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Genetic and Phenotypic Trends of Productive and Reproductive Traits in Iranian Holstein Dairy Cattle of Isfahan Province

Research Article

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ABSTRACT

Productive and reproductive traits have great importance in international dairy cattle breeding objectives. Production, reproduction (days open and calving interval) and pedigree data of Iranian Holstein dairy cattles were collected between 2002 and 2012 from 47 herds in Isfahan province. The data set consisted of 30179 records from 18837 registered Iranian Holstein dairy cattles. Single trait repeatability animal model was used to estimate genetic parameters by restricted maximum likelihood procedures. Estimates of heritability of milk, fat and protein yields were 0.30 ± 0.014, 0.065 ± 0.0089 and 0.083 ± 0.0098 respectively and also these value for calving interval (CI) and days open (DO) were 0.074 ± 0.0094 and 0.023 ± 0.0057 respectively. Low heritability for reproductive traits indicates the importance of using available relatives' information for selection of these traits. Average increase in breeding value for milk, fat and protein over the 11 years period were 130, 0.22 and 0.09 kg/year, respectively. The means of breeding value of DO increased by 0.08 d/year from -0.17 d in 2002 to 0.58 d in 2012 and for CI decreased irregularly by -0.01 d/year from 0.05 d in 2002 to -0.03 d in 2012. In general, all traits showed negative phenotypic trends for the studied period.

KEY WORDS genetic and phenotypic trends, Iranian Holstein, productive traits, reproductive traits.

INTRODUCTION

In dairy farms in Iran, producer revenue and costs depend on the production level and number of animals raised to marketing. Reproduction traits are a source for animals breeding and high production, thus cow productivity has more contribution in the revenue and costs of dairy farms. Therefore, cow productivity has been identified as a key factor affecting the efficiency and economic viability of the dairy cattle industry. Reproductive failure causes economic losses due to reduced production as a result of prolonged calving intervals (Olori *et al.* 2002). Breeding programs for dairy cattle in Iran have been based primarily on increasing both production traits and reproduction performance. Reproductive efficiency of a cow is measured by factors such as age at first calving, calving interval, days open and number of services per conception (Nilfrooshan *et al.* 2004). Calving intervals (CI) reflect the periods that a cow reproduces again (Hare *et al.* 2006). Days open (DO) is calving interval to pregnancy (time from calving to conception). Reproductive traits have been neglected in the past in most dairy cattle genetic improvement programs worldwide, mainly because these traits are known to exhibit a low heritability (Kadarmideen, 2004). Most breeding programs give more weight to yield traits than the reproductive performance in selection indices. Use of these programs has caused to genetic improvement in yield and depression in reproductive traits (Faraji-Arough *et al.* 2011). Breeding program for increasing production in dairy cattle has negative side effects on fertility traits (Pryce *et al.* 1997; Roxström *et al.* 2001). Selection for higher production under one management system may lead to more health risks compared to other management systems. Therefore, management and genetics have to be integrated to develop an effective program for improvement of health and fertility in dairy cattle (Windig *et al.* 2006). Reproduction problems make economic losses in two ways: first, the production loss as a result of prolonged CI; second, increase of replacement costs because of fewer calves per cow (Boichard *et al*. 1998; Olori *et al*. 2002). Genetically, most studies of the association between milk yield and reproductive measures in dairy cattle showed a negative relationship among them (Jones *et al.* 1994; Shook, 1989; Van Dorp *et al.* 1998). Higher milk yield per lactation has been associated with more DO (Berger *et al.* 1981; Hansen *et al.* 1983) and longer CI. Estimating genetic and phenotypic trends in a population provide the animal breeders with essential information to develop more successful breeding programs and also to assess the effectiveness of their selection procedure. Despite remarkable changes in selection indices in different countries (Interbull, 2000) in the last fifteen years, the main emphasis in selecting bulls and cows in Iran is based on estimated breeding value of milk yield (Sadeghi-Sefidmazgi *et al.* 2009). Although several investigations have been carried out in Iranian Holstein cows on the genetic trend of 305-day milk yield (Razmkabir, 2005; Sahebhonar, 2007; Khorshidie *et al*. 2012) and one research on the genetic trend of persistency of milk yield (Khorshidie *et al*. 2012), but the genetic trends for CI and DO have not yet been appropriately evaluated. The primary objective of this study was to estimate the genetic parameters of productive (milk, fat and protein) and reproductive (CI and DO) traits. The secondary objective was to calculate breeding values and to demonstrate the genetic and phenotypic trend of these traits.

