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Research Article

EVALUATION OF GENETIC AND NON GENETIC FACTORS AFFECTING REPRODUCTIVE PERFORMANCE ON HOLSTEIN DAIRY COWS OF ISFAHAN

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ABSTARCT
The objective of this study was to analyze the effects of factors affecting reproductive traits in the Holstein population of the Isfahan dairy farms for subsequent compilation of the model for genetic evaluation as well as for herd management practice**.** A data set containing 99012 records were analyzed by a linear model with fixed effects of year , herd ,season, parity of dam, calving interval, age at first calving, period from calving to first insemination, service per consumption. All these effects were not significant; also their appropriate categorization was considered. Analyses of additional factors such as gestation length, age at first calving and service per consumption were performed. The results revealed that gestation length was in a relationship with Holstein dairy cow's performance. Data for the calving interval (day) showed that the mean of calving interval in experimental animal is 390.43±58.88 and period of lactation was significant effect on calving interval. In this study the mean period of calving to first insemination was 63.64±21.28 days. Data showed that different levels of fixed effects also affecting reproductive traits on Holstein dairy cow. The effect of herd, year and season were significant for those traits. In addition the effect of parity was also significant on calving interval and period of gestation and services per conception. We demonstrated that the additive variance, fixed environmental variance, remained variance and phenotypic variance for this trait were 0.25, 4.54, 2.15 and 2.40 respectively. Also the variance components for age at the first calving were 33.59, 3203.14, 3263.73 and 0.01 for additive variance, remained variance and phenotypic variance respectively. It is obviously that genetic and non genetic factors be must adjusted for the factors that they could improve the performance of Holstein dairy cows.

Keywords: *Calving Interval, Gestation Length, Age at First Calving, Holstein Dairy Cow*

INTRODUCTION
The reproductive activity of cows in dairy operations is an important factor in dairy cow and milk production. The more frequently a dairy cow calves the greater is the amount of milk produced in her lifetime (Raheja *et al.*, 1989). The calving interval should not be longer than 1 year for obtaining lower costs, profitability and optimum viability of the dairy enterprise (Kamdasamy *et al.*, 1993; Makuza *et al.*, 1996). In several studies some antagonistic genetic and phenotypic correlations between reproductive performance and lactation yield were reported (Berger *et al.*, 1981). To obtain a simultaneous improvement in productive and reproductive traits by overcoming this antagonism, it will be useful to use a practical measure that combines these traits and shows the overall efficiency of a cow (Dong *et al.*, 1989; Tekerlu and Gundogan, 2005). Gestation length, the period from effective fertilization until calving, is a reproductive trait that significantly affects cattle breeding and production. The cow's age is the key environmental factor influencing gestation length. Gestation length is shorter in heifers than in older cows (Przysucha and Grodzki, 2009). Cervantes *et al.*, (2009) reported significant genetic correlations between GL vs. CE and SB, whereas Hansen *et al.*, (2004) observed a weak correlation between GL and other reproductive traits. Owing to the high significance of CE and SB values in the production of high yielding dairy cattle, other traits contributing to the optimization of reproductive traits should also be studied. In dairy cattle, female reproduction problems lead to prolonged calving intervals, increased insemination and veterinary costs, higher culling rates, and thus increased replacement costs.

Several studies using field data (Janson *et al.*, 2001) found unfavorable genetic correlations between milk yield and female fertility traits. Importance of fertility in dairy cattle is well known, both in functionality and farm economy (Pryce *et al.*, 2004).

Age at first calving is the period between birth and first calving and influences both the productive and reproductive life of the female, directly through its effect on her lifetime calf crop and milk production and indirectly through its influence on the cost invested for upbringing (Kelay, 2002).

Calving interval is the period between successive parturitions and is a function of postpartum anestrous period from calving to first estrus, service period first postpartum estrus to conception and gestation length (Tewodros, 2008).

Number of services preconception is number of services per conception, which is defined as the number of services natural or artificial required for a successful conception, depends largely on the breeding system used, the reproductive health status of the animal, the management and feeding practices in a farm and the semen quality of artificial insemination or natural service bulls (Tewodros, 2008).

