RELATIONSHIPS BETWEEN MILK YIELD AND FERTILITY IN HOLSTEIN CATTLE

By

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ABSTRACT
Data on 946 Holstein cattle at the Esehaqie Cattle Station, north of Baghdad, Iraq, were used to estimate the relationship among the level of milk yield, days open, number of services and calving interval. General Linear Model (GLM) within the SAS program was used to investigate the influence of some fixed effects (season and year of calving, age at first calving and level of milk yield) on previous traits. Components of variance for the random effects were estimated by the Restricted Maximum Likelihood (REML) for all fertility traits, total milk yield and the later trait, considered independent to estimate genetic and phenotypic correlations among all traits.

The results revealed that means of days open, number of services and calving interval were 159.96, 2.67 and 402.13 days respectively, whereas, the heritability of the same traits were 0.05, 0.02 and 0.03 respectively, while the heritability of total milk yield was 0.21. Results revealed that the genetic correlations among milk yield with days open (0.28), number of services (0.24) and calving interval (0.33) were significant (P < 0.01) and positive. The corresponding estimations of phenotypic correlations were 0.19, 0.17 and 0.22 respectively.

KEYWORDS: Fertility, milk production, genetic parameters

INTRODUCTION
Milk production and reproductive performance are the dominant factors with respect to profitableness of dairy production systems, and much of attention has been given to fertility traits and their association with milk production (Oltenacu et al., 1991). High milk yield has been the primary selection emphasis in dairy breeding. Many dairy producers are currently confronting the challenge of maintaining satisfactory reproductive performance in their cattle at high levels of milk production (Weigel and Rekaya, 2000). Numerous authors (Hansen et al., 1983; Emanuelson, 1988; Dunklee, 1991; Lyons et al., 1991; Dematawewa and Berger, 1998) have reported antagonistic phenotypic or genetic relationships between milk production and fertility. Such relationships can lead to increased semen costs, veterinary costs, days open, number of services and calving interval. Reduction in reproductive performance could affect culling rates and herd life and reduce genetic gain from primary traits (Congelton and King, 1984). Van Raden et al. (2004) reported selection for high yield over several generations has contributed to longer calving interval because of an unfavorable genetic correlation between yield and days open. There is some evidence that the magnitude of correlation between milk production and fertility has increased with time (Dematawewa and Berger, 1998). In a study conducted by Wall et al., (2003), which included 1828389 Holstein cows in UK during period from 1997 to 2002, results revealed an annual increasing in milk yield associated with increasing in days open, number of services and calving interval.
These results supported previous results reported by Vukasinovic et al., (1997) and Weigel et al., (2002), who observed that culling rate increased in dairy cattle herds, as a result of low fertility associated with continuous intensive selection of cows for high milk yield. Windig et al., (2006) reported that high milk production in dairy cattle can have negative side effects on health and fertility traits. Thus selection for higher milk yield is expected to cause decline in fertility and depression in health. Relatively, little is known about the exact cause and effect relationships (genetic and phenotypic) between production and reproduction of the cows. Understanding the nature of these relationships enables breeder to go for further genetic improvement of primary traits without sacrificing performance of secondary traits by incorporating secondary traits in bull indices (Hermas et al., 1987). Kadarmideen and Simm, (2002) reported that fertility is of major economic importance. Ignoring it in selection is a lost opportunity, because it will lead to deterioration in genetic merit of this trait as a result of unfavorable correlation with milk production.

The objective of this study was to estimate genetic parameters of total milk yield and some fertility traits (days open, number of services and calving interval) and to determine the effects of some factors on those traits.

**MATERIALS AND METHODS**

**Edits of Data**

Data of this study came from Esehaqie Dairy Station in the middle of Iraq and consisted of all cows between 1997 and 1999. In the present study, three reproductive traits (days open, number of services and calving interval) were considered.

To analyze the data, the first editing step only records that had a second calving were selected. For these records, all dates (birth, calving, last breeding and number of services), sire number, and production information were available.

In the second editing step, only sires with four or more daughters at least were selected. Final data set consisted of 946 cow records. Number of observations varied in response to variable (calving interval 2636 records, days open 2343 records and number of services 2122 records). Days open was limited to a maximum of 365 d. The number of services was defined as total breeding for all lactation till conception. Calving interval higher than 700 d was ignored.

**Statistical analysis**

The mathematical model to estimate environmental effects included season of calving, year of calving, parity, age at first calving and level of milk yield was as follows:

\[
Y_{ijklmn} = \mu + A_i + E_j + P_k + R_l + M_m + e_{ijklmn}
\]

Where \(Y_{ijklmn}\) = studied trait, 
\(\mu\) = overall population mean,  
\(A_i\) = fixed effect of \(i\)th calving season (\(i=1-4\)),  
\(E_j\) = fixed effect of \(j\)th calving year (\(j =1991-2003\)),  
\(P_k\) = fixed effect of \(k\)th parity (\(k =1-4\)),  
\(R_l\) = fixed effect of \(l\)th age at first calving (\(R =1-3\)),  
\(M_m\) = fixed effect of \(M\)th milk yield (\(M =1-5\)),  
\(e_{ijklmn}\) = random residual effects.

