Estimation of Genetic Parameters and Trends for Age at First Calving and Calving Interval in Iranian Holstein Cows

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Received: 11 December 2010 Accepted: 21 April 2011

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ABSTRACT
The objective of this study was to estimate genetic parameters coupled with genetic and phenotypic trends for age at first calving (AFC) and first and second calving interval (CI1 and CI2) in Iranian Holstein cows. Records of reproduction from 1983 to 2007 for AFC, CI1 and CI2 were 261116, 163234 and 92661, respectively. Single and two trait animal model was used to estimate genetic parameters by restricted maximum likelihood procedures using Average Information algorithm in ASREML software. Estimates of heritability were 0.19±0.005 for AFC, 0.04±0.003 for CI1, and 0.04±0.004 for CI2. Genetic trends for AFC, CI1 and CI2 were -0.75±0.11, 0.004±0.02, -0.02±0.01 day per year and phenotypic trends were -2.35±0.38, -1.13±0.39, -0.28±0.23 day per year, for AFC, CI1 and CI2, respectively. The genetic, phenotypic and environmental correlations were –0.049, 0, 0.002 for AFC and CI1; 0.014, -0.004, -0.004 for AFC and CI2; and 0.877, 0.081, 0.043 for CI1 and CI2, respectively.

Keywords: Genetic trend, Reproductive traits, Iranian Holstein cows.

Introduction
Most breeding programs give more weight to yield and type traits than the reproductive performance in selection indices (Lucy, 2001). Use of these programs has caused genetic improvements in yield and depresses in reproductive traits (Amimo et al., 2006). The negative correlation between fertility and production is reported in several studies (Lucy, 2001; Ojango and Pollot, 2001; Roth, 2004; Pryce and Veerkamp, 2001).

Reproduction problems make economic losses in two ways. First, due to lost production as a result of prolonged calving interval, and second, increasing of replacement costs became of fewer calves per cow (Mantysaari and Van Vleck, 1989; Van Arendonk et al., 1989; Bagnato and Oltenacu, 1994; Boichard et al., 1998; Olori et al., 2002). Age at first calving is the period that a cow reaches second
maturity and born for first time and calving intervals are the periods that cow reproduce next calves. Age at first calving and calving interval are important indicators in economical outcome of dairy records. (VanRaden and Klaaskate, 1993; Grohn and Rajala-Schultz, 2000; Hare et al., 2006).

Genetic analysis for age at first calving and calving interval is studied in different countries. Hinojosa et al. (1980) reported that mean calving interval for Zebu cow in Mexico was 382±3.7 days. Trends for 5 breeds in United States (Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey) using the data from 1980 to 2004 are reported by Hare et al. (2006). Means of age at first calving for Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey were 28.9, 28, 27.7, 26.9 and 25.6 months, respectively. Also means for first calving interval were 399.8, 406.5, 405.2, 402.9 and 390.5 days for those breeds, respectively. Phenotypic trends for age at first calving in these 5 breeds were -0.09,-0.26, -0.26, -0.29 and -0.28 month per year, respectively. For first calving interval, phonotypic trends were 0.97, 0.90, 1.07, 0.97 and 0.49 month per year, respectively (Hare et al., 2006).

Heritability estimates for age at first calving and first and second calving interval for South African Holstein cows were 0.26, 0.03, 0.4 and phenotypic and genetic trends were -0.2 and - 0.06 month per year for AFC and 1.9 days and 0.27 days per year for CI, respectively. For first and second calving interval, heritabilities were 0.03 and 0.04 and genetic and phenotypic trends were 0.27 and 1.9 days per year (Makgahlela et al., 2008). Heritability estimates for age at first calving, first and second calving interval in Columbia cattle were reported 0.15, 0.11 and 0.18, respectively, by Vergara et al. (2009). The genetic trends for these traits were -6.26, -0.32 and -1.16 days per year, respectively.

The phenotypic trends for calving age and calving interval were estimated for Iranian Holstein in Fars Province in Southern Iran. Mean for calving age was 30 month in year 2000 and decreased to 26 month in 2005. Mean of calving interval was decreased from 435 days in year 2000 to 389 days in 2005 (Ansari- Lari et al., 2009).

