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GENETIC AND PHENOTYPIC PARAMETERS FOR MILK YIELD, DAYS OPEN AND NUMBER OF SERVICES PER CONCEPTION OF HOLSTEIN COWS OF A COMMERCIAL HERD IN EGYPT

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SUMMARY

A total of 1391 lactation records were obtained from 726 Holstein cows raised at a commercial farm. Records were analyzed to obtain (co)variance estimates for actual 305 day milk yield, days open and number of services per conception. Variance components were estimated by the DF-REML procedure with a multiple-trait repeatability animal model. The model included year-season of calving (16 groups) and parity (first three lactations) as fixed effects and additive genetic and permanent environmental as random effects.

Averages of 305 day milk yield, days open and number of services per conception were 7504 kg, 229 days and 2.8 services, respectively. Estimates of heritability for the three traits were 0.090, 0.045, and 0.003, respectively. The corresponding repeatability estimates were 0.386, 0.081 and 0.030, respectively. Genetic correlations between 305 day milk yield with both days open and number of services per conception were high and positive (0.61 and 0.97, respectively). The nature of the relationship between milk yield and fertility traits may cause a problem in realizing rapid improvement for both of them simultaneously. The corresponding phenotypic correlations were 0.131 and 0.091, respectively. Genetic and phenotypic correlations between days open and number of services per conception were 0.706 and 0.703, respectively. The results indicate that improvement of fertility traits would be brought about by improving management conditions.

Keywords: Holstein Friesian, genetic parameters, milk yield, fertility, Egypt.

INTRODUCTION

Milk yield has been the best selection criterion for Holsteins in Egypt due to its great economic importance. However, other traits, such as fertility, are important to improve the profitability of the dairy cow and to maximize the net return of the dairy farm. Conception and consequently calving at regular intervals are important in maintaining efficient milk production. Therefore, economic returns of dairy farms depends on both milk production and reproductive efficiency.

Emphasis on milk yield only may have antagonistic genetic relationship with fertility (Schneeberger and Hagger, 1986). Studies on dairy cows indicated that reproductive failure was responsible for 16 to 30% of the total cow disposal (Arnaud *et al.*, 1980). Days open (DO) and number of services per conception (NSPC) are considered important measures of reproductive performance. Heritability estimated for both traits has been shown to be moderately low ≤ 0.05 (Raheja *et al.*, 1989; Moore *et al.*, 1990; Badran and Shebl, 1991; Hayes *et al.*, 1992; Marti and Funk, 1994; Makuza and McDaniel, 1996; and Dematawewa and Berger, 1998). Little is known about the exact cause and effect relationships among milk production and reproduction of the dairy cow during different lactations. Understanding the nature of these relationships would enable breeder to further genetic improvement of primary traits without scarifying performance of secondary traits by incorporating secondary traits in bull selection indices (Hermas *et al.*, 1987).

The objective of this study was to estimate heritability, repeatability and genetic and phenotypic correlations for actual 305 day milk yield, DO and NSPC using multiple lactation records of Holstein cows raised in a commercial farm in Egypt.

MATERIALS AND METHODS

Data on milk yield and reproductive performance of 726 lactating Holstein cows in a single commercial herd (International Company For Animal Wealth), located at Giza Governorate (Egypt), were collected during the period from 1991 to 1998. Measures of reproductive performance included days open (DO) and number of services per conception (NSPC). Milk production was represented by actual 305 day milk yield (305-MY). Data included 1391 lactation records for 726 Holstein cows sired by 220 sire and distributed in 16 year-season groups. Most of the cows were imported as pregnant heifers from U.S.A. Cows are artificially inseminated at the first estrus observed after parturition using frozen semen imported from U.S.A. All cows were machine milked daily according to their productivity. Each year was divided into two seasons, hot (March to August) and cold (September to February).

The following multiple-trait repeatability animal model was used to calculate (co) variance components for the three studied traits:

$$Y_{ijkl} = \mu + YS_i + P_j + A_k + PE_k + e_{ijkl}$$

where,

Y_{ijkl} = record of trait t, (t =305-MY, DO and NSPC) for the kth record of the jth parity during the ith year-season,

μ = an overall mean,

YS_i = the fixed effect of the ith year-season (16 levels),

P_j = the fixed effect of the jth parity (3 levels representing the first three parities),

A_k = the random effect of the additive genetic effect of the animal (726 levels),

PE_k = the random permanent environmental effect on the animal, and

e_{ijkl} = the random residual effect associated with each observation.

