The Journal of Animal & Plant Sciences, 25(6): 2015, Page: 1527-1531
ISSN: 1018-7081

GENETIC EVALUATION OF LACTATION PERSISTENCY AND MILK YIELD IN IRANIAN HOLSTEIN DAIRY CATTLE USING RANDOM REGRESSION MODELS

F. Bankizadeh[1], N. Emam-Jomee Kashan[2], S. Eghbalsaied[1] and R. Safari[3]

[1]Department of Animal Science, Khorasgan Branch, Islamic Azad University, Isfahan, Iran.
[2]-Department of Animal Science, Paradise of Aburaihan, University of Tehran, Tehran, Iran.
[3]Animal and Poultry Nutrition in Etka Company
Corresponding author email address: bankizadeh_f@yahoo.com

ABSTRACT

In the present study, 44,440 test day milk yield records, for first lactation of Iranian Holstein cattle, collected between 1983 and 2010 were used to genetic analysis of the lactation persistency of Iranian Holstein cattle with Legendre Polynomials based Random Regression Models. For analysis, animals with 10 test day records were considered and their breeding values for different measures of persistency and 305-days milk yield (305MY) were estimated by Random Regression analysis. Spearman correlations between breeding values of different persistency measures and 305MY were estimated. The correlations between estimated breeding values for different measures of lactation persistency ranged between 0.32 to 0.99. In addition, the correlation between different persistency measures and 305MY varied from 0.35 to 0.99. In general, results showed that because of positive correlations between some measures of persistency with each other as well as with 305MY, these traits could be used to improve lactation persistency and milk production of Iranian Holstein dairy cows

Keywords: persistency, milk yield, Spearman correlation, dairy cow, Random Regression Model.

INTRODUCTION

Lactation and fertility performance have a significant effect on productivity of dairy cows (Eghbalsaied, 2011). The milk production during lactation period, which defines the lactation curve, can be divided in three phases: the first is ascending which occurs between calving and peak of lactation; the second is relatively constant which occurs around peak of lactation; and the third, is descending, which occurs between the peak of lactation until the end of the lactation period. The last phase is used to describe the persistency of lactation. Persistency of lactation is a trait of great importance as it reflects the ability of an animal to maintain milk production at a high level after the peak of lactation until the end of lactation period (Jonas *et al*., 2011, Jamrozik *et al*., 2007). It can be defined as the difference in milk yield between peak and a defined day later in lactation (Weller *et al*., 2006). In addition to genetics, environmental factors such as the age of production, year and season and those whose effects cannot be calculated such as climate, disease and pasture, conditions can also influence cattle's productivity. High production can be reached by increasing the genetic potential of animals and improving the environmental conditions (Cakilli, 2011).

It has been reported that cows with improved persistency of lactation require less feed and have lower health care and reproductive costs due to reduced stress at peak of lactation (Dekkers *et al.,* 1996). In addition, it is documented that increased lactation persistency is associated with lower incidences of metabolic diseases (Appuhamy *et al.,* 2007; Cole *et al*., 2006). The persistency of lactation is affected by genetics and environmental factors such as herd management, lactation number, open days, feeding, gestation and age of calving (Atashi *et al*., 2006). In a study by Atashi *et al.* (2012), the effects of twinning and stillbirth on the lactation curve was studied in Iranian Holstein cows during the first lactation. The results showed that persistency of lactation were higher for twin birth than single birth calving (Atashi *et al.,* 2012).

So far, many approaches have been proposed to model persistency of lactation, including the Wood function (Wood, 1967) which is used for genetic evaluation with different mathematical forms of the function. Recently, Random Regression Models (RRM) have been proposed to genetic analysis of the test day milk records as well as the lactation curve in dairy cows (Kirkpatrick *et al.,* 1989). Application of RRM improves the accuracy of genetic evaluation of lactation curve and can be used in all the mammal species with different lactation curves (Jamrozik *et al.,* 1997). The accuracy of genetic parameters estimated by RRM depends on the regression functions used and on the covariance structure for additive genetic, permanent environmental and residual effects (Bignardi *et al.*, 2011).