Non-genetic factors influencing reproductive performance in dairy cattle Non-genetic factors such as age of dam, sex of the calf, gestation length, parity, cow weight influenced birth weight in cattle, which is useful in selection criterion for increased production and reproductive efficiency of dairy cattle (Olawumi and Salako, 2010), they had significant effect on reproductive traits. Knowledge on these factors and their influence on cattle performance are important in formulation of management and selection decisions (Goyache *et al.*, 2003). It would be highly desirable to identify factors associated with reproductive performance; such information could be beneficial and developing management techniques to maximizing the Performance in the breeding herd. The main indicators that would be considered in assessing reproductive performance are age at puberty, age at first calving, calving interval, days open and number of services per conception (Aynalem *et al.*, 2011; Demissu *et al.*, 2013). The objective of this study was to investigate the factors affecting reproductive performance in the Holstein dairy cow's population of the Isfahan dairy farms in Iran. Furthermore, the knowledge of these investigated effects might also be applied in herd management practice.

MATERIALS AND METHODS

Records of reproductive traits such as days of gestation, birth weight, age of each cow, year and season of calving, twin birth, length of gestation, calving interval in the Holstein breed gathered by Vahdat Agriculture and Dairy Cooperative Company in Isfahan, Iran dairy farms due 1987-2012 were used in this study (about 99012 record were used). Mother's age at calving was obtained by subtracting the date of their birth and calving date of them. Gestation period was obtained by subtracting of inoculation resulted in pregnancy and calving date. Summary of experimental pedigrees are shown in Table 1.

Table 1: Experimental animal's pedigree data

Description	Number
Animals under study	99012
Record numbers of animals	61764
Animals that they have offspring	4517
Animals that they haven't offspring	4949
Animals that they have unknown sire	6484
Animals that they have unknown mother	17611
Animals that they have unknown sire and mother	5984

Statically Analysis

Data were arranged by Fox pro and excel (2011) programs. To identify none genetic sources of variation we used the GLM procedure of SAS (2003) for the multivariate least squares method and to investigate the genetic parameters the Wombat program was used (Meyer, 1991; Meyer, 2007).

Estimation of Genetic Parameters

Since most of animals have more record for certain traits, so in such traits in addition to the genetic effects, fixed environmental effects have affective. For this reason we used the model as follow:

$$y = xb + (o \quad z)\begin{pmatrix} a_o \\ a_r \end{pmatrix} + Zp + e$$

Where: y = vector of fixed effects, a = vector of random effects, a_r and a_o = animal with or without recorded data, p= environmental permanents effects, e = vector of remained effects.

Reproducibility of traits in each animal also expressed as the ratio of variances.

$$r = \frac{\sigma_a^2 + \sigma_p^2}{\sigma_a^2 + \sigma_p^2 + \sigma_e^2} \geqslant h^2 = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_p^2 + \sigma_e^2}$$

And the mixed model equations as follows:

$$Y = Xb + Z_1a + Z_2p + e$$

$$\begin{bmatrix} \acute{x}x & \acute{x}z_1 & \acute{x}z_2 \\ \acute{z}_1x & \acute{z}_1z_1 + K_1A^{-1} & \acute{z}_1z_2 \\ \acute{z}_2x & \acute{z}_2z_1 & \acute{z}_2z_2 + k_2I \end{bmatrix} \begin{bmatrix} \hat{b} \\ \hat{a} \\ \hat{p} \end{bmatrix} = \begin{bmatrix} \acute{x}y \\ \acute{z}_1y \\ \acute{z}_2y \end{bmatrix}$$

Where y= column vector for each trait, b= column vector for fixed effects, a= randomize effects vector, p= environmental fixed effects, e= remain effects vector, z_1 for all animal and z_2 for animal that they have recorded data.

RESULTS AND DISCUSSION

Results

Calving Interval (CI)

Table 2: Descriptive statistics for the calving interval (day)

Traits	No	Means	Standard deviation	Min	Max
Calving interval	54622	390.43	58.88	300	550
First lactation period	22157	390.76	59.48	300	550
Second lactation period	14848	390.64	58.89	300	550
Thirst lactation period	9385	390.82	58.49	300	550
Fourth lactation period	5374	387.68	57.42	300	550
Fifth lactation period	2858	390.58	57.96	300	550

Descriptive statistics for the calving interval (day) showed that the mean of calving interval in experimental animal is 390.43±58.88 and period of lactation was significant effect on calving interval, So that the least square means of first due to fifth lactation period showed that calving interval was lesser 387.68 compared to others.

