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## Genetic and non Genetic Factors Affecting Days Open, Number of Services per Conception and Age at First Calving in a Herd of Holstien-Friesian Cattles

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**Abstract:** The data were used to estimate the effect of genetic (sire) and non-genetic factors on some reproductive traits, and to estimate the genetic and phenotypic parameters for the same traits. The actual means of day open (DO), number of service per conception (NSPC) and age at first calving (AFC) were, 124 days, 1.95 and 27 months, respectively. Coefficients of variation of the three studied traits were 56.9, 61.0 and 12.7%, respectively. Year of calving had highly significant effects on DO and NSPC while year of birth had highly significant effects on AFC. Month of calving had no while effect on DO and NSPC, while it had on AFC. Estimates of partial linear and quadratic regression coefficients of DO and NSPC on age at AFC were not significant. While the same were highly significant on the total milk yield (TMY) of the first lactation. The sire of heifers had highly significant effect on all traits studied. The sire variance components ( $\sigma^2_s$ ) were 4.20, 2.64 and 4.08% of the total variance for DO, NSPC and AFC, respectively. The estimates of heritability ( $\pm$  SE) of reproductive records of the cows in their first parity based on paternal half-sibs method for DO, NSPC and AFC were  $0.163 \pm 0.042$ ,  $0.105 \pm 0.038$  and  $0.163 \pm 0.042$ , respectively. High phenotypic and environmental correlation coefficients were found between DO and NSPC (0.50 and 0.564, respectively). Low genetic correlation was found between DO and NSPC

**Key words:** Dairy cattle, Holstein-Friesian, genetic parameters, reproductive traits.

### Introduction

Reproductive status of a dairy herd has a large bearing on production and profitability. Insufficient reproductive performance results in excessively late age at first calving and long lactations. Both are costly to the dairy producers because of the veterinarian breeding expense, high reproductive replacement costs and fewer calves being born. Kubik (1992) stated that an average of 20 – 25 % of dairy cows are culled every year due to poor reproductive performance.

In order to evaluate herd reproductive performance various measures of reproductive efficiency must be calculated for the herd and compared to realistic goals. Days open (DO), number of services per conception (NSPC) and age at first calving (AFC) are probably the most often used indices of reproductive efficiency, especially DO considers the management component of the calving interval.

Many factors influence reproductive performance in a dairy herd. These factors include genetic influence and management factors.

The objectives of present study are to investigate the effects of genetic and non-genetic factors affecting DO, NSPC and AFC also to estimate genetic and phenotypic parameters for the same traits using reproductive records of Holstein Friesian cattles.

### Materials and Methods

Total of 3347 reproductive records of Holstein Friesian cows in their first parity, maintained at Mezohegyes State Farm, Hungary during the period from 1982 to 1990 were used in this study. The number of sires and the average number of daughters per sire were 282 and 10.9, respectively.

The animals were kept in shaded-stables under the feeding and management system of Mezohegyes State Farm and were fed routine feed. Depending on season of the year the following rations were offered to the animals: hay, high moisture feedstuff (ear corn, silage, sugar beet-pulp, grass silage and molasses), green mixture (alfalfa, soybeans, sun flowers, red clover, hybrid Sudan grass, mixed corn silage and ear-corn silage). In addition, concentrate mixture (corn, wheat bran and corn meal), supplemented with mineral and vitamins

was also provided. The lactating cows were milked twice a day at 0500 and 1700 h and were dried off about two months before the expected calving date.

Heifers were put for insemination for the first time when they reached about 14 to 16 months of age. Cows were observed for standing oestrous twice daily. Animals seen on heat were artificially inseminated using frozen semen at least 45 days after calving. Pregnancy was detected by rectal palpation 60 days after service and cows that failed to conceive were artificially inseminated again at the following heat.