Age at first calving for Iranian Holstein cows was 26.4 months, and first and second calving intervals ware in the range of 396.6- 400.7 days. Heritability estimates for AFC was 0.14. For CL1 and CL2, heritability was in the range of 0.03-0.07 and 0.035. The genetic correlation between AFC and CL1 was – 0.01 and phonotype correlation for these traits was 0.01 (Farhangfar and Naeemipour Younesi, 2007; Pozveh and Shadparvar, 2009; Ghiasi et al., 2011; Chookani et al., 2010).

Genetic correlation between AFC and CL1 was reported in the range of -0.92 to 0.53 and for AFC and CL2 was between - 0.06 and 0.4 in the literatures (Frazier et al., 1999; Mercadante et al., 2000; Gressler et al., 2005; Farhangfar and Naeemipour Younesi, 2007; Makgahlela et al., 2008; vergara et al., 2009).

The objectives of present study were: i) estimation of genetic parameters for age at first calving, and first and second calving interval with using of univariate and multivariate animal model; and ii) estimation of phenotypic and genetic trends for age at first calving, and first and second calving intervals in Iranian Holstein cows.

**MATERIALS AND METHODS**

Data used in this study were obtained from Animal Breeding Center (ABC) of Iran. The reproduction traits were age at first calving (AFC), days between first and second calving (CI1) and days between second and third calving (CI2). The original data set had a total of 26116
records that calved between 1983 and 2007, and pedigree information of 223502 animals was also available. Since for some individuals the records of second and third calving dates were not available, therefore, number of records for CL1 and CL2 were different from number of records used for analysis of AFC trait.

Reproduction traits were obtained from birth data, first calving data and second and third calving data. Age at first calving was calculated as difference between first calving date and birth date of animals. Calving intervals were calculated as difference between calving dates from successive parities. Records of with unknown birth and calving dates were ignored. Records for age at first calving were included in analysis if age at first calving was between 20 and 42 months. According to South African Holstein cattle (Mosert et al., 2006) calving interval was restricted to the range of 260 and 750 days as Ansari et al. (2009).

The data were analyzed by using single and two trait mixed models. The model equation, in matrix notation, for single and two trait was as follows:

\[ y = Xb + Zu + e \]

Where: \( y \) : the vector of observations; \( b \) : the vector of fixed effects (calving herd-year-season (HYS) and age at first calving, only for calving interval 1 and 2); \( u \) : the random vector associated with additive effects of animal; \( X \) and \( Z \) : Identical matrix to relate observations with fixed and random effects, respectively; \( e \) : Residual effects.

Model assumptions in single trait analysis:

\[ E(y) = Xb; \ E(\alpha) = E(e) = 0; \ var(\alpha) = \sum_{2}^{2} = G; \ var(e) = I\sigma_{e}^{2} = R; \ var(y) = ZGZ + R \]

Model assumptions in two trait analysis:

\[ E \begin{bmatrix} y_{1} \\ y_{2} \\ \vdots \\ y_{p} \\ \vdots \\ y_{q} \\ \vdots \\ y_{n} \end{bmatrix} = \begin{bmatrix} X_{1} \\ X_{2} \\ \vdots \\ X_{p} \\ \vdots \\ X_{q} \\ \vdots \\ X_{n} \end{bmatrix} \begin{bmatrix} b_{1} \\ b_{2} \\ \vdots \\ b_{p} \\ \vdots \\ b_{q} \\ \vdots \\ b_{n} \end{bmatrix} \]

\[ \text{var}(y_{i})= ZG_{i}Z + R_{ii}; \ \text{cov}(y_{i}, y_{j}) = ZG_{ij}Z + R_{ij} \]

\[ M= \begin{bmatrix} \alpha_{1} \\ \vdots \\ \alpha_{p} \\ \vdots \\ \alpha_{q} \end{bmatrix} \]

\[ R_{ii} = I\sigma_{e}^{2}; \ G_{jj} = A\sigma_{g}^{2}; \ R_{ij} = \sigma_{e}^{2}I \]

ASReml software (Gilmour et al., 2000) was used to fit the linear mixed model based on Residual Maximum Likelihood (REML) and breeding values were estimated by best linear unbiased prediction (BLUP) procedure. Yearly genetic changes of cows EBVs for AFC, CI1, and CI2 were computed to study genetic trends between 1983 and 2007.