Period from Calving to First Insemination (DFS)

Table 3: Descriptive statistics for Days from calving to first insemination (day)

Traits	No	Means	Standard deviation	Min	Max
Period from calving to first insemination	86351	63.46	21.28	28	150
First lactation period	33801	63.38	21.31	28	150
Second lactation period	24001	63.57	21.41	28	150
Thirst lactation period	1536	63.49	21.28	28	150
Fourth lactation period	8714	63.42	21.06	28	150
Fifth lactation period	4474	63.52	20.75	28	150

The results of days from calving to first insemination are shown in table 3. According to these data we demonstrated that the mean period of calving to first insemination is 63.64±21.28 days. The result of this table showed that lactation period is not affective on days from calving to first insemination.

The Number of Services per Conception (S/C)

Table 4: Descriptive statistics for the number of services per conception (day)

Traits	No	Means	Standard deviation	Min	Max
Number of services per conception	14626	2.22	1.59	1	8
First lactation period	61746	1.67	1.14	1	8
Second lactation period	39142	2.52	1.72	1	8
Thirst lactation period	24691	2.72	1.77	1	8
Fourth lactation period	13725	2.62	1.73	1	8
Fifth lactation period	6956	2.71	1.77	1	8

Data showed that the mean of number of services per conception is 2.22±1.59. The least square means of first due to fifth lactation period showed that at the first lactation period there was significant difference compared to others.

Period of Gestation (PG)

Table 5: Descriptive statistics for the gestation period (day)

Traits	No	Means	Standard deviation	Min	Max
Number of services per conception	99012	277.27	6.16	240	300
First lactation period	43243	276.34	5.93	240	300
Second lactation period	27453	277.64	6.18	240	300
Thirst lactation period	15985	278.26	6.32	240	300
Fourth lactation period	8254	278.31	6.46	240	300
Fifth lactation period	4075	278.51	6.42	240	300

There was significant relation between lactation period and gestation length between first and multiparous cows. Data showed that the mean of number gestation length is 277.27±6.16. The least square means of first due to fifth lactation period showed that significant relationship between traits.

Age at the First Calving (AFC)

Table 6: Descriptive statistics for the mean age at first calving (day)

Trait	No	Means	Standard deviation	Min	Max
Ages at the first calving	51766	758.54	59.31	--	--

Table 7: The least square means for different levels of fixed effects on reproductive traits on Holstein dairy cow

Traits	CI	DFS	S/C	PG	AFC
-------	390.43±58.58	63.64±21.28	1.21±1.49	277.26±6.16	758.54±56.88
Herd, Season Year	**	**	**	**	**
Parity	**	ns	**	**	ns
1	390.76±00 ^{a}	62.90±0.26	1.61±0.02^{d}	267.03±0.07^{c}	--
2	390.64±0.97^{a}	63.24±0.28	2.44±0.02^{c}	277.37±0.07^{b}	--
3	390.82±0.39^{a}	63.11±0.30	2.60±0.01^{a}	277.85±0.08^{a}	--
4	378.67±0.16^{b}	62.88±0.34	2.46±0.02^{b}	277.95±0.10^{a}	--
5	290.58±0.5^{a}	62.74±0.41	2.52±0.03^{a}	287.07±0.12^{a}	--

CI= calving interval, DFS = days from calving until first insemination, S/C = service per consumption, PG= gestation period, AFC= Age at the first calving.

Data about the age at the first calving are shown in table 6.According to this data; the mean age at first calving was 758.54±59.31 for 51766 records.

The least square means for different levels of fixed effects on reproductive traits on Holstein dairy cow are shown in table7. These data showed that effect of herd, year and season were significant for calving interval, age of first calving, periods of gestation and for the number of services per conception.

These data showed that different levels of fixed effects also affecting reproductive traits on Holstein dairy cow. The effect of herd, year and season were significant for those traits. In addition the effect of parity was also significant on calving interval and period of gestation and services per conception.

Table 8: The variance components for calving interval traits (CI)

Calving interval (day)	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	h^2	Pe^2	r
Total	8.62	7.38	3345.54	3432.54	0.01	0.01	0.00002
At first parity		--	3505.53	3505.50	0.01	--	--
At second parity		--	3400.72	3416.30	0.01	--	--
At third parity		--	3365.65	3365.60	0.01	--	--
At fourth parity		--	3170.49	3252.60	0.03	--	--
At fifth parity		--	3203.57	3308.70	0.03	--	--

σ2a = Additive variance, σ2pe = Fixed environmental variance, σ2e = Remained variance, σ2p= phenotypic variance, h 2= Heritability, Pe2 = Shared environment and r = repetition rate

A multivariate analysis by the linear model for variance components and genetic parameters for calving interval traits is shown in table 8. Considering these data additive variance, phenotypic variance, shared environment, heritability and repetition rate for calving interval were 8.62, 7.38, 3345.54, 3432.54, 0.01, 0.01 and 0.00002 respectively.

