Characterization of Friesian Heifer Fertility under Egyptian Conditions
Zahed, S. M.* and Anas A. A. Badr

ABSTRACT
Data from 3081 reproductive records of Friesian heifers covering the period from 1979 to 2013 belongs to Sakha and El-Karada experimental farms - Kafr-El-Sheikh Governorate, Animal Production Research Institute, Ministry of Agriculture, Egypt were analyzed. A multitrait animal model was used to estimate genetic parameters, genetic and phenotypic changes for age at first breeding (AFB), age at successful breeding (ASB), age at first calving (AFC), number of services per conception (NSC) and service period (SP). Heritabilities of AFB, ASB, AFC, NSC and SP were 0.15, 0.12, 0.11, 0.02 and 0.01, respectively. Genetic correlations between AFB, ASB and AFC were high and ranged from 0.97 to 0.99, however the phenotypic correlations were ranged from 0.78 to 0.99. Genetic correlations between NSC and both AFB, ASB and AFC were -0.12 to 0.16, however the corresponding phenotypic correlations were ranged from -0.04 to 0.46. The genetic correlations between SP and both AFB, ASB and AFC were ranged from 0.38 to 0.79, however that corresponding estimates of phenotypic correlations were ranged from 0.01 to 0.56. The genetic and phenotypic correlations between NSC and SP were 0.72 and 0.94, respectively. A linear regression analysis of estimated breeding values on year of birth of heifers showed favorable genetic improvement of all fertility traits, however the reverse phenotypic trend was observed for AFB, ASB and AFC.

Keywords: Characterization - Friesian heifer – Fertility - Genetic, phenotypic trend

INTRODUCTION
Continuous increasing milk yield by selection has induced a decrease in reproductive performance due to antagonistic genetic relationship between milk yield and fertility traits (Pryce and Veerkamp, 2001, Lin et al., 2008, Guo et al., 2014). The inclusion of fertility in the breeding goal is necessary to optimize the result of genetic improvement of dairy cattle (Buaban et al., 2015). Fogh et al., (2004) concluded that the deteriorating genetic trend for Holstein is showing the importance of including fertility in a total merit index so the genetic trend can be at least hold constant.

Although there are large numbers of publications on cow fertility, very little has been published about virgin heifer fertility (Hansen et al., 1983, Raheja et al., 1989, Kuhn, et al., 2006, Hagiya et al., 2013). Hahn (1969) found higher heritabilities of fertility for heifers than cows and submitted that selection for heifer fertility may be of greater benefit than selection for cow fertility. However, virgin heifer traits are measured relatively early in life, and therefore they should be included in dairy cattle breeding program to improve the efficiency of fertility (Buaban et al., 2015).

The objective of this study was to characterize Egyptian Friesian ( virgin) heifer fertility. In addition to a basic description of the data that has been received, this characterization included two general aspects. The first part involved assessment of factors affecting heifer fertility. Identification of such factors is needed for modeling purposes and can also be useful for management as well as mating programs. The second part of this characterization was to estimate heritabilities, genetic and phenotypic correlations for various fertility traits as well as the genetic and phenotypic trends to assist in national genetic programs for the selection of fertility traits in the future.

MATERIALS AND METHODS
A total of 3081 reproductive records of Friesian heifers covering the period from 1979 to 2013 were used. Heifers in this study belongs to two experimental farms, Sakha and El-Karada – Kafr-El-Sheikh Governorate, belonging to Animal Production Research Institute, Ministry of Agriculture, Egypt. Heifers were inseminated by professional artificial insemination technician at 18-22 months of age (about 350 kg body weight), using frozen semen. For mating that were less than 6 day a part, only the later mating was kept. A maximum of 5 services per heifer was imposed; services beyond 5 were excluded. Pregnancy was detected by rectal palpation 60 days after the last service. Calves were left with their dams for suckling during the first three days after birth and thereafter were housed in calf-boxes and bucket-fed on milk and/or milk replacer till weaning at 90-100 kg in weight (about 3-3.5 months of age). After weaning and up to six months of age, calves of the same age were group-housed in pens provided with yards for exercise. At six months of age, male calves were separated from female and housed in open sheds up to sexual maturity.