The RR models use a fixed regression to describe the average shape of a lactation curve, and a random regression for each animal to account for deviations from the fixed regression. This allows the repeated records collected on an animal to be directly incorporated into genetic evaluations and, since an animal model is fitted, results in the predicted lactation curve being heritable (Takma and Akbas, 2009). However, for preferably analyzing the lactation curve, RRM requires a large number of lactations test day records (Jonas *et al.,* 2011). The RRM has some advantages over traditional multi-trait animal models such as ability to predict lactation yield at any stage of lactation and using incomplete lactations which increases the number of records per animal in genetic evaluation.

So far, a few researches regarding genetic analysis of lactation curve have been conducted in Iranian Holstein dairy cows. Therefore, this study was conducted to genetic analysis of five different measures of persistency of lactation in Iranian Holstein cows. In addition, estimating correlation between breeding values of persistency measures with each other and with 305-days milk yield was the secondary objective.

MATERIALS AND METHODS

According to Jamrozik *et al.* (1997) and Jakobsen *et al.* (2002) lactation persistency was defined with five different measures as follow:

The PS1, PS2 and PS4 measures were estimated based on the estimated breeding values (EBVs) for milk yield on two test-days during the lactation.

$$PS_1 = (EBV_{280}/EBV_{65}) \qquad PS_3 = (\sum_{t=206}^{305} EBV_t - \sum_{t=6}^{105} EBV_t)$$

$$PS_2 = (EBV_{280} - EBV_{60}) \qquad PS_4 = (EBV_{290} - EBV_{90})$$

$$PS_5 = \sum_{61}^{280} (EBV_t - EBV_{60})$$

PS_3 and PS_5 were calculated using EBV for milk yield during different lactation periods.

The RRM parameters were standardized to the following fixed effect: first lactation, monthly test day milk records, twice milking/day and seasons for milk yield. The factors which were used for standardization differed across the lactation traits, as each factor didn't have a significant effect on all traits. In the framework of RRM, the following model was used for analyzing the data (Cobuci *et al.,* 2007):

$$Y_{ijkl} = HTD + \sum_{n=1}^{3} b_{km} z_{jlm} + \sum_{n=1}^{3} a_{jm} z_{jlm} + \sum_{n=1}^{3} p_{jm} z_{jlm} + e_{ijkl}$$

where Y_{ijkl} is the l_{th} test day record of j_{th} cow recorded on the t_{th} days in milk of the first lactation for cow belonging to the k_{th} subclass of age-season of calving; *HTD* is the fixed effect of herd-year-month of the test; b_{km} is the fixed regression coefficient of test-day milk yield as a function; a_{jm} and p_{jm} are random regression coefficients that describe the genetic and permanent environmental effects on each animal, respectively, e_{ijkl} is the random residual effect associated with Y_{ijkl}; Z_{1-3} is the Legendre Polynomials (Gengler *et al.,* 1999):

$$z_1 = 1; z_2 = \sqrt{3}x; z_3 = \sqrt{5/4}\left(3x^2 - 1\right)$$

where x = -1+ 2×DIM, and are standardized between -1 and +1. It was assumed that:

$$\begin{pmatrix} a \\ p \\ e \end{pmatrix} \sim N(0,V) with, V = \begin{pmatrix} G \otimes A & 0 & 0 \\ 0 & P \otimes A & 0 \\ 0 & 0 & R \end{pmatrix}$$

G is considered as the genetic covariance matrix of the random regression coefficients assumed to be the same for all cows; **A** is considered as the additive genetic relationship matrix among all animals; $\otimes$ is the Kronecker product operator; P is the permanent environment covariance matrix of the random regression coefficients assumed to be the same for all cows; residual covariance matrix was equal to R = I σ_e^2 in which I is an identity matrix, and σ_e^2 the residual variance was assumed to be constant throughout the lactation. Breeding values for 305MY for each animal is received by the sum of the EBV of each t_{th} DIM (Cobuci *et al.,* 2007):

$$EBV_{305\,MY} = \sum_{t=6}^{305} EBV_t$$

All the analyses were done with the DXMRR software of Meyer (1998).