**Statistical analysis:** Data were analyzed using linear mixed model least squares and maximum likelihood (LSMLMW) computer program of Harvey's (1990). Two models of statistical analysis were used for studying factors affecting DO (the period from parturition to conception), NSPC and AFC which are as follows:

1) The following mixed model was used to analyze DO and NSPC:

$$Y_{ijkm} = \mu + S_i + M_j + Y_k + bL_1 (x_1 - \bar{x}_1) + bQ_1 (x_1 - \bar{x}_1)^2 + bL_2 (x_2 - \bar{x}_2) + bQ_2 (x_2 - \bar{x}_2)^2 + e_{ijkm}$$

Where:

- $Y_{ijkm}$  = individual observation;
- $\mu$  = overall mean;
- $S_i$  = random effect of the  $i$ th sire,
- $M_j$  = fixed effect of the  $j$ th month of calving,  $k = 1, 2, 3, \dots, 12$  (from January to December);
- $Y_k$  = fixed effect of the  $k$ th year of calving,  $l = 1, 2, 3, \dots, 9$  (from 1982 to 1990);
- $bL_1$  &  $bQ_1$  = partial linear and quadratic regression coefficients, respectively for DO and NSPC traits on age at first calving (month),
- $bL_2$  &  $bQ_2$  = partial linear and quadratic regression coefficients, respectively for DO and NSPC traits on total milk yield in the current lactation (TMY), kg,
- $x_1 - \bar{x}_1$  =  $x_1$  age at first calving of cow,  $\bar{x}_1$  average AFC, month;

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$x_2 - \bar{x}_2$  =  $x_2$  total milk yield of cow,  $\bar{x}_2$  average TMY, kg; and

$e_{ijkm}$  = residual term assumed to be random and distributed as a normal distribution with mean zero and variance  $\sigma^2$ .

2) The following mixed model was used to analyze AFC:

$$Y_{ijkm} = \mu + S_i + M_j + Y_k + e_{ijkm}$$

where:

$Y_{ijkm}$  = individual observation;

$\mu$  = overall mean;

$S_i$  = random effect of the  $i$ th sire,

$M_j$  = the fixed effect of the  $j$ th month of birth,  $k = 1, 2, 3, \dots, 12$  (from January to December);

$Y_k$  = the fixed effect of the  $k$ th year of birth,  $l = 1, 2, 3, \dots, 9$  (from 1980 to 1988);

$e_{ijkm}$  = residual term assumed to be random and distributed as a normal distribution with mean zero and variance  $\sigma^2$ .

Heritability estimates ( $h^2$ ) were computed by the paternal half-sibs method according the formula:

$$h^2 = 4 \sigma_s^2 / (\sigma_s^2 + \sigma_e^2)$$

Estimates of heritability ( $h^2$ ) and genetic (with standard errors), phenotypic and environmental correlation coefficients among different traits were computed by the LSMLMW program of Harvey (1990). All estimates were based on 3347 reproductive records of the first parity.

## Results and Discussion

**Actual means variation of records:** Un-adjusted means, standard deviations (SD) and coefficients of variations (CV%) of DO, NSPC and AFC in the first lactation are presented in Table 1.

The un-adjusted mean of DO reported here (124 days) is nearly similar to that reported by Stefler *et al.* (1986) on Holstein cattle in Hungary (127.5 days); Silva *et al.* (1992) in Florida, USA (123 days); Simerl *et al.* (1992) on Holsteins and Jerseys (120 and 122 days respectively); Mokhtar (1993) on Friesian cattle in Egypt (129 days) and Salem and Abdel-Raouf (1999) on Friesian cow in Egypt (125 days). The present result of DO was shorter than that

Table 1: Unadjusted means, standard deviations (SD) and coefficients of variation (CV%) of days open, number of service per conception and age at first calving ( $n = 3347$ ).