For estimation of heritability and phenotypic and genetic correlations, the random variable sire was added to the model and milk production considered as independent trait.

\[
Y_{ijklmn} = \mu + A_i + E_j + P_k + R_l + S_m + e_{ijklmn}
\]

Where \(S_m\) = random effect of sire, other notations were similar to first model.

Estimation of variance components was by REML method. Preliminary least squares analysis using PROC GLM option of SAS (2001) submitted for all traits.
RESULTS AND DISCUSSION
Least squares means and overall arithmetic means are depicted in Table 1. The mean days open, number of services and calving interval were 122.81 d, 2.35 and 402.13d respectively which were similar to estimates in Holstein reported by some researchers in Iraq (Al-Cassey and Raheem, 1997; El-Dessouky et al., 1990; Al-Timimy, 2003; Hermiz et al., 2005). The variation in fertility traits due to season of calving was significant (P < 0.01) in number of services and calving interval and non significant in days open. Although the days open was more closely related to calving interval, the effects of season of calving differed between them in the present study. This may be attributed to the difference in data set (number of observations) used in an analysis. Determinative effects of heat stress are represented by an increase in the number of services per conception and calving interval following parturitions in spring due to the insemination of those cows will be accomplished in summer and then will suffer more from heat stress. Longer calving interval of heat-stressed animals were expected (Thatcher et al., 1978).

Van Raden et al., (2004) indicated that fertility in dairy cattle is best following fall calvings and poorest following spring calvings. This was expected because fewer cows express estrus or conceive during hot summer months (De Rensis and Scaramuzzi, 2003). The impacts of Parity are shown in Table 1. The mean of all traits increased because parity was increased. Weigel and Rekaya, (2000) detected similar effect. Marti and Funk, (1994) suggested that older cows might have lower fertility because of more reproductive disorders. Previously, Dematawewa and Berger, (1998) reported that the number of services has increased because parity has increased; whereas, the days open have no specific trend. Also Berger et al., (1981) and Silva et al., (1992) noticed no distinct trends with parity for days open and number of services. The effect of level of milk yield was significant (P < 0.01) for all traits. Generally, most fertility traits had increased as the level of milk production increased. These results agree to the results revealed by Zmudski, (1974); Boichared et al., (1998) and Jonsson et al., (1999).

Weigel and Rekaya, (2000) thought that many cows with high milk yield had exhibited a negative energy balance in early lactation, which could have a determinative effect on fertility. Decrease in fertility traits associated with high level milk yield may be due to those cows could had more probability to incidence with reproductive disorders. Stress associated with high milk level, or producer's policy, who delays in insemination the high yield cows to avoid the probability of any decrease in milk yield due to gestation. The effects of a year of calving and age at first calving were non significant for all traits.

Table 2 shows heritability, genetic and phenotypic correlations for fertility traits and milk production. The heritability of total milk yield was moderate (0.21), while heritability of all fertility traits was low (0.02 – 0.05). Genetic correlations among total milk yield, each of days open (0.28), number of services (0.24) and calving interval (0.33) were positive and significant, as well as the phenotypic correlations which were 0.19, 0.17 and 0.22 respectively. It is obvious that increased days open, number of services and calving interval indicated loss of fertility. Thus, the positive genetic and phenotypic correlations found between the milk production and fertility traits in this study (Table 2) strengthen the evidence of an antagonistic relationship between milk yield and fertility.

The genetic correlations found in the present study suggest that incorporating reproductive performance measures in sire indices is very important to hinder the deterioration of fertility in high yielding cows, as proposed by Hermas et al., (1987), can be effective. However, the antagonistic nature of the relationship may cause a problem in realized rapid improvement. The complex genetic and phenotypic relationships between milk yield and fertility may be due to direct cause and effect relationships as well as the involvement of many secondary factors (Dematawewa and Berger, 1998). The stress of milk yield could directly cause health and reproductive disorders, and diseases and reproductive disorders can directly affect yield (Erb et al., 1985).
CONCLUSIONS
Understanding the relationships between milk yield and fertility was very necessary to increase the profitableness of dairy projects. According to the results of the present study, the genetic correlation between milk yield and fertility was shown to be moderate but undesirable; hence it is necessary to use fertility measures in sire index to improve the productive and reproductive performance of the herd.