RESULTS AND DISCUSSION

A model for analyzing test day records including both fixed and random coefficients was applied for the genetic evaluation of first lactation data of Iranian Holstein dairy cows. Means, standard deviations (SD) and range of the EBV for each persistency measure and 305MY is given in Table 2. The maximum and minimum mean were observed for PS5 (8.36) and PS2 (0.06). The average EBV for milk yield was 103.66 with maximum and minimum of, respectively, 3941 and -2696. Standard deviations varied among different measures of persistency. The estimated standard deviations of EBV were lower for the PS2 and PS3 compared with other measures. Higher values of SD shows higher variation among animals and that a higher percent of EBVs are far from the mean.

The EBVs for the 305MY of the top ten cows and their corresponding EBV for each measure of persistency of lactation are given in Table 3. There are differences in the ranking of cows, regarding different persistency measures and milk yield. The top five cows for 305MY ranked 4, 5, 7, 3, and 10 for PS_1, while their ranking was 1, 2, 3, 4, and 6 for PS_2. The spearman correlation between 305MY and PS_2 was very high. But, the correlation between 305MY and PS_1 was low. The low correlation between PS1 and 305MY showed that this measure is not a suitable criterion for selection to improve both lactation persistency and milk yield.

The estimated correlation between persistency of lactation and 305MY differed among persistency measures (Table 4). Correlations between EBVs of different measures of lactation persistency ranged from 0.32 to 0.99. Genetic correlation between persistency and milk yield significantly depends on the lactation order and the measures of used persistency (Cobuci and Costa, 2012). The correlation between cow EBVs for PS3 and PS4 was very high (0.99). The high correlation between persistency measures showed that selection based on these measures of persistency would result in higher lactation persistency and higher 305MY (Moradi Shahrbabak, 1997). The same trend was observed for correlation between PS_3 and PS_4 (0.99) and PS_2 and PS_4 (0.98). The correlation between PS_1 and PS_5 was low (0.32). Reported estimates of correlations between EBVs of different measures of persistency of lactation are larger than 0.90 for both sires and cows which show that different measures of persistency provide similar ranking of animals (Cobuci *et al.,* 2007).

The correlations between measures of persistency and 305MY had a range between 0.35 to 0.99 (Table 4), with the lowest correlation observed between PS1 and 305MY (0.35). Jacobsen *et al.* (2002) studied five different measures of persistency using RRM and showed that the estimated genetic correlation between persistency of lactation measures and 305MY ranged from 0.00 to 0.47. In addition, Jamrozik *et al.* (1997) estimated genetic correlations between persistency measures and 305MY of 0.1 to 0.55. Their estimates were lower than current findings. Togashi *et al*. (2004) reported that selection on breeding values at 280 days improves both lactation persistency and milk yield.

The correlation between 305MY and PS_2, PS_3, and PS_4 were considerably high (0.97-0.99), while the observed correlation between 305MY and PS5 was relatively low (0.52) which was in agreement with Cobuci *et al*. (2007). Thus, selection on PS_2, PS_3, and PS_4 is expected to provide similar results. The correlations between 305MY and PS_2, PS_3 and PS_4 reported by Cobuci *et al.* (2007) were 0.5, 0.59 and 0.46, respectively, which were lower than our estimates. Kheirabadi and Alijani (2014) studied six persistency measures in Iranian Holstein dairy cows using RRM and reported estimates of genetic correlation with 305MY from -0.33 to 0.55. Also, they reported the correlation between 305MY and PS_5 as 0.52 which was similar to current result (0.52). However correlation between 305MY and PS_4 measure was 0.41 which was lower than our result (0.94). Also Cobuci *et al*. (2004) showed a weak genetic correlation between PS_4 and 305MY (0.31) which indicate that, cows with the same milk production may present different levels of lactation persistency. According to our results, selection of animals that show higher levels of lactation persistency can result in positive correlated response in 305MY.