Trait	Abbr.	Mean	SD	CV %
Days open (day)	DO	124	70.6	56.9
Number of services per conception	NSPC	1.95	1.19	61.0
Age at first calving (month)	AFC	27.0	3.43	12.7

estimated by Khattab and Ashmawy (1988) being 171 days and Ali *et al.* (1999a) on local born and imported Holstein-Friesian cows in Pakistan being 161.5 and 132.9 days for the two origins, respectively. The present estimate of DO was longer than that (111 days) estimated by Mantysaari and Van Vleck (1989) working on Finnish Ayrshire cattle in USA and Ali *et al.* (1999b) on local born and imported Jersey cows in Pakistan being 100.1 and 107.0 days for the two origins, respectively. Khattab and Ashmawy (1988) pointed out that DO length between 60 – 90 days will be desirable for reducing calving interval about 12 – 13 months. El-Keraby

and Aboul-Ela (1982) reported that the longer DO in dairy cows may be caused by several factors (e.g. silent estrus missed estrus due to weak symptoms, frequency and timing of estrus detection, feeding season and level of milk production).

The overall mean of NSPC found in the present study (1.95) is close to that obtained by different authors working on dairy cattle in different countries (Berger *et al.*, 1981; Mantysaari and Van Vleck, 1989 and Szucs *et al.*, 1989). On the other hand, lower NSPC were found by Sharma (1983) being 1.52; Rahega *et al.* (1989) being 1.55; and Moore *et al.* (1990) being 1.58. Higher NSPC was estimated by Kumar (1982) being 2.36; Juma *et al.* (1988) being 2.27 and by Mokhtar (1993) being 2.6.

The overall mean AFC reported in the present study (27.0 months) lie within the range of age at first calving reported by different authors on Holstein-Friesian cows in different countries (e.g. Rade *et al.*, 1986 being 953 days; Dohy and Zelfel, 1986 being 870 days and Mokhtar, 1993 being 23.7 months).

The coefficients of variations of both DO and NSPC (56.9 and 61.0%) reflected wide variations between cows in these two traits which may be due to poor management leading to such higher variation in DO and NSPC comparing with AFC (12.7%) (Table 1). Mokhtar (1993) found that coefficients of variation of DO, NSPC and AFC were 58.3, 59.2 and 5.43%, respectively.

The differences between the present estimates of DO, NSPC and AFC and those reported previously could be attributed to one or more of the following reasons: (1) the cows were under different climatic and management conditions; (2) number of used animals differed and (3) different methods of analysis.

**Non-genetic effects:** Least square means and least squares analysis of variance of different reproductive traits as affected by different environmental factors are presented in Tables 2 and 3, respectively.

**Effect of year of calving/birth:** Year of calving showed highly significant ( $P < 0.001$ ) effect on DO and significant ( $P < 0.05$ ) on NSPC, year of birth showed the same trend on AFC (Table 3). Maximum values of DO, NSPC and AFC were 148 days, 2.01 and 29.5 months for the years (calving or birth) 1982, 1988 and 1984 respectively (Table 2). The minimum corresponding values (108 days, 1.68 and 25.9 months were for the years (calving or birth) 1990, 1986 and 1988, respectively (Table 2). Such significant differences and changes in reproductive traits from year to year are due to annual changes in atmospheric conditions, quantity and quality in feeds available and differential management practices introduced every year. These results agree with the findings on dairy cows raised in different countries by Rajan *et al.* (1981); Sharma (1983); Juma *et al.* (1988); Mokhtar (1993); Khattab and Atil (1999); Salem and Abdel-Raouf (1999).

**Effect of month of calving/birth:** Month of calving had no significant effect on either DO or NSPC. Similar results were found by Kumar (1982); Deshpande *et al.* (1988) and Khattab and Atil (1999), whereas month of birth of heifers had a highly significant ( $P < 0.001$ ) effect on their AFC (Table 3). Heifers born in October and November had lesser AFC (26.8 and 26.9 months, respectively) than those born in March and April (28.2 and 29.7 months, respectively) (Table 2). Similar results were found by Kumar (1982). The highly significant effect of month of birth on AFC of heifers may be related to growth cycles of heifers coinciding with months of the year

Table 2: Least squares means ( $\pm$  SE) for days open, number of service per conception and age at first calving as affected by different factors.