MATERIALS AND METHODS

Data

In this study, data were provided by the Vahdat corporation in the Isfahan province. The data were comprised of production, reproduction and pedigree databases of Iranian Holstein cattle calved in the Isfahan province between 2002 and 2012 in 47 herds. The production traits were consisted of milk, fat and protein yields and reproduction traits were CI and DO. The initial data set included 37075 lactation records. Records were edited to include only those cattle with a valid identification, valid sire and dam registration number. Records with unknown birth and calving dates were deleted. Age at calving with in each lactation was restricted by removing outlier data, using the following ranges, as used by Mostert *et al*. (2006): 20-42 months for lactation 1, 30-54 months for lactation 2, 40-67 months for lactation 3, 50-75 months for lactation 4 and 60-90 months for lactation 5. Records with CI less than 300 days or greater than 600 days and days open less than 30 days or greater than 300 days were also discarded. The final data set comprised 30179 lactation records of 18837 animals from 47 herds, 1224 sires and 13957 dams. The descriptive statistics for the traits described are in Table 1.

Statistical model

Statistical analyses of all traits considered in this study were performed using single trait repeatability animal models in ASREML (Gilmour *et al*. 2006). Variance and covariance estimates obtained from these analyses were used to estimate heritability. The following statistical models were applied to obtain variance components:

Model 1 (for milk, fat and protein yields):

$$Y_{ijkmns}=\mu+L_i+HYS_j+\sum_{n=1}^{k}a_n(age_{ijk})^n+\sum_{n=1}^{k}b_n(DO_{ijm})^n+\sum_{n=1}^{k}c_n(DIM_{ijn})^n+\alpha_m+\beta_n+e_{ijkmns}$$

Model 2 (for calving interval):

$$Y_{ijkmns}=\mu+L_i+HYS_j+\sum_{n=1}^{k}a_n(age_{ijk})^n+\sum_{n=1}^{k}b_n(DO_{ijm})^n+\sum_{n=1}^{k}c_n(DIM_{ijn})^n+\alpha_m+\beta_n+e_{ijkmns}$$

Model 3 (for days open):

$$Y_{ijkmns}=\mu+L_i+HYS_j+\sum_{n=1}^{k}a_n(age_{ijk})^n+\alpha_m+\beta_n+e_{ijkmns}$$

Where:

Y_{ijkmns} and $Y_{ijklmns}$: observation of 305-d milk, fat, protein yields (kg) or DO and CI respectively.

μ: overall population mean.

L_i: fixed effect of lactation yield (i=1, . . . ,5).

HYS_j: fixed effect of herd-year-season of calving.

HYS_k: fixed effect of herd-year-season of insemination.

a_n: age at calving fixed effect coefficient.

b_n : DO fixed effect coefficient.

c_n: days in milk fixed effect coefficient.

α_m: additive genetic random effect.

β_n: permanent environmental random effect.

e_{ijkmns} and $e_{ijklmns}$: residual random effect.

RESULTS AND DISCUSSION

Means

Selection for milk yield in dairy cattle is mostly made on the basis of 305-d milk yield (Bilal *et al.* 2008; Seyedsharifi *et al.* 2008; Bilal and Khan, 2009). In this study, means of milk, fat and protein yields were 11779.65, 303.9 and 286 kg/yr respectively. Mean of milk yield for Holsteins dairy cattle of Khorasan Razavi province in Iran for first, second and third parity were 7126.27, 7985.86, 8246.53 kg, respectively and for fat yield 305-d were 230.61, 252.46 and 259.86 kg, respectively (Teimurian, 2009). Samore *et al.* (2008) reported mean of protein 269, 296 and 300 kg for first, second and third parity, respectively.