Genetic and phenotypic trends were computed as a linear regression of yearly means on year using the REG procedure of the Statistical Analysis System (SAS, 2007).

RESULTS AND DISCUSSION

Table 1 present the structure and descriptive statistics of traits used in the analyze. Mean of age at first calving was 811.1 days (26.6 month). This mean is less than the mean of ACF in South African Holstein (840 days) (Makgahlela et al., 2008) but these result agree with results of Iranian Holstein (Farhangfar and Naeenipour Younesi, 2007; Choookani et al., 2010). Mean of Calving interval 1 and 2 were 412.8 and 599 days, respectively. Hultgren and Svensson (2010), Makgahlela et al. (2008), Farhangfar and Naeenipour Younesi (2007) and Choookani et al. (2010) . Hare et al. (2006) reported mean of first calving interval in Jerseys (390 day), Ayshire (398 d), Holsteins (404 d), Guernsey (406 d) and Brown Swiss (407 d) and for calving interval 2, the mean ranged from 399 to 419 d across breeds in 1998.
Table 1. Structure and descriptive statistics for reproduction traits in Iranian Holsteins

<table>
<thead>
<tr>
<th>trait</th>
<th>No of records</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at first calving (d)</td>
<td>26116</td>
<td>608</td>
<td>1277</td>
<td>811.1</td>
<td>101.5</td>
</tr>
<tr>
<td>Calving interval 1 (d)</td>
<td>16324</td>
<td>261</td>
<td>749</td>
<td>412.8</td>
<td>86.4</td>
</tr>
<tr>
<td>Calving interval 2 (d)</td>
<td>92661</td>
<td>301</td>
<td>399</td>
<td>599</td>
<td>64.9</td>
</tr>
</tbody>
</table>

SD: Standard Deviation

Table 2. Variance components and heritability estimates (SE) for AFC, CI1 and CI2 in Iranian Holstein cows

<table>
<thead>
<tr>
<th>Trait</th>
<th>VA (SE)</th>
<th>VR (SE)</th>
<th>VP (SE)</th>
<th>h^2 (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC</td>
<td>1132 (35.11)</td>
<td>4786 (28.11)</td>
<td>5918 (19.87)</td>
<td>0.19 (0.005)</td>
</tr>
<tr>
<td>CI1</td>
<td>293.3 (24.94)</td>
<td>6447 (31.35)</td>
<td>6740 (25.63)</td>
<td>0.04 (0.003)</td>
</tr>
<tr>
<td>CI2</td>
<td>138.2 (17.64)</td>
<td>3875 (24.69)</td>
<td>4013 (20.42)</td>
<td>0.03 (0.004)</td>
</tr>
</tbody>
</table>

AFC= age at first calving; CI1= first calving interval; CI2= second calving interval; VA= Additive genetic variance; VR= Residual variance; VP= Phenotypic variance; h^2= Heritability.

Table 3. Linear regression coefficients of breeding values and phenotypic values (standard deviations) for reproduction traits on year of calving for Iranian Holstein

<table>
<thead>
<tr>
<th>Traits</th>
<th>Genetic trend (SD)</th>
<th>Phenotype trend (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at first calving (d)</td>
<td>-0.75 (0.10) **</td>
<td>-2.35 (0.37) **</td>
</tr>
<tr>
<td>Calving interval 1 (d)</td>
<td>0.004 (0.02) ns</td>
<td>-1.13 (0.39) **</td>
</tr>
<tr>
<td>Calving interval 2 (d)</td>
<td>-0.02 (0.01) ns</td>
<td>-0.28 (0.23) ns</td>
</tr>
</tbody>
</table>

ns = No significantly different from zero.

**Significant (p<0.01)
SD: Standard Deviation

Effects of HYS and calving age for calving interval 1 and 2 were significant (p <0.01). Significant effects of year and season were reported in ACF and CI traits by Ansari- Lari et al. (2009).

Estimates of variance components and heritability for ACF, CI1 and CI2 are shown in Table 2. Estimates for additive genetic variance were less than residual variance. The residual variance effects consist of a large proportion of the total variation in AFC, CI1 and CI2. Therefore, estimates for heritability for these traits were low. These estimates were in agreement with reports of Wasike et al. (2009) for Boran cattle in Kenya.