Classification	No. of obs.	Trait		Classification	No. of obs.	Trait
		DO (day)	NSPC			AFC (Month)
Overall mean	3347	128 $\pm$ 3.17	1.96 $\pm$ 0.05	Overall mean	3347	27.4 $\pm$ 0.18
<b>Year of calving:</b>				<b>Year of birth:</b>		
1982	54	148 $\pm$ 3.17	2.05 $\pm$ 0.22	1980	70	27.8 $\pm$ 0.66
1983	70	119 $\pm$ 9.88	1.92 $\pm$ 0.19	1981	82	28.3 $\pm$ 0.58
1984	93	140 $\pm$ 8.42	2.05 $\pm$ 0.16	1982	118	29.5 $\pm$ 0.51
1985	232	133 $\pm$ 6.76	1.99 $\pm$ 0.13	1983	258	27.6 $\pm$ 0.39
1986	406	117 $\pm$ 5.75	1.68 $\pm$ 0.11	1984	435	27.3 $\pm$ 0.34
1987	508	141 $\pm$ 4.98	1.93 $\pm$ 0.09	1985	547	27.8 $\pm$ 0.30
1988	774	127 $\pm$ 5.06	2.10 $\pm$ 0.09	1986	744	26.1 $\pm$ 0.31
1989	739	122 $\pm$ 5.61	2.05 $\pm$ 0.11	1987	745	26.6 $\pm$ 0.34
1990	471	108 $\pm$ 6.64	1.90 $\pm$ 0.13	1988	348	25.9 $\pm$ 0.46
<b>Month of calving:</b>				<b>Month of birth:</b>		
January	273	127 $\pm$ 4.63	1.92 $\pm$ 0.09	January	322	27.6 $\pm$ 0.27
February	239	127 $\pm$ 4.83	1.94 $\pm$ 0.09	February	278	27.7 $\pm$ 0.33
March	297	133 $\pm$ 4.53	1.97 $\pm$ 0.08	March	278	28.2 $\pm$ 0.30
April	247	139 $\pm$ 4.87	1.96 $\pm$ 0.09	April	275	27.9 $\pm$ 0.28
May	259	127 $\pm$ 4.73	1.99 $\pm$ 0.09	May	278	27.8 $\pm$ 0.27
June	311	125 $\pm$ 4.47	2.04 $\pm$ 0.08	June	311	27.6 $\pm$ 0.27
July	331	125 $\pm$ 4.47	1.96 $\pm$ 0.08	July	318	27.3 $\pm$ 0.29
August	331	126 $\pm$ 4.42	1.99 $\pm$ 0.08	August	253	27.3 $\pm$ 0.29
September	279	127 $\pm$ 4.64	2.06 $\pm$ 0.09	September	242	27.1 $\pm$ 0.29
October	257	126 $\pm$ 4.72	1.89 $\pm$ 0.09	October	234	26.8 $\pm$ 0.29
November	278	130 $\pm$ 4.55	1.98 $\pm$ 0.08	November	279	26.9 $\pm$ 0.27
December	245	130 $\pm$ 4.74	1.87 $\pm$ 0.09	December	279	27.2 $\pm$ 0.28
<b>Regression on:</b>						
Age at first calving (Linear)		0.433 $\pm$ 0.40	-0.005 $\pm$ 0.008			
Age at first calving (Quad.)		0.008 $\pm$ 0.009	0.0002 $\pm$ 0.00			
Total milk yield (linear)		0.02 $\pm$ 0.0005	0.0002 $\pm$ 0.00			
Total milk yield (quadratic)		-0.00 $\pm$ 0.00	0.00 $\pm$ 0.00			

Table 3: Least squares analysis of variance for Days open, number of services per conception and age at first calving.