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Table-1: Least squares estimates of some fertility traits in Holstein

<table>
<thead>
<tr>
<th>Factors</th>
<th>Days open</th>
<th>No. of services</th>
<th>Calving interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall means</td>
<td>122.81 ± 3.37</td>
<td>2.35 ± 0.08</td>
<td>402.12 ± 4.24</td>
</tr>
<tr>
<td>Calving season</td>
<td>**</td>
<td>N.S</td>
<td>**</td>
</tr>
<tr>
<td>Winter</td>
<td>126.50 ± 12.62</td>
<td>2.05 ± 0.16</td>
<td>405.15 ± 6.53</td>
</tr>
<tr>
<td>Spring</td>
<td>138.39 ± 14.65</td>
<td>2.64 ± 0.18</td>
<td>433.03 ± 8.45</td>
</tr>
<tr>
<td>Summer</td>
<td>139.03 ± 12.42</td>
<td>3.02 ± 0.15</td>
<td>437.20 ± 5.92</td>
</tr>
<tr>
<td>Autumn</td>
<td>132.11 ± 12.20</td>
<td>2.52 ± 0.16</td>
<td>417.24 ± 6.31</td>
</tr>
<tr>
<td>Calving year</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
</tr>
<tr>
<td>1997</td>
<td>131.67 ± 11.31</td>
<td>2.78 ± 0.09</td>
<td>427.53 ± 4.50</td>
</tr>
<tr>
<td>1998</td>
<td>139.52 ± 13.55</td>
<td>2.65 ± 0.16</td>
<td>413.23 ± 7.60</td>
</tr>
<tr>
<td>1999</td>
<td>130.83 ± 12.83</td>
<td>2.25 ± 0.26</td>
<td>429.21 ± 6.74</td>
</tr>
<tr>
<td>Age at first calving</td>
<td>N.S</td>
<td>N.S</td>
<td>N.S</td>
</tr>
<tr>
<td>28 months and lower</td>
<td>130.92 ± 12.31</td>
<td>2.73 ± 0.15</td>
<td>418.86 ± 6.05</td>
</tr>
<tr>
<td>29 – 31</td>
<td>134.17 ± 13.04</td>
<td>2.39 ± 0.16</td>
<td>423.60 ± 6.76</td>
</tr>
<tr>
<td>32 months and higher</td>
<td>136.93 ± 11.86</td>
<td>2.55 ± 0.13</td>
<td>427.51 ± 5.21</td>
</tr>
<tr>
<td>Parity</td>
<td>N.S</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>1</td>
<td>113.48 ± 8.72</td>
<td>2.33 ± 0.15</td>
<td>405.37 ± 6.72</td>
</tr>
<tr>
<td>2</td>
<td>133.28 ± 6.76</td>
<td>2.48 ± 0.17</td>
<td>413.64 ± 6.76</td>
</tr>
<tr>
<td>3</td>
<td>137.21 ± 7.38</td>
<td>2.62 ± 0.17</td>
<td>435.00 ± 7.38</td>
</tr>
<tr>
<td>4</td>
<td>151.06 ± 6.17</td>
<td>2.80 ± 0.16</td>
<td>439.28 ± 6.17</td>
</tr>
<tr>
<td>Level of milk yield</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>2000 kg and lower</td>
<td>122.40 ± 14.71</td>
<td>1.79 ± 0.20</td>
<td>366.84 ± 8.40</td>
</tr>
<tr>
<td>2001 - 3000</td>
<td>118.94 ± 12.29</td>
<td>1.80 ± 0.14</td>
<td>366.16 ± 5.65</td>
</tr>
<tr>
<td>3001 - 4000</td>
<td>121.93 ± 12.19</td>
<td>2.26 ± 0.15</td>
<td>404.13 ± 5.72</td>
</tr>
<tr>
<td>4001 - 5000</td>
<td>156.29 ± 13.23</td>
<td>3.04 ± 0.19</td>
<td>450.40 ± 8.14</td>
</tr>
<tr>
<td>5001 kg and more</td>
<td>150.43 ± 16.14</td>
<td>3.91 ± 0.27</td>
<td>529.08 ± 12.00</td>
</tr>
<tr>
<td>No. of observations</td>
<td>2343</td>
<td>2122</td>
<td>2636</td>
</tr>
</tbody>
</table>

**= P < 0.01  N.S: Non significant differences

Table-2: Heritabilities¹ and genetic² and phenotypic³ correlations of some fertility traits in Holstein

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability¹</th>
<th>Genetic²</th>
<th>Phenotypic³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total milk yield</td>
<td>0.21</td>
<td>0.33**</td>
<td>0.28**</td>
</tr>
<tr>
<td>Calving interval</td>
<td>0.22**</td>
<td>0.03</td>
<td>0.90**</td>
</tr>
<tr>
<td>Days open</td>
<td>0.19**</td>
<td>0.89**</td>
<td>0.05</td>
</tr>
<tr>
<td>No. of services</td>
<td>0.17**</td>
<td>0.47**</td>
<td>0.54**</td>
</tr>
</tbody>
</table>

¹ On diagonal
² Above diagonal
³ Below diagonal
** P < 0.01
REFERENCES