The estimate of heritability for AFC (0.19±0.005) was higher than Vergara et al. (2009) for Angus Blanco Orejinegro Zebu cattle in Colombia (0.15±0.13), Wasike et al. (2009) for Boran cattle in Kenya (0.04±0.06) and Farhangfar and
Naeemipour Younesi (2007), Chookani et al. (2010) for Iranian Holstein (0.014±0.005) but close to Romosinuano in Colombia cattle (0.16±0.09; Suárez et al., 2006) and less than that of Makgahlela et al. (2008) reports for South African cattle (0.26 ±0.02). Estimates of heritability for CI1 and CI2 were similar to Makgahlela et al. (2008) for South African cattle and Gressler et al. (2005) for Nellore in Brazil and Farhangfar and Naeemipour Younesi (2007), Chookani et al. (2010) for Iranian Holstein, but higher than Wasike et al. (2009) for Boran cattle in Kenya. Vergara et al. (2009), Toghiani Pozveh and Shadparvar (2009) and Ghiasi et al. (2011) showed that heritability for CI was between 0.11 and 0.18.

Different values estimated for heritability in this study could be due to several factors such as: breed of animal, management system, environmental factors, size and structure of data, model of analyses, and statistical methods employed.

Low estimates of heritability for CI1 and CI2 indicated that these traits might be greatly influenced by environmental conditions. Therefore, improvements in nutrition and reproductive management would likely have a larger impact on reducing CI1 and CI2 than the genetic selection (vergara et al., 2009). Due to the low heritability for AFC, CI1 and CI2, selection for improving these traits in dairy cattle would not worthwhile (Pryce et al., 1998; Kadermideen, 2004; Makgahlela et al., 2008). However, some other studies reported relatively high additive genetic variation in fertility traits (Philipsson, 1981; Raheja et al., 1989; Oltenacu, 1991; De Jong, 1998), therefore, it could be conclude that there would be a potential to improve these traits genetically through selection, and this could be achieved by increasing the amount of information used in the genetic evaluation (e.g., using information offspring). Incorporation of traditional measures of fertility and all these correlated traits, directly and indirectly, could be used to improve the accuracy of genetic predictions for fertility traits (Makgahlela et al., 2008).

The results for two traits analyses are shown in Table 4. All correlations between AFC, CL1 and CL2 traits were close to zero except for genetic correlation between CL1 and CL2 which was 0.877. High genetic correlation between CL1 and CL2 suggest that calving intervals in different lactation period could be considered as one trait. Negative genetic correlation between AFC and CL1 suggests that cows with high EBV for AFC would have low CL1. Low correlation between AFC and CL is reported in other studies. Vergara et al. (2009) reported 0.33 and 0.4 for genetic correlation between AFC and CL1 and AFC and CL2, respectively. These values are higher than the ones reported in this study. However, genetic correlation between AFC and CL1 was reported in the range of -0.92 to 0.53 and for AFC and CL2 was between -0.06 and 0.4 in the literature (Frazier et al., 1999; Mercadante et al., 2000; Gressler et al., 2005; Farhangfar and Naeemipour Younesi, 2007; Makgahlela et al., 2008 and vergara et al., 2009). Differences in sign and value of genetic correlation estimates between AFC and calving interval might be due to breed of animal, environmental conditions, method of estimation. The estimate of genetic correlation between CI1 and CI2 was highly positive that is in agreement with other reports (vergara et al., 2009; Haile –Mariam et al., 2003). Estimates of phenotypic correlations between AFC and CI2, and between CI1 and CI2 were low. This indicates that there is little phenotypic association between these traits. Result for residual correlation was in the range of values reported in the literature for these traits, i.e, Makgahlela et al. (2008) and Farhangfar and Naeemipour Younesi (2007).
Table 4. Genetic, residual and phenotypic correlation for age at first calving, first calving and second calving interval get from two trait analysis

<table>
<thead>
<tr>
<th>Trait</th>
<th>Genetic correlation (SE)</th>
<th>Residual correlation (SE)</th>
<th>Phenotypic correlation (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC</td>
<td>-0.049 ± 0.01</td>
<td>0.002 ± 0.001</td>
<td>0</td>
</tr>
<tr>
<td>CI1</td>
<td>0.014 ± 0.01</td>
<td>-0.004 ± 0.003</td>
<td>-0.004</td>
</tr>
<tr>
<td>CI2</td>
<td>0.877 ± 0.04</td>
<td>0.043 ± 0.003</td>
<td>0.081</td>
</tr>
</tbody>
</table>

SE: Standard Error

a: Estimates of standard errors rounded to zero.