Means of CI and DO were 386.8 and 108.3 days, respectively. Estrada-Leon *et al.* (2008) in Mexico, Hammoud *et al.* (2010) in Egypt, Shirmoradi *et al.* (2010) in Iran, Ghiasi *et al.* (2011) in Iran and Gunawan *et al.* (2011) in Indonesia, reported mean of CI 453.9, 393.8 and 360.9 days in *Brown swiss*, Iranian Holsteins and Bali dairy cattles, respectively. Mean of DO in this research was in agreement with results of Iranian Holstein cattle (Ghiasi *et al.* 2011; Deljoo Isaloo *et al.* 2012) but less than the mean of DO in Friesian cattle (130.7) (Hammoud *et al.* 2010). Mean of DO for US Holstein cattle was 113 days (Oseni *et al.* 2004). Hultgren and Svensson (2010), Makgahlela *et al.* (2008), Farhangfar and Naeemipour Younesi (2007), Chookani *et al.* (2010) and Hare *et al.* (2006) reported mean of first calving interval in Jerseys (390 day), Ayrshire (398 d), Holsteins (404 d), Guernsey (406 d) and *Brown swiss* (407 d). Ansari-Lari and Kafi (2010) using 8204 calving records in five herds, reported that mean of DO and CI in Holstein cows in Fars province were 134 and 403 d, respectively.

Variance component

Estimates of the variance components are shown in Table 2. Estimates of additive genetic variance for all traits were less than residual variance. In reproductive traits the residual variance effects comprised of a large proportion of the total variation, therefore heritability estimates for these traits were low. Most previous research concluded that additive genetic variation for reproductive traits is very low in proportion to phenotypic variation, which lead to heritabilities for those to be close to zero and selection for improving of these traits would not be worthwhile (Berger *et al.* 1981; Hansen *et al.* 1983).

Heritability and repeatability

The rate of genetic gain that could be made by selection is depends on the heritability of the trait, therefore high heritability of traits is an important index for response to selection. Estimation of heritability and repeatability of the traits is an essential genetic parameter which is required for animal breeding programs. Lower heritability of fat yield indicates that this trait greatly influenced by environmental conditions. In this research heritability estimated for milk, fat and protein yields were 0.305 ± 0.014, 0.065 ± 0.009 and 0.083 ± 0.098, respectively and for CI and DO were 0.074 ± 0.009 and 0.023 ± 0.006, respectively. Heritability estimated in these research for milk yield was in agreement with the results obtained Ojango and Pollott (2001) in Holstein Friesian cattle (0.30±0.04) and Gebreyohannes *et al.* (2013). Also, these estimates were in agreement with the results obtained by Mostert *et al.* (2010) for CI and Haile *et al.* (2009) for DO. These estimates for heritability of CI and DO are higher than the results obtained by Estrada-Leon *et al.* (2008) and Gunawan *et al.* (2011). Misztal *et al.* (1992) obtained much higher heritability estimates than those in the present study of 0.26, 0.149 and 0.238, for yields of milk, fat, and protein, respectively. Visscher and Thompson (1992), also reported higher heritability estimates for yields of milk and fat of 0.39 and 0.36, in British cattle respectively. The heritability estimate obtained for CI was slightly larger than that obtained by Ojango and Pollott (2001) for first and first three parities (0.06±0.02 and 0.05±0.02, respectively). Heritability estimates by Haile *et al.* (2009) for DO in Ethiopian Boran cattle and their crosses with Holstein Friesian in central Ethiopia were 0.047 and 0.1, respectively. Estimates of heritability for CI were lower than those value obtained by Makgahlela *et al.* (2008) for South African cattle, Gressler *et al.* (2005) for Nellore in Brazil, Farhangfar and Naeemipour Younesi (2007) and 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 estimated values for heritability of production and reproduction traits in this research compared to above mentioned authors could be due to several factors such as: animal breed, management system, environmental factors, size and structure of data, model of analyses, and statistical methods employed.

Low estimates of heritability for CI and DO 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 CI and DO than the genetic selection (Vergara *et al.* 2009). Also, due to the low heritability of reproduction traits, selection for improving these traits in dairy cattle would not worthwhile (Kadarmideen, 2004; Makgahlela *et al.* 2008). Therefore there is a genetically improvement potential for these traits through selection, and this could be achieved by increasing the amount of information used in genetic evaluation (e.g., using information offspring). In this research productive traits had higher repeatability than reproductive traits. Repeatability estimates were 0.592 ± 0.006, 0.329 ± 0.009 and 0.328 ± 0.009 for milk, fat and protein, respectively.

Table 1 Summary statistics for productive and reproductive traits

Trait	Record	Max	Min	Mean	SD
Milk	30179	18000	6000	11779.65	2432
Fat	30179	800	90	303.9	104.4
Protein	30179	800	90	286	83.4
CI	29350	600	300	386.8	59.5
DO	29070	300	30	108.3	59.6

CI: calving interval and DO: days open.
SD: standard deviation.