In conclusion, our results showed a relatively weak association between 305MY with PS_1 and PS_5, while the correlations with PS_2, PS_3 and PS_4 with 305MY were strongly positive. So, these traits could be used to improve lactation persistency and milk production of Iranian Holstein dairy cows. Further, studies are needed to use other methods for modeling the lactation curve of dairy cows and to know best method for genetic evaluation of dairy cows concerning lactation curves.

Table 1. Summary of the data and pedigree file used for genetic analysis.

No. of Animals with record	4344
No. of Animals in pedigree	12827
No. of Sire	1041
No. of Dam	8039
No. of Herd	81
No. of Herd- year-test day classes	1127

Table 2.The mean persistency of lactation, milk yield for a population of Holstein.

Trait	Mean	SD	Maximum	Minimum
PS_1	1.94	5.80	168.30	-123
PS_2	0.06	0.95	5.60	-4.302
PS_3	0.149	1.04	5.67	-4.295
PS_4	0.86	5.34	30.22	-21.53
PS_5	8.36	619.40	99.12	-53.60
305MY	103.66	13.57	3941	-2696

SD, standard deviation; PS1- PS5, Measures of persistency lactation; 305MY. 305-day milk yield

Table3. Estimated breeding values for PS1 and PS2 measures and 305 milk yield.

Cow	PS_1	Rank	PS_2	Rank	305MY	Rank
1	1.502	4	5.003	1	1656.67	1
2	1.495	5	3.752	2	1500.50	2
3	1.447	7	3.556	3	1316.16	3
4	1.550	3	3.338	4	1245.46	4
5	1.333	10	2.833	6	1196.93	5
6	1.399	8	1.418	10	1181.93	6
7	1.572	1	1.962	8	1131.63	7
8	1.564	2	3.056	5	1126.11	8
9	1.452	6	1.918	3	1099.34	9
10	1.373	9	2.147	7	1088.08	10

Table 4. Rank correlation of estimated breeding values for different lactation persistency and milk yield

Trait	PS_1	PS_2	PS_3	PS_4	PS_5	t305MY
PS_1	1	0.33	0.34	0.35	0.32	0.35
PS_2		1	0.99	0.981	0.40	0.97
PS_3			1	0.99	0.44	0.98
PS_4				1	0.48	0.99
PS_5					1	0.52
305MY						1

PS_1- PS_5, Measures of persistency lactation 305MY, 305-day milk yield

Acknowledgements: Thanks goes to Aburaihan Paradise, University of Tehran, for the complete support of this research and providing farms to survey regularly, as per objective of this research are concerned.

REFERENCES

Atashi, H., M. Moradi Shahrbabak and A. AbdolMohamadi (2006). Study of some suggested measures of milk yield persistency and their relationship. J. Agri. Biol 8(3): 387-390.

Atashi H., M.J. Zamiri, M.B. Sayyadnejad (2012). Effect of twinning and stillbirth on the shape of lactation curve in Holstein dairy cows of Iran. Arch Tierz 55: 226-233.

Appuhamy J., B.G. Cassell, C.D. Dechow and J.B. Cole (2007). Phenotypic relationships of common health disorders in dairy cows to lactation persistency estimated from daily milk weights. J Dairy Sci., 90:4424-4434.

Bignardi A.B., L.E.l. Faro, R.A.A. Torres Júnior, V.L. Cardoso, P.F .Machado and L.G. Albuquerque (2011). Random regression models using different functions to model test-day milk yield of Brazilian Holstein cows. Genet. Mol. Res 10(4): 3565-3575.

Cakilli F. (2011). Some factors affecting on persistency of lactation milk yield in Brown Swiss cattle. PhD thesis, University of Istanbul Faculty of Veterinary Medicine, Department of Animal Breeding and Husbandry.

Cobuci J.A. and C.N. Costa (2012). Persistency of lactation using random regression models and different fixed regression modeling approaches. R. Bras. Zootec.41(9):1996-2004.