Heritabilities, repeatabilities and genetic and phenotypic correlations were obtained employing a multiple-trait repeatability animal model through the

Derivative Free Restricted Maximum Likelihood (DF-REML) procedure modified by Thompson and Hill (1990). Initially, heritabilities were estimated for each one of the three traits using univariate analysis. These univariate heritability estimates were used as starting values for the multiple-trait analysis to facilitate convergence.

RESULTS AND DISCUSSION

Preliminary least squares analysis using the PROC GLM option of SAS (1990) showed highly significant effects for year-season on all traits studied (305-MY, DO and NSPC) as presented in table 1. However, parity had a non significant effect only on NSPC.

Table 1. Mean squares of 305 day milk yield (305-MY), days open (DO) and number of services per conception (NSPC) of Holstein cows.

Source of variation	df	Mean squares 305-MY	DO	NSPC
Year- season	15	14543022**	73855.80**	12.41**
Parity	2	8043706*	220614.73**	0.35NS
Erorr	1373	2067195	85525.87	2.82

* p <0.05 ** p < 0.01 NS = Not significant

Table 2 shows least squares means and standard errors for the three traits across the first three parities and for each parity.

The mean of 305-MY across all parities estimated by using SAS (1990) from the present study (Table 2) falls within the range reported in the literature (Moharram, 1988;Badran and Shebl, 1991; Marti and Funk, 1994 ; Moon, 1994 and Dematawewa and Berger, 1998). The mean of DO across all parities was 229 day. Values found in the literature were clearly lower for the same breed and ranged from 96 to 169 day (Oltenacu *et al.*, 1980; Moharram, 1988; Hayes *et al.*, 1992; Marti and Funk, 1994; Moon, 1994 and Dematawewa and Berger, 1998). Oltenacu *et al.* (1980) added that low producing cows tend to have less DO (96 day) and high productive ones had longer DO periods (104.4 day). The mean of NSPC across all parities was 2.8

Table 2. Least squares means[1]($\overline{X}$) and standard errors (SE) for 305 day milk yield (305-MY), days open (DO) and number of services per conception (NSPC) of Holstein cows across all parities and for each parity.

	No.of records	$\overline{X}$ 305-MY (Kg)	DO (day)	NSPC (no.)
All parities	1391			
Parities :				
First parity	697	7426[a]	255[a]	2.9[a]
Second parity	434	7661[b]	213[b]	2.9[a]
Third parity	260	7728[b]	207[b]	2.8[a]

[1] Means followed by different letters differ significantly (p<0.01).

services. This value is clearly higher than the values frequently found in the literature for the same breed which vary from 1.5 to 1.9 (Aragonosa and Rigor, 1988; Moore *et al.*, 1990; and Dematawewa and Berger, 1998) according to milk productivity. On this context Bagnato and Oltenacu (1994) reported that high yielding cows had 12 days longer interval from calving to the first service and required 0.32 more services per conception. The authors suggested that the negative effect of high milk yield on fertility may be reduced by better reproductive management. Results of Hegazy *et al.* (1997) added that poor fertility in high yielding cows is not directly related to their high level of milk yield but rather to the loss of weight and body condition.

As can be realized from table 2, means for 305-MY increased as parity advanced, however, means for DO decreased and means for NSPC were almost constant. Hansen *et al.* (1983) showed similar results. These authors mentioned that growth and stress factors during the first lactation may inhibit fertility whereas cows in their third lactation overcome the depressing effect of age on fertility.

Estimates of heritability and phenotypic correlations for 305-MY, DO, and NSPC for each parity are presented in table 3.

Table 3. Heritability estimates (on diagonal) and phenotypic correlations (above diagonal) for 305 day milk yield (305-MY), days open (DO) and number of services per conception (NSPC) of Holstein cows for each parity.

Trait	305-MY	DO	NSPC
First parity (N=697)			
305-MY	0.1347	0.1308	0.0906
DO		0.0691	0.7340
NSPC			0.0004
Second parity (N=434)			
305-MY	0.1567	0.1342	0.0994
DO		0.0754	0.6715
NSPC			NA
Third parity (N=260)			
305-MY	0.5182	0.0832	0.0599
DO		0.1003	0.6550
NSPC			0.0209

NA = not available.