In the two farms, animals (Heifers and cows) were kept under similar feeding system. During summer and autumn months (from June to the end of November), all animals were fed concentrates and corn silage, and during the winter and spring months (from December to May) the...
animals were supplied with Egyptian clover (*Trifolium alexandrinum*). In addition, rice straw was available all the year round. Feed was supplied to heifers according to their live weight, while cows were fed according to their live weight, production and pregnancy status. Free clean water and mineral mixture were available at all times.

Fertility traits under study were age at first breeding (AFB), age at successful breeding (ASB), age at first calving (AFC), number of services per conception (NSC) and days from first to last service (service period, SP). Criteria for data editing included: (1) heifers with correct pedigree, all heifers with missing sire or dam were discarded; (2) the ranges for AFB, ASB, AFC, NSC and SP were 11-32 mo., 11-32 mo., 20-42 mo., 1-5 and 15-200 d. The records that included abortion were eliminated from heifer's data set. The structure of the data analyzed is shown in table 1.

Table 1. Structure of the fertility data set for Friesian dairy heifers.

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of sires</td>
<td>66</td>
</tr>
<tr>
<td>No. of dams</td>
<td>427</td>
</tr>
<tr>
<td>No. of Service sires</td>
<td>127</td>
</tr>
<tr>
<td>No. of base animals</td>
<td>622</td>
</tr>
<tr>
<td>No. of non-base animals</td>
<td>3081</td>
</tr>
</tbody>
</table>

Preliminary statistical analyses were performed for identifying non-genetic effects to be included in the final model using MIXED procedure of SAS software (SAS, 2011). The applied model was as follows:

\[
Y_{ijklm} = F_i + R_j + M_k + FR_{ij} + RM_{jk} + e_{ijklm} \quad (1)
\]

**Where:** \(Y_{ijklm}\) was the individual observation, \(F_i\) was the fixed effect of farm, \(R_j\) was the fixed effect of month of first service, \(M_k\) was the fixed effect of farm by year of first service, \(FR_{ij}\) was the fixed effect of farm by year of first service, \(RM_{jk}\) was the fixed effect of year by month of first service and \(e_{ijklm}\) was random residual term.

All non-significant interactions were removed from the model (1).

Genetic parameters as heritability, genetic and phenotypic variation and genetic and phenotypic correlations were estimated using VCE6 program (Groeneveld et al., 2010). A linear animal model was applied as follows:

\[
Y_{1ijklm} = F_i + R_j + M_k + FR_{ij} + RM_{jk} + a + e_{ijklm} \quad (2)
\]

\[
Y_{2ijklm} = F_i + R_j + M_k + FR_{ij} + RM_{jk} + a + s_{ijklm} + e_{ijklm} \quad (3)
\]

**Where:** \(Y_{1ijklm}\) was the individual observation on AFB, ASB and AFC traits, and \(Y_{2ijklm}\) was the individual observation on NSC and SP, \(a\) was the random additive genetic effect of animal, \(s_{ijklm}\) was the random effect of service sire, and the remaining effects as described in model (1).

For animal effect pedigree data was included. Multivariate EBVs were estimated by PEST program (Groeneveld et al., 2001) fitting an animal model and using genetic parameters obtained as described above.

The genetic trend was estimated as the linear regression of means of estimated breeding values on year of birth for all traits. Phenotypic trend was estimated by regressing phenotypic values on year of birth. Genetic and phenotypic trends were estimated by SAS (2011).

**RESULTS AND DISCUSSION**

Descriptive statistics for heifer fertility traits are presented in table 2. The mean estimate of AFB in the present study (21.7 mo.) was nearly the same (22.9 mo.) as reported by Buaban et al. (2015), however it was higher than 16.2, 16.7, 17.3 and 17.3 mo., as reported by deHaer et al. (2013), Jamrozik et al. (2005), Abe et al. (2009) and Guo et al. (2014), respectively. The longer AFB in Egyptian dairy Friesian heifers could be due to the managerial condition, particularly feeding level. It is generally recognized that dairy heifers in tropical areas have a lower growth rate than those in temperate areas (Vaccaro and Rivero, 1985). The estimated mean value of ASB was 23.2 mo., which was higher than 18.1, 18.2, 20.0 and 20.7 as reported by Abe et al. (2009), Jagusia (2005), Raheja et al. (1989) and Hansen et al. (1983), respectively. AFC mean value in the present study was 32.2 mo. which was nearly the same (32.9 mo.) as reported by Buaban et al. (2015), however it was higher than 31.22, 27.4, 28.0, 29 and 27.2 mo. as published by Khatab and Sultan (1991), Jagusia (2005), Berry et al. (2007), Janzekovic et al. (2009) and Salem and Hammoud (2016). The average value of NSC in the present study (2.07service) which was nearly the same (2.0) as reported by Salem and Hammoud (2016) with another herd of Friesian in Egypt and was higher than 1.31, 1.57 and 1.56 service (Mohkhtari et al., 2015, Buaban et al., 2015 and Tiezzi et al., 2012, respectively) in virgin heifer. The estimated mean value for SP in virgin Friesian heifers was 43.9 d. which was greater than 18.1, 26.8, 33.0 and 35.6 d. as reported by Muuttonanta et al. (2019), Buaban et al. (2015), deHaer et al. (2013) and Tiezzi et al. (2012), respectively.