Table 9: The variance components for calving to first insemination period (DFS)

DFS (day)	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	h^2	Pe^2	r
Total	1.31	6.39	440.97	442.28	0.01	0.01	0.00002
First lactation	0.79	--	448.05	448.85	0.01	--	--
Second lactation	2.78	--	450.47	453.25	0.01	--	--
Third lactation	7.90	--	437.96	445.80	0.01	--	--
Fourth lactation	3.76	--	435.73	428.50	0.01	--	--
Fifth lactation	7.91	--	416.78	424.78	0.01	--	--

σ2a = Additive variance, σ2pe = Fixed environmental variance, σ2e = Remained variance, σ2p= phenotypic variance, h 2= Heritability, Pe2 = Shared environment and r = repetition rate

Data for additive variance, phenotypic variance, heritability, shared environment and repetition rate for calving to first insemination period were 1.31, 6.39, 440.97, 442.28, 0.01, 0.01 and 0.00002 respectively.

Table 10: The variance components for service per consumption

S/C (day)	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	h^2	Pe^2	r
Total	0.25	4.54	2.15	2.40	0.05	0. 94	0. 2
First lactation	0.76	--	1.18	1.90	0.37	--	--
Second lactation	0.36	--	2.46	2.82	0.01	--	--
Third lactation	0.34	--	2.65	2.99	0.01	--	--
Fourth lactation	0.36	--	2.51	2.88	0.01	--	--
Fifth lactation	0.25	--	2.74	2.74	0.09	--	--

σ2a = Additive variance, σ2pe = Fixed environmental variance, σ2e = Remained variance, σ2p= phenotypic variance, h 2= Heritability, Pe2 = Shared environment and r = repetition rate

Table 10 showed that the data for additive variance, phenotypic variance, heritability, shared environment and repetition rate for service per consumption were 0.25, 4.54, 2.15, 2.40, 0.05, 0.94 and 0.2 respectively.

Table 11: The variance components for period of gestation

PG (day)	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	h^2	**Pe²**	***r***
Total	0.25	4.54	2.15	2.40	0.05	0. 94	0. 2
First lactation	0.76	--	1.18	1.90	0.37	--	--
Second lactation	0.36	--	2.46	2.82	0.01	--	--
Third lactation	0.34	--	2.65	2.99	0.01	--	--
Fourth lactation	0.36	--	2.51	2.88	0.01	--	--
Fifth lactation	0.25	--	2.74	2.74	0.09	--	--

σ2a = Additive variance, σ2pe = Fixed environmental variance, σ2e = Remained variance, σ2p= phenotypic variance, h 2= Heritability, Pe2 = Shared environment and r = repetition rate

Data showed that the heritability of gestation period was 0.05, 0.37, 0.01, 0.1, 0.01and 0.09 for total, first, second, third, fourth and fifth lactating cows. Also we demonstrated that the additive variance, fixed environmental variance, remained variance and phenotypic variance for this trait were 0.25, 4.54, 2.15 and 2.40 respectively.

Table 12: The variance components for age at the first calving

Age at the first calving (day)	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	h^2	**Pe²**	***r***
Total	33.59	--	3203.14	3236.73	0.01	--	--

σ2a = Additive variance, σ2pe = Fixed environmental variance, σ2e = Remained variance, σ2p= phenotypic variance, h 2= Heritability, Pe2 = Shared environment and r = repetition rate

The variance components for age at the first calving were 33.59, 3203.14, 3263.73 and 0.01 for additive variance, remained variance and phenotypic variance respectively.

Discussion

Mostert *et al.,* (2010) reported on genetic parameters for calving interval in the four major South African dairy breeds. Van *et al.,* (2004) reported preliminary results for four fertility traits, that is, age at first service in heifers, non-return rate to 56 d in heifers and cows, and the interval from calving date to first insemination date for Canadian dairy breeds. Jamrozik *et al.,* (2005) found that service per consumption for first parity and older Holstein cows in Canada was 1.64 ± 1.09 and 2.14 ± 1.50, respectively. According to an Australian survey (Little, 2003), an average SPC above 2.32 indicates herd reproductive problems. SPC was higher than 2.3 in seven of the herds surveyed in the present study. This would reduce mean service per consumption values, thereby showing a better reproductive performance by dairy farmers.