Source of variation	d.f	Mean squares and significance		
		DO	NSPC	AFC
Sire	281	4349.3 ***	1.52 ***	16.8 ***
Year of calving/birth <sup>+</sup>	8	17333.1 ***	2.69 *	85.5 ***
Month of calving/birth <sup>+</sup>	11	3941.0 NS	0.76 NS	32.5 ***
<b>Regression on:</b>				
AFC (linear)	1	3514.0 NS	0.388 NS	
AFC (quadratic)	1	2159.7 NS	1.84 NS	
TMY (linear)	1	4444900.4 ***	499.3 ***	
TMY (quadratic)	1	949364.7 ***	242.5 ***	
Remainder <sup>++</sup>	3042	2945.4	1.18	11.5

NS = not significant. \* and \*\*\* = significant at  $P < 0.05$  and  $0.001$ , respectively.

+ Year or month of birth in the case of AFC, ++ Remainder of AFC is 3046.

where the favorable conditions (climate and feed availability) are found.

**Effect of AFC and TMY on DO and NSPC:** Estimates of partial linear and quadratic regression coefficients of DO and NSPC on AFC were not significant (Tables 2 and 3), being  $0.433 \pm 0.40$  day/month and  $0.008 \pm 0.009$  day/month, respectively for DO and  $-0.005 \pm 0.008$  service/month and  $0.0002$  service/month, respectively for NSPC. The non significant effect of AFC on both DO and NSPC may be attributed to influence of managerial factors, such as time of resumption of oestrous, success rate of oestrous detection, timing of artificial insemination, quality of semen used and efficiency of the insemination process.

Estimates of partial linear and quadratic regression coefficients of DO and NSPC on TMY of the current season were highly significant ( $P < 0.001$ ) (Tables 2 and 3), being  $0.02 \pm 0.0005$  day/kg and  $-0.0$  day/kg, respectively for DO and  $0.0$  service/kg<sup>2</sup> and  $0.0$  service/kg<sup>2</sup>, respectively for NSPC. The present results indicated that one tone increase in TMY is associated with increase of 20 days in DO. In the same respect, Seykora and McDaniel (1983) found that genetic increase of 1000-kg milk would result in 5 to 10 additional days open.

In the literature, however, there have been conflicting reports about effect of milk yield on postpartum reproductive performance. While some authors reported positive correlation between milk yield and DO or NSPC such as Bodo *et al.* (1980); Wood and Frappell (1982) and Juma *et al.*

(1988) who reported that level of milk production and services per conception were positively and significantly related. Such relationship between TMY and NSPC may be due to physiological interactions between milk yield and ovarian functions (Hafez, 1974). Meanwhile other authors did not report these relations between milk yield and DO or NSPC such as Bar-Anan and Wiggins (1985) who reported that high yields had changes during month of insemination, adversely affected conception rate of cows within herds. Also Weller *et al.* (1985) pointed out that for cows with high peak production maximum yield was with 12 to 14 DO than for cows with moderate peak. They added that conception prior to 2 months postpartum had an adverse effect on cumulative yield. However, in the recent years with the tendency of increasing average production level in commercial dairy levels, there is growing evidence of negative effect of high milk yield on DO. Such effect has been attributed to the large deficit in energy balance that occurs in high yielding cows.

Table 4: Estimation of sire variance components ( $\sigma^2_s$ ) and error variance components ( $\sigma^2_e$ ) and proportion of variance (V%) due to random effect for different studied traits.

Trait	Sire		Error	
	( $\sigma^2_s$ )	(V%)	( $\sigma^2_e$ )	(V%)
DO	129.1	4.20	2945.4	95.80
NSPC	0.032	2.64	1.18	97.36
AFC	0.489	4.08	11.5	95.92

d.f of sires and error components were 281 and 3042, respectively and for DO and NOD, and for AFC were 281 and 3046, respectively.

Table 5: Heritability estimates  $\pm$  SE (on diagonal), genetic  $\pm$  SE (below diagonal), phenotypic (above diagonal) and environmental (between parentheses) correlations between DO and NSPC, and Heritability estimate  $\pm$  SE for AFC.