Table 2 Variance components estimates for production and reproduction traits

Trait	V_P	V_A	V_{EP}	V_e
Milk	4036600	1232590	1155350	1648640
Fat	4476.63	289.65	1182.04	3004.94
Protein	2862.01	237.45	700.25	1924.31
CI	21.8	0.69	3.21	17.91
DO	2249.55	51.6	64.46	2133.53

CI: calving interval and DO: days open.
V_P: phenotypic variance; V_A: additive genetic variance; V_{EP}: animal permanent environmental variance and V_e: error variance.

For reproductive traits, repeatability was 0.215 ± 0.009 and 0.052 ± 0.009 for CI and DO traits, respectively.

Trends in estimated breeding values and phenotypic

Comparison of genetic and phenotypic trends helps to assess genetic improvement which due to superior performance.

Over the 11-years period, the average increase in mean breeding value for milk, fat and protein were 130, 0.22 and 0.09 kg/yr, respectively. Genetic trends for CI and DO have irregular trends as some years are positive while the other years are negative. The trends of these traits showed that selection for decreasing CI 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. In reproductive traits, an increase observed in the mean breeding value for DO and a decrease in CI at the rate of 0.08 and -0.01 d/yr, respectively.

CI and DO decreased from 398.17 and 115.42 d in 2002 to 341.85 and 58.25 d in 2012 (Figures 4 and 5). The reason for declining phenotypic trend of CI and DO in current study might be due to increasing calf price relative to milk price in recent years that encourages farmers to reduce waiting period and open days after calving.

Mean breeding values and phenotypic trends in productive and reproductive traits by year of birth were plotted against time (Figures 1-5).

In general, all traits showed negative phenotypic trends for the studied period. Negative trend for milk production in whole period was due to a negative trend for last trend (2011 to 2012).

Deljoo Isaloo *et al*. (2012) analyzed over 10891 records collected from 23 years (1988 to 2010) from animal breeding center of Iran.

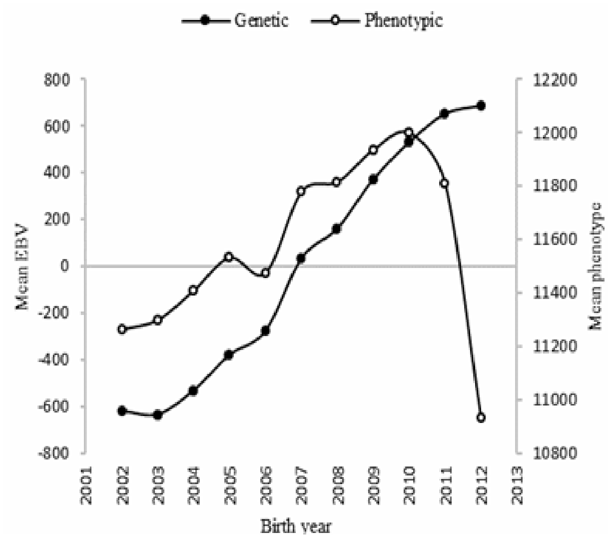

Figure 1 Genetic and phenotypic trend of milk yield (kg)

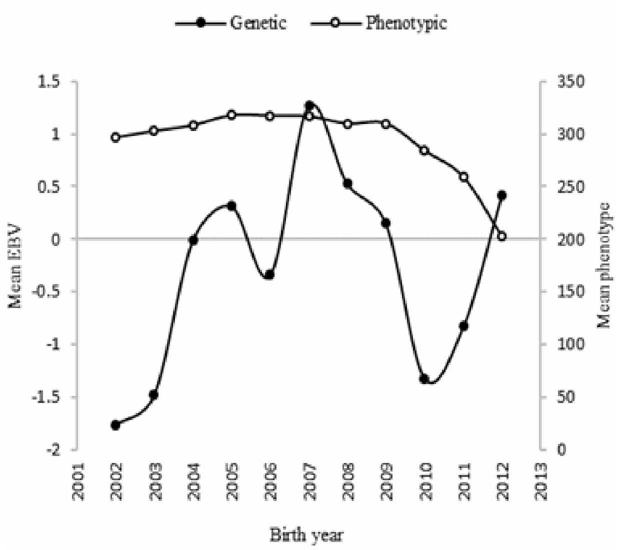

Figure 2 Genetic and phenotypic trend of fat yield (kg)