Coefficients of phenotypic variation (C<sub>V</sub>) for NSC and SP (Table 2) were 70.04 and 65.97 which were higher than the estimates of 61.1 and 43.4, respectively, reported by Salem and Hammoud (2016) with another herd of Friesian cows in Egypt and which were higher than the estimates of AFB, ASB and AFC (17.05, 18.18 and 13.57, respectively). Raheja et al. (1989) reported that estimate of C<sub>V</sub> were 17.25, 17.93 and 52.89 for AFB, ASB and NSC, respectively. Additive genetic variation (C<sub>V</sub>) in the present study were lower than those of C<sub>V</sub> for AFB, ASB, AFC, NSC and SP (6.38, 6.08, 4.47, 8.35 and 6.81, respectively). These estimates were higher than 3.73, 3.89 for AFB and ASB, respectively, however it was lower than 9.39 for NSC as reported by Raheja et al. (1989).

Table 2. Descriptive statistics for heifer fertility traits.

<table>
<thead>
<tr>
<th>Trait*</th>
<th>No. Records</th>
<th>Mean</th>
<th>S.D.</th>
<th>C.V.</th>
<th>C.V.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFB (mo.)</td>
<td>3081</td>
<td>21.7</td>
<td>3.70</td>
<td>17.05</td>
<td>6.38</td>
<td>13</td>
<td>32</td>
</tr>
<tr>
<td>ASB (mo.)</td>
<td>3081</td>
<td>23.2</td>
<td>4.21</td>
<td>18.18</td>
<td>6.08</td>
<td>14</td>
<td>32</td>
</tr>
<tr>
<td>AFC (mo.)</td>
<td>3081</td>
<td>32.2</td>
<td>4.37</td>
<td>13.57</td>
<td>4.47</td>
<td>22</td>
<td>42</td>
</tr>
<tr>
<td>NSC</td>
<td>3081</td>
<td>2.07</td>
<td>1.45</td>
<td>70.04</td>
<td>8.35</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>SP (d)</td>
<td>1410</td>
<td>43.9</td>
<td>63.20</td>
<td>65.97</td>
<td>6.81</td>
<td>15</td>
<td>200</td>
</tr>
</tbody>
</table>

*AFB= age at first breeding; ASB= age at successful breeding; AFC= age at first calving; NSC= number of services per conception; and SP= service period.

**Variance and heritability estimates of heifer fertility traits are given in table 3. Estimated heritability of AFB was 0.145, which was higher than 0.100, 0.107 and 0.128 as reported by Guo et al. (2014), Eghbalasaied (2011) and Abe et al. (2009), respectively, however it was lower than estimates of 0.324, 0.227 and 0.26, reported by Jagusia
reported that \( r_g \) and \( r_p \) estimates between AFB and AFC were 1.0 and 0.94, respectively.

### Table 4. Genetic (above diagonal) and phenotypic correlations (below diagonal) for heifer fertility traits.

<table>
<thead>
<tr>
<th>Trait</th>
<th>AFB</th>
<th>ASB</th>
<th>AFC</th>
<th>NSC</th>
<th>SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASB</td>
<td>0.9790</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFC</td>
<td>0.9990</td>
<td>0.7680</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSC</td>
<td>-0.0440</td>
<td>0.4510</td>
<td>0.7230</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP</td>
<td>0.0140</td>
<td>0.5610</td>
<td>0.9390</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- a: the abbreviations as described in table 1.