**Genetic and phenotypic trends**

Figure 1 and 2 show the phenotypic trends for yearly means of cows for AFC, CI1 and CI2 during years of 1983 to 2007. The AFC, phenotypic levels were increased from 1983 to 1985 and reached to 877 days in 1985, and it decreased to 800 days in 1987. Decreasing trend continued from 1988 to 2007. Decreasing the levels could be due to the selection for low age at first calving. Ansari- lari et al. (2009) reported that age at first calving decreased from 30 months in 2000 to 26 months in 2005 for Iranian Holsteins in Fars province, southern Iran. The change from 1980 to 2004 ranged from a decrease of 3 months for Ayrshire to 8 months for Brown Swiss and Jerseys (Hare et al., 2006). The decrease of trends for AFC might represent earlier maturity from better calf-raising practices or from intense selection for high milk yield during early parities (Hare et al., 2006). Reductions in age at first calving were also found in Netherland (Nederlands Rundvee...
Syndicaat, 2005) and Spain (Gonzalez-Recio et al., 2004).

Decreasing trend for CI1 and CI2 had harsh slope from 1983 until 1985. In 1985, the Animal breed Center of Iran began the registration of Iranian Holstein cows and the decrease in 1985 could be due to registration. From 1986 to 2007, phenotypic trend for CI1 and CI2 irregularly decreased. The mean of CI1 was 465 days in 1983 and decreased to 373 days in 2006. The mean of CI2, was 402 days in 1983 and decreased to 372 days in 2005. These trends show that calving interval in Iranian Holstein is improving. Ansari –Lari et al., (2009) reported that calving interval in Iranian Holsteins in Fars province decreased from 435 days in 2000 to 389 days in 2005. Increasing trend for calving interval in other breeds was reported by Hare et al. (2006). The changes of EBVs for AFC, CI1 and CI2 are shown in Figure 3 and 4. Genetic trends for AFC are positive from 1983 to 1998 and then negative. Decreasing of genetic trend for AFC had harsh slope after 1998. Figure 3 shows that breeding value levels for AFC was improved and selection to decrease these traits is used in Iranian Holsteins. Genetic trends for CI1 and CI2 have irregular trends, some years positive and some years negative. The trends for CI1 and CI2 showed that selection for decreasing calving interval has not been performed in Iranian Holstein Cows. This could be due to the fact that selection was only focused on production traits, and there were no selection on reproduction traits in breeding program of Iranian Holstein cows. Linear regression coefficient of yearly means of breeding value and phenotypic value for AFC, CI1 and CI2 are showed in Table 3. Regression coefficient for EBV and phenotypic trend was negative for all traits (except for genetic trend of CI1). Linear regressions of phenotypic and genetic trends for AFC in South African Holstein were estimated -0.23 and -0.07 months per year, respectively. These estimates are more than the result of this study. For CI, linear regression for phenotypic and genetic trend was 1.94 and 0.27 days. In this study, genetic trends were positive and less than those of Makgahlela et al. (2008) reports. However, the phenotypic trend was negative in this study (-1.13). Makgahlela et al. (2008) reported a positive phenotypic trend. Hare et al. (2006) reported that regression for phenotypic trend AFC was between -0.09 and -0.28 months per year, and for CI, it was between 0.9 and 1.07 months. Genetic and phenotypic trend for AFC and phenotypic trend for CI was significant (p<0.01). However, they were not significant for other traits (P>0.05).

In conclusion, the estimates of heritability values for AFC, CI1, and CI2 were very low and residual variance was very large. The low heritability for these traits suggested that their genetic improvement would be slow. For improving these traits, improvements in nutrition and reproductive management could be useful. The trends for these traits were negative. The age at first calving and calving interval were decreased from 1983 to 2007. This could be attributed, partly to better management and improvement in nutrition during this period and also to the fact that large genetic trend for milk which has been observed in countries with decreasing reproductive performance has not occurred in Iranian Holsteins.

ACKNOWLEDGEMENT

The authors thank to the Animal Breeding Center of Iran, for providing the pedigree data and records.
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