Some studies (Rothschild and Henderson, 1979; Tong *et al.*, 1979; Powell *et al.*, 1981; Berger *et al.*, 1981; Raheja *et al.*, 1989; and Dematawewa and Berger 1998) have shown an increase in heritability for 305-MY, DO and NSPC with the increase in lactation number. These results are in good agreement with our results. For the three traits, reduction in phenotypic variance relative to additive variance is further evidenced by the higher heritability estimates for later parities than for the first parity. Phenotypic correlations between fertility traits (DO and NSPC) with 305-MY were positive but no clear trend was observed from the first to the third parity. Strong positive phenotypic correlations were found between DO and NSPC (0.7), in agreement with the results found by Raheja *et al.* (1989) and Dematawewa and

Berger (1998), for cows in all parities. Both traits are indicators of loss in fertility and therefore both are subjected to many managerial factors such as estrous detection and efficiency of insemination technician which may affect the value of their phenotypic correlation.

Estimates of heritability, genetic and phenotypic correlations for 305-MY , DO and NSPC of Holstein cows across all parities are shown in table 4.

Heritability estimated for 305-MY was 0.09. This estimate is lower than the range (from 0.135 to 0.310) found in the literature (Weller, 1989; Short and Lawlor, 1992; Marti and Funk, 1994 and Dematawewa and Berger, 1998). Differences in heritability estimates among the various studies for the same trait of the same breed may be due to differences in the number of records used, the correction for non-genetic factors, the model used and the methodology employed. Badran and Shebl (1991) obtained very close estimate (0.10) with our results for estimating heritability of milk yield.

Table 4. Heritability estimates (on diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations for 305 day milk yield (305-MY), days open (DO) and number of services per conception (NSPC) of Holstein cows across all parities.

Trait	305-MY	DO	NSPC
305-MY	0.090	0.605	0.974
DO	0.131	0.045	0.706
NSPC	0.091	0.703	0.003

Estimate of heritability for DO was 0.045 (Table 4) which is comparable to other reports in the literature (Berger *et al.*, 1981; Hayes *et al.*, 1992; Marti and Funk, 1994; Rekaya *et al.*, and 1996; Dematawewa and Berger, 1998). Although the adjustment to some environmental factors reduced much of the variation in production associated with DO, its heritability is still low suggesting that the trait is largely affected by the environmental conditions (Marti and Funk, 1994). The estimated heritability of NSPC was only 0.003. However, the estimates of previous researches ranged from 0.008 (Moore *et al*,1990) to 0.06 (Berger *et al.*, 1981). Because heritability estimates of reproductive traits are almost zero, therefore genetic selection to improve reproductive efficiency would be meaningless.

Estimates of genetic and phenotypic correlations across all parities are shown in table 4. The phenotypic correlations between milk yield and fertility traits are similar to within parity correlations (Table 3). This result is in good agreement with those obtained by Dematawewa and Berger (1998). Genetic correlations between 305-MY with DO (0.61) and NSPC (0.97) are strong but undesirable. Therefore, the use of fertility measures in bull indices may be questionable.

Estimates of repeatability for 305 day milk yield (305-MY), days open (DO) and number of services per conception (NSPC) of Holstein cows were 0.386 ,0.081 and 0.030, respectively. The estimate of repeatability of 305-MY (0.386) was lower than those found in the literature (Dematawewa and Berger, 1998; Marti and Funk, 1994 and Welper and Freeman, 1992). Repeatability estimate for DO (0.081) was close to the literature values (ranged from 0.096 to 0.143) estimated for the same breed (Hayes *et al.*, 1992; Marti and Funk, 1994; and Dematawewa and Berger, 1998).

Meanwhile, repeatability for NSPC (0.03) was somewhat lower than the estimates obtained from other studies (ranged from 0.07 to 0.08) for the same breed (Hayes *et al.*, 1992; and Dematawewa and Berger, 1998). All these estimates are still low indicatin

performance in later lactations. Low estimates of repeatability for fertility traits obtained are in concordance with their low heritabilities. Hayes *et al.* (1992) reported that factors other than genetic and permanent environmental effects (detection of estrus and managerial and nutritional factors) were main determinants of reproductive efficiency.

Pairwise repeatability estimates between the three parity groups are shown in table 5. As expected repeatabilities for fertility traits (DO and NSPC) were much lower than those for 305-MY. These low repeatabities for fertility traits indicate that fertility performance during first lactation may not be very repeatable in the subsequent ones. Therefore, cows in their first lactation having some difficulty in conceiving may not repeat the same problem in their later lactations.

Table 5. Pairwise repeatability estimates between groups for 305 day milk yield (305-MY), days open (DO), and number of services per conception (NSPC) of Holstein cows.