Mackey *et al.,* (2007) also noted that the major cause of poor reproductive performance in Irish dairy herds was the prolonged interval to first service and the poor success rate at first artificial insemination. Ray *et al.,* (1992), who reported that the fertility parameters were depressed in cows freshening in spring and summer in Arizona, USA.

Estimated heritability of GL based on the direct effect were determined in the range of h^2 = 0.27-0.45, whereas much lower values were reported based on the indirect effect (Jamrozik *et al.,* 2005). Cervantes *et al.,* (2009) reported significant genetic correlations between gestation length vs. calving ease and stillbirth, whereas Hansen *et al.,* (2004) observed a weak correlation between gestation length and other reproductive traits. Toghiani (2012) demonstrated that most genetic correlations between reproductive performances were found close to zero. Genetic correlation estimates of production traits with reproductive performance were from −0.513 for open days and protein yield to 0.96 for protein yield and calving interval. Most studies of the association between milk yield and reproductive measures in dairy cattle showed an unfavorable relationship between them. High milk yield per lactation has been associated with longer postpartum intervals to first service (Berger *et al.,* 1981) and longer service period (Hansen *et al.,* 1983). Most estimates of heritability of reproductive traits are less than 0.10 (Hansen *et al.,* 1983).

Rust and Groeneveld (2001) mentioned that reproductive recording is affected by the age structure of the herds and the prevailing environmental and management conditions. Rege and Famula (1993) demonstrated that calving interval has traditionally been the predominant measure of reproduction during the productive life of the animal particularly in dairy cattle, However, calving interval might not be the most desirable mea sure of fertility to include in a breeding objective in beef cattle. Cows with a shorter calving interval are often those whose first calves were born late. Selecting these animals or their offspring could result in indirect selection for a later age at puberty. Estimates of genetic correlation between age at first calving and calving interval found in the literature are: frequently negative ranging from 2 0.056 (Haile and Kassa, 1994), to 2 0.22 (Tonhati *et al.*, 2000).

Braga (1998) found a high positive phenotypic correlation between age at first calving and calving interval (0.43), while genetic correlation was low positive (0.10). Age at first calving appears to be a crucial trait in the reproductive life of the dam. Selection for a shorter age at first calving would lead to an improvement of calving interval performance. Colmenares *et al.,* (2007) showed that calving interval as a non-adjusted average of 473.9 ± 3.0 days, with a coefficient of variation of 16.3 %and adjusted average of 485.1 ± 3.9 days.

The repeatability index, 0.022, is similar to those obtained by Plasse *et al.*, (1968) of 0.03 and 0.08 in Brahman cattle and slightly less than those calculated by Lemka *et al.*, (1973) 0.12 and 0.10 in Hariana and Deshi cattle, respectively.

This result shows that the genetic variation in calving interval is very small relative to the variation caused by other factors and, in spite of the justification to eliminate animals with poor reproductive efficiency, the genetic improvement in calving interval will be limited. Basically repeatability value is greater than heritability value since repeatability estimates include the permanent maternal environmental variance in addition to the additive genetic variance component. The low repeatability values indicate that an animal evaluation for the traits based on repeated observations is more reliable than evaluation on a single observation. Cows should not be culled on single (or only few) initially available records. Lower repeatability estimate for traits could be also due to higher influence of specific environmental effects on a given record that may inflate within animal records variability(Solomon and Gemeda, 2000). In various studies, a number of factors have been included in analyses as main factors or their two or three way interactions either as fixed effects or as continuous effects to account for environmental sources of variation in animals' performance (Wasike, 2006).

A respective heritability value for Days Open of 0.0006 and 0.1 for Boran and Boran × HF was reported by (Ayenalem *et al.,* 2006). Calving interval has a very low heritability (Cassell, 2001). Million and Tadelle (2003), reported that, heritability value of 0.03 for first calving interval in Holstein dairy cattle. The low heritability is caused not only by a low genetic variance but also by a higher phenotypic variance due to small size of the herd and by random or unidentified environmental factors (Khalid *et al.,* 2001).

Conclusion

Development of effective genetic evaluation and improvement programs requires knowledge of the genetic parameters (genetic variance of each trait and covariance among traits) for economically important production traits**.** Accurate estimation of these genetic parameters requires data to be corrected to accommodate differences in known environmental effects that influence the production and reproductive performances of livestock. To increase the estimates of genetic parameter, uniform environment, use of multiple measurements, adjustment of records and accurate measurement of data are the basics need to be considered.

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