Estimates of \( r_g \) and \( r_p \) between NSC and AFB were low and negative (-0.123 and -0.044, respectively), however it was low and positive between NSC and each of ASB and AFC (0.119 and 0.160, respectively) for \( r_g \) and were medium and positive between the same traits for \( r_p \) (0.458 and 0.451, respectively). Raheja et al., (1989) reported that genetic correlations between NSC and each of AFC and ASB were -0.08 and 0.17, respectively however the corresponding \( r_p \) estimates between the same traits were -0.04 and 0.30, respectively. Also, Buaban et al., (2015) found that \( r_g \) between NSC and AFB was -0.19. AFB in the present study was negatively correlated with NSC in both genetic and phenotypic correlations, which mean that when heifer breeding was started at young ages, it takes a lot of number of services to be pregnant. Hansen et al., (1983) found that phenotypically, AFB was negatively related with numerous measures of fertility, and concluded that perhaps fertility was hindered when heifer breeding was initiated at young ages. Estimates of \( r_g \) between SP and each of AFB, ASB and AFC traits ranged from 0.580 to 0.795, however the corresponding estimates of \( r_g \) between the same traits ranged from 0.014 to 0.561 (Table 4). Buaban et al., (2015) reported that \( r_g \) estimates between SP and each of AFB and AFC were -0.31 and -0.02, respectively, however the corresponding \( r_p \) estimates were -0.08 and 0.29, respectively for the same traits. Estimates of \( r_g \) and \( r_p \) between NSC and SP were 0.723 and 0.939, respectively (Table 4). Buaban et al., (2015) reported that \( r_g \) estimates between SP and each of AFB and AFC were -0.31 and -0.02, respectively, however the corresponding \( r_p \) estimates were -0.08 and 0.29, respectively for the same traits. Estimates of \( r_g \) and \( r_p \) between NSC and SP were 0.723 and 0.939, respectively (Table 4). Buaban et al., (2015) reported that \( r_g \) estimates between SP and each of AFB and AFC were -0.31 and -0.02, respectively, however the corresponding \( r_p \) estimates were -0.08 and 0.29, respectively for the same traits. The overall genetic trend in fertility traits of heifers were as desired negative and significant in almost traits, indicating a genetic improvement in heifer fertility traits (Figure 1). The regression coefficients of mean breeding values for AFB, ASB and AFC decreased during the study period at the rate of -0.01, -0.01 and -0.002 m/yr (Table 5), respectively.

### Table 5. Genetic and phenotypic trends for heifer fertility traits.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Genetic Trend</th>
<th>Sig.</th>
<th>Phenotypic Trend</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFB</td>
<td>9.7x - 0.0050</td>
<td>0.01</td>
<td>9.2x + 0.0060</td>
<td>NS</td>
</tr>
<tr>
<td>ASB</td>
<td>11.9x - 0.0060</td>
<td>0.02</td>
<td>8.5x + 0.0220</td>
<td>NS</td>
</tr>
<tr>
<td>AFC</td>
<td>4.3x - 0.0020</td>
<td>NS</td>
<td>1.3x + 0.0220</td>
<td>NS</td>
</tr>
<tr>
<td>NSC</td>
<td>10.5x - 0.0050</td>
<td>0.001</td>
<td>16.1x - 0.0070</td>
<td>0.01</td>
</tr>
<tr>
<td>SP</td>
<td>-416.7x - 0.21</td>
<td>0.0001</td>
<td>-549.6x - 0.29</td>
<td>0.02</td>
</tr>
</tbody>
</table>

- a: the abbreviations as described in table 1.
The same trend was also observed for NSC and SP, the regression coefficients of mean breeding values decreased at the rate of -0.01 service/yr and -0.21 d/yr for NSC and SP, respectively. The corresponding phenotypic trends were positive in AFB, ASB and AFC, however it were negative in NSC and SP (Figure 2). The regression coefficients of mean phenotypic values for AFB, ASB and AFC increased during the study period at the rate of 0.01, 0.02 and 0.02 mo/yr, however it were decreased at the rate of -0.01 service/yr and -0.29 d/yr for NSC and SP, respectively (Table 5).
The favorable negative genetic trends for all fertility traits in heifers were a result of good selection program, however the unfavorable positive phenotypic trend for AFB, ASB and AFC may be attributed to un correct culling policy, low nutritional level applied and low management practices through the study period.

REFERENCES


REFERENCES