Trait	Repeatability estimates between parity groups		
	1 and 2	1 and 3	2 and 3
305-MY	0.3830	0.3230	0.4426
DO	0.0987	0.0228	0.0411
NSPC	0.0394	0.1022	0.0001

As shown in table 5, repeatability estimates for adjacent lactations were higher than non-adjacent ones except for NS. This result concur with those reported by Hansen *et al.* (1983); Raheja *et al.* (1989); and Dematawewa and Berger (1998). Butcher and Freeman (1968) observed that relationships between consecutive lactations increased gradually as animals aged and relationships between non-consecutive lactations decreased gradually as lactations become more separated in time. Higher estimates between the second and the third parities compared with those between the first and the second parities for 305-MY may be a result of several reasons. As suggested by Dematawewa and Berger (1998) intensive selection may contribute to more homogeneity (smaller phenotypic variance) among cows in later parities than among heifers, resulting in a higher ratio between components of permanent environmental and phenotypic variance. Hansen *et al.* (1983) speculated that the effect of permanent environmental effect tends to be greater for older cows.

Conclusion

The heritability estimates of reproductive traits (DO and NSPC) were low. Therefore, the direct genetic improvement for these traits is expected to be ineffective. Also, reproductive traits are very lowly repeatable. Poor fertility in cows appears to be a managerial problem. Therefore, improvement must be brought about by improving management conditions that influence fertility.

The positive genetic correlation found between milk yield and fertility traits in this study strengthen the evidence for an antagonistic relationship between yield and fertility. The results suggest that incorporating reproductive measures in bull indices in a suitable way would hinder the deterioration of reproductive performance in high yielding cows.

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المقاييس الوراثية و المظهرية لصفة إنتاج اللبن فى ٣٠٥ يوم و الفترة المفتوحة وعدد التلقيحات اللازمة للحمل للأبقار الهولشتين فى مزرعة تجارية بمصر

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أجريت الدراسة على١٣٩١ سجل تم جمعهم من سنة ١٩٩١ إلى سنة ١٩٩٨ من ٧٢٦ بقرة هولستين فريزيان تابعة لمزرعة تجارية هى الشركة العالمية للثروة الحيوانية فى مصر بهدف تقدير المقاييس الوراثية و المظهرية لكل من صفة إنتاج اللبن فى ٣٠٥ يوم و بعض الصفات التناسلية مثل الفترة المفتوحة و عدد التلقيحات اللازمة للحمل. تم تقدير مكونات التباين لتلك الصفات باستخدام طريقة DF-REML و إشتمل النموذج الإحصائى على موسم و سنة الولادة (١٦ مجموعة) و الموسم (أول ثلاث مواسم) وذلك كتاثير ثابت بينما أستخدم التأثير الوراثى التجمعى و البيئى الدائم كتأثير عشوائى .

ويمكن تلخيص النتائج المتحصل عليها كالتالى: كان متوسط انتاج اللبن فى ٣٠٥ يوم و الفترة المفتوحة و عدد التلقيحات اللازمة للحمل هو ٧٥٠٤ كجم و ٢٢٩ يوم و ٢,٨ تلقيحة على الترتيب.كانت قيم العمق الوراثى للصفات الثلاثة هي ٠,٠٩ و ٠,٠٥ و ٠,٠٠٣ على الترتيب. بينما كانت القيم المناظرة لمعامل التكرر للصفات الثلاثة هى ٠,٣٨٦ و ٠,٠٨١ و ٠,٠٣ على الترتيب. كانت قيم معاملات الإرتباط الوراثى بين صفة إنتاج اللبن فى ٣٠٥ يوم وكل من الفترة المفتوحة و عدد التلقيحات اللازمة للحمل عالية و موجبة (٠,٦١ و ٠,٩٧ على الترتيب). بينما كانت القيم المناظرة لمعاملات الإرتباط المظهرى هى ٠,١٣١ و ٠,٠٩١ على الترتيب. كانت قيم معامل الإرتباط الوراثى و المظهرى بين الفترة المفتوحة و عدد التلقيحات اللازمة للحمل هى ٠,٧٠٦ و ٠,٧٠٣ على الترتيب. يلاحظ من هذه الدراسة أن تحسين الصفات التناسلية يجب عمله من خلال تحسين الظروف البيئية المحيطة بالحيوان . حيث طبيعة العلاقة بين صفة انتاج اللبن و الصفات التناسلية ربما تسبب مشكلة فى تحقيق تحسين وراثى سريع لهذه الصفات نتيجة للارتباط الوراثى العالى بينهما.