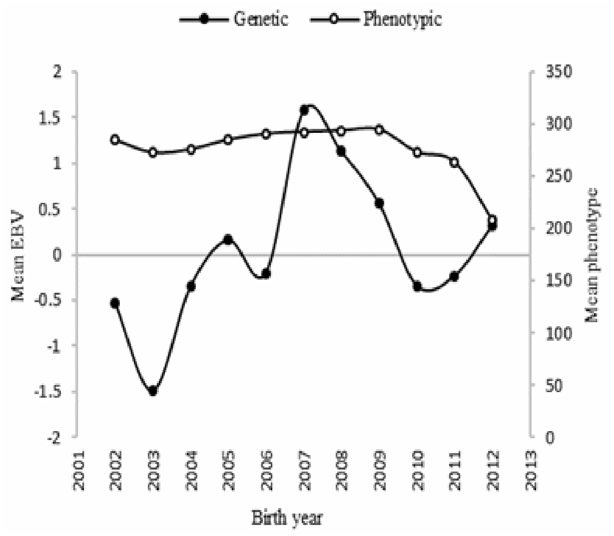

Figure 3 Genetic and phenotypic trend of protein yield (kg)

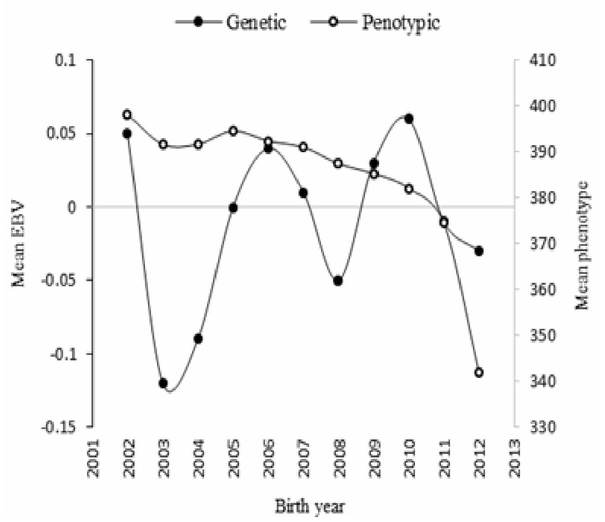

Figure 4 Genetic and phenotypic trend of calving interval (day)

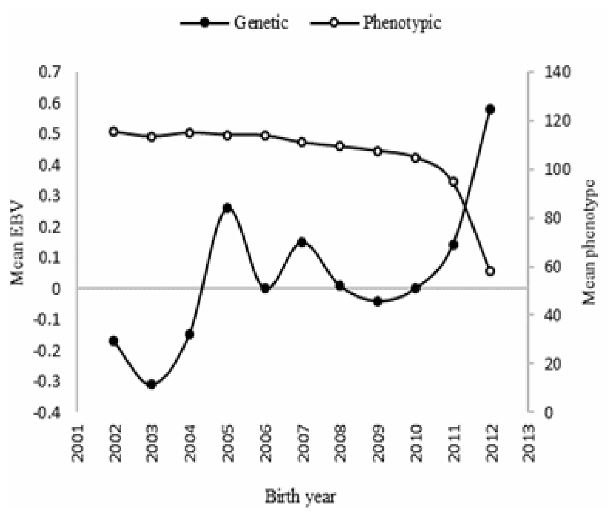

Figure 5 Genetic and phenotypic trend of days open (day)

Genetic trends for DO and CI for Iranian Holstein cattle were -0.002 and - 0.04, and phonotypic trends were 0.006 and -0.04, respectively. Ansari-Lari *et al*. (2009) reported a decrease in DO from 435 days in 2000 to 389 days in 2005 in Iranian Holstein cattle in Fars province. Also, Deljoo Isaloo *et al*. (2012) reported a negative trend for these traits in Iranian Holstein cattle.

CONCLUSION

In general, results of this investigation show that genetic improvement for production traits was at an acceptable level in Holstein cattle of Iran. However breeding programs to increase genetic merit of milk volume were more effective than milk components. Also indicated that phenotypic trends of reproduction traits are improving in Iranian Holstein dairy cattle. Specific causes of such improve in reproductive performance are not clear, but could be due to improvements in nutrition and reproductive management. Low heritability and repeatability in some productive (fat and protein) and reproductive traits have been deprived of improve in the phenotypic trends during some periods which may be partly attributed to responses to direct and indirect genetic selection. Also, genetic selection may not always yield substantial additive gains. However, because of economic importance of productive and reproductive traits an attempt should always be made to keep these traits at their optimum.

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