Cows	0.85	0.81	0.82	0.79
AMY				
All animals			0.73	0.68
Sires			0.75	0.69
Cows			0.73	0.69

A305-d MY= actual 305-d milk yield; AMY= annualized milk yield and M/dCA= milk per day of cow age.

r_{PM}= Product moment correlation; r_s = rank correlation.

The product moment correlations were generally positive and high. They showed the same trend observed in table 5 for genetic correlation among milk production traits. The highest r_{PM} estimates were those between A305-d MY and AMY. There were no marked differences in r_{PM} estimates obtained for all animals, sires or cows. Almost, similar trend was observed for rank correlation, with, however, relatively lower values. The results indicate that ranking breeding values for any of the studied traits would give comparable ranking in the other traits.

CONCLUSIONS

Results of the study indicate that Holstein cows, raised under intensive farming practices followed in the studied herd, can maintain high milk production. Their high genetic potential was largely manifested in the first two lactations. These animals produced, on the average, over 7000 kg in the first 305 days of their first three lactations. The milk production declined gradually after that due probably to more sensitivity to local environmental of high yielding animals to environmental conditions. This was true for both imported and locally born cows sired by North American bulls. More attention paid to the environmental stresses, especially climatic and nutritional, may enhance production of these high yielding animals in successive lactations. Further investigations are needed for the better housing and feeding.

The almost similar milk production characteristics of the imported and locally born cows may indicate the effectiveness of using imported semen of proven North American bulls to maintain high genetic potential of the locally born cows in this herd

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المقاييس المظهرية والوراثية لصفات إنتاج اللبن لقطيع هولشتين تجارى فى مصر

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استخدم ٢٢٤٥ سجلاً لعدد ٨٦٧ بقرة بنات ٢٨٨ طلوقة من قطيع الهولشتين التابع للشركة العالمية للثروة الحيوانية– الجيزة– لدراسة خصائص إنتاج اللبن، قدرت الدراسة قيم العمق الوراثى ومعاملات التلازم المظهرى والوراثى بين صفات إنتاج اللبن. حللت البيانات إحصائيا باستخدام برنامج SAS (1996) وبرنامج DF-REML (Meyer, 1998).

كانت متوسطات محصول اللبن الفعلى فى ٣٠٥ يوم، محصول اللبن فى السنة (AMY) و إنتاج اللبن فى اليوم من عمر الحيوان هى ٧١٢٨ كيلو جرام، ٦٦٨٠ كيلو جرام و ٩,٧٨ كيلو جرام (على الترتيب). لم يظهر منشأ الحيوان (مستورد أو مولود محليا) تأثيراً معنوياً على أى من صفات إنتاج اللبن بينما أثر موسم و سنة الولادة وكذا ترتيب موسم الولادة معنوياً ($P<0.0001$) على جميع الصفات التى درست. وقد انخفض إنتاج اللبن بعد الموسم الثانى بشكل تدريجى.

كانت قيم العمق الوراثى لمحصول اللبن الفعلى فى ٣٠٥ يوم، محصول اللبن فى السنة (AMY) وإنتاج اللبن من عمر الحيوان هى ٠,٠٥ ، ٠,٠٤، (على الترتيب). كانت قيم معامل التكرر للصفات الثلاثة هى ٠,٣٥، ٠,٢٦، ٠,٧٦ (على الترتيب).

استنتجت الدراسة قدرة أبقار الهولشتين المرباة تحت النظام المكثف فى المزرعة التجارية التى درست فى الحفاظ على مستوى عال من إنتاج اللبن.