Cobuci J.A., R.F. Euclydes, C.N. Costa, P.S. Lopes, R.A. Torres and C.S. Perreira (2004). [Análises da persistêncianalactação de vacas da raçaHolandesa, usandoprodução no dia do controle e modelo de regressãoaleatória]. Brazilian J Animal Sci 33:546-554.

Cobuci J.A., R.F. Euclydes, CN. Costa, R.D.A. Torres, P.S. Lopes and C.S. Pereira (2007). Genetic evaluation for persistency of lactation in Holstein cows using a random regression model. Genetic and Biology 30(2): 349- 355

Cole J.B. and P.M. VanRaden (2006). Genetic evaluation and best prediction of lactation persistency. J Dairy Sci 89:2722-2728.

Dekkers J.C.M., J. Jamrozik, J.H. Hag, L.R. Schaeffer and A. Wewrsink (1996). Genetic and economic evaluation of persistency in dairy cattle. Interbull Bulletin 12:97-102.

Eghbalsaied S. (2011). Estimation of genetic parameters for 13 female fertility indices in Holstein dairy cows. Trop Anim Health Prod 43:811–816.

Jonas E., P.C. Thomson, E.J.S. Hall, D. McGill, M.K. Lam and H.W. Raadsma (2011). Mapping quantitative trait loci (QTL) in sheep. IV.

Analysis of lactation persistency and extended lactation traits in sheep. J Genetics Selection Evolution 43:22.

Gengler N., A. Tijani, G.R. Wiggans and I. Misztal (1999). Estimation of (co) Variance Function Coefficients for Test Day Yields With Expectation-Maximization Restricted Maximum Likelihood Algorithm. Online. Available: http:// 12.24.208.139/manuscripts/843e/.

Kheirabadi K. and S. Alijani (2014). Genetic parameters for milk production and persistency in the Iranian Holstein population by the multitrait random regression model. JArchiv Tierzucht 57: 12, 1-12.

Jakobsen J. H., P. Madsen, J. Jensen, J. Pedersen, L.G. Christensen and D.A. Sorensen (2002). Genetic parameters for milk production and persistency for Danish Holstein estimated in random regression models using REML. J. Dairy Sci. 85: 1607- 1616.

Jamrozik J., J. Fatehi and L.R. Schaeffer (2007). Application of robust procedures for estimation of breeding values in multiple-trait random regression testday model. J Anim Breed Genet 124:3-11.

Jamrozik J., L.R. Schaeffer and J.C.M. Dekkers (1997). Genetic evaluation of dairy cattle using test day yields and random regression model. J Dairy Sci 80:1217-1226.

Kirkpatrick. M and N**.** Heckman. (1989). A quantitative genetic model for growth, shape, and other infinite-dimensional characters. J. Math. Biol. 27: 429-450.

Meyer K. (1998). “DXMRR” – a program to estimate covariance functions for longitudinal data by restricted maximum likelihood, in: Proc. 6th World Conger. Genet. Appl. Livest. Proc., Armidale, NSW, Australia. 27: 465-466

Moradi Shahrbabak M. (1997). Studies of Random Regression Test Day Model and Persistency For Iranian Holstein Production Traits. PhD Thesis, University of Guelph, Guelph, ON, Canada.

Takma C. and Y. Akbas (2009). Variance components and genetic parameter estimates using random regression models on test day milk yields of Holstein Friesians. Kafkas Univ. Vet. Fak. Derg., 15(4): 547–551.

Togashi K and C.Y. Lin (2004). Efficiency of different selection criteria for persistency and lactation milk yield. J. Dairy Sci. 87: 1528- 1535.

Wood P.D.P. (1967). Algebraic model of the lactation curve in cattle. Nature 216:164-165.

Weller J.I., E. Ezra and G. Leitner (2006). Genetic analysis of persistency in the Israeli Holstein population by the multitrait animal model. J Dairy Sci 89:2738-2746.