Trait	DO	NSPC	AFC
DO	0.168 $\pm$ 0.042	0.500 (0.564)	
NSPC	0.099 $\pm$ 0.228	0.105 $\pm$ 0.038	
AFC			0.163 $\pm$ 0.042

**Sire effect:** Least square analysis of variance for effect of sire (as random effect) on DO, NSPC and AFC traits is shown in Table 3 while sire variance components and proportions of variance are shown in Table 4. Results showed that the sire of the cow had a highly significant ( $P < 0.001$ ) effect on all studied traits. Such significant effect of sire on DO was found also by Abdel Gilil (1996). The sire variance components ( $\sigma^2_s$ ) adjusted for fixed effects of environmental factors ranged between 2.64 and 4.20% of the total variance for all reproductive traits studied (Table 4). The present estimate of sire component concerning DO (4.20%) is higher than that obtained by Salem and Abdel Raouf (1999) being 2.5%. In spite of the significant effect of sire on the reproductive traits studied, it was observed that the magnitude of this significant effect, proportional to the total variance, corresponded to low heritability estimates of these traits (Table 5). Therefore, improvement of such traits can be attained mainly through other means than genetic. Juma *et al.* (1988) came to the same conclusion.

**Heritability estimates and correlations:** The estimates of heritability based on paternal half-sibs for reproductive traits studied as well as genetic, phenotypic and environmental correlations between DO and NSPC are given in Table 5.

The estimates of heritability for the three studied traits ranged between 0.105 and 0.168 and are in accordance with the estimates of the different authors for the same reproductive traits working on different dairy cattle breeds in various countries. Kumar (1982) found that heritabilities of service period, NSPC and AFC were 0.04, 0.07 and 0.38, respectively; Hermas *et al.* (1987) found that heritability estimates for reproductive traits ranged from 0.01 to 0.04; Raheja *et al.* (1989) stated that heritabilities of fertility traits (days from calving to first insemination, NSPC and DO) ranged from 0.03 to 0.06; Smith *et al.* (1989) found that heritability of AFC was 0.01. Moore *et al.* (1990) found that heritabilities of fertility traits (days open and NSPC) were all less than 0.015 in the multi-trait analyses. Abdel Gilil (1996) found that heritability of DO was 0.12. Salem and Abdel Raouf (1999) found that heritability of DO and NSPC were 0.01 and 0.10, respectively.

The low estimates of heritability for different measurements of the reproductive traits studied indicated that the major part of the variation in these traits was environmental and selection may not prove effective in bringing about genetic improvement in these traits. Therefore, better management can play a major role in improving these traits. Kumar (1982) and Mokhtar (1993) came to the same conclusion.

The phenotypic correlation between DO and NSPC was positive and high (0.50). Therefore, any reduction in NSPC would be phenotypically associated with lowering DO. It is understood that DO consisted of two main components, the period from calving to the 1<sup>st</sup> service and the period from the 1<sup>st</sup> service to the conception service. While unsuccessful insemination would be naturally associated with longer DO, yet delay in the 1<sup>st</sup> service also caused prolongation of DO. This explains the relatively low  $R^2$ -value (25%) for the phenotypic relationship between DO and NSPC obtained in this study. On the other hand the genetic correlation between DO and NSPC was very low (0.099) and this may indicate that both traits have uncommon genetic background. Consequently, shortening of DO can be achieved through better management practices.

Environmental correlation between DO and NSPC (0.546) was nearly similar to phenotypic correlation (0.50), and phenotypic correlation between DO and NSPC was higher than the genetic correlation (0.099) (Table 5) and this emphasize the large environmental influences on these traits.

In conclusion the low estimates of heritability for different measurements of the reproductive traits indicated that the major part of the variation in these traits was environmental and selection may not prove effective in bringing about genetic improvement in these traits. Therefore, better management (environmental influences) can play a major role in improving these traits.

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