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Correlation of Breeding Value, Milk Production and Lactation Persistency Traits During Complete and Incomplete Lactation Using Random Regression Model

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Abstract: In this investigation, 29800 data related to test day of milk production from 2716 Holstein first calving and daughter from 167 sire cows were analyzed based of random regression model (RR/CF) and REML (Restricted Maximum Likelihood). Method incomplete lactating 5-90 and 5-120 days in correlations to complete lactating were 0.67 and 0.72, respectively. With lactation progress, the correlation was increased. The correlation during incomplete lactation period 5-240 days was 0.91. The correlation value for lactating persistency trait for incomplete lactating period 5-150 days were 0.68. By milk production increasement during incomplete production period of 5-240 days this value reached to 0.91. Also, this correlation for 2 month interval (3 month recording) for milk production and lactating persistency was 0.88 and 0.59, respectively. This correlation for milk production and lactating persistency in 1 month interval (2 month recording) was reached to higher than 0.90.

Key words: Milk production and persistency, random regression model, test day records

INTRODUCTION

In recent years, numerous studies have investigated the topic of genetic evaluation of dairy cattle using test-day (TD) models. Advantages of the TD model over an approach using 305 days lactation yields are now widely acknowledged. Use of a test-day model may alleviate some of the problems seen in models for 305 days lactation yields. In a test-day model, extension procedures are not needed and temporal environmental effects of individual test days can be taken into account (Swalve, 2000; Zumbach *et al*., 2008; Sawalha *et al*., 2005).

In random regression models, curves are estimated for random effects. In the earliest random regression test-day models, only the additive genetic effect was modeled with random regression and the permanent environmental effect was modeled as in a repeatability model. However, this model gave unrealistic genetic variances especially in the ends of the lactation (Schaeffer *et al*., 2000; Reents *et al*., 1995; Veerkamp and Thompson, 1999).

Indeed this model can be applied for analysis of the repeated data about trait which gradually changed during the time. In case of using this models, there is no need to use the constant value for variance and correlation. In test day model, the genetically evaluation are increased due to higher data for each animal. Comparison the results from 305 days and test day models showed that test-day model related to 305 days lactation model in evaluated genetic animals due to the low error variety and possibility of permanent environment effect this test high accuracy (Degroot *et al*., 2005, 2007).

Genetically evaluation with test day models led to identification of sir and dam dairy cattle with low breeding value and also these animals are eliminated from 305 days evaluation, finally this method reduces the costs in progeny tests program in comparison to classic models (305 days) results from an investigation with test day model indicated that the breeding value of sirs can be predicted by daughters with having former lactation period data (Pool *et al*., 2000; Szyda *et al*., 2008).

Persistency of lactation yield is an important element of total yield and is advantageous because of better use of feed and reduction of stress due to high peak yield (Gengler *et al*., 2005). Dairy cows with the same peak yield can differ in total yield because of differences in persistency. A typical lactation curve can be described as increasing from initial yield at calving to maximum or peak yield, maintaining peak yield and decreasing from peak yield to the end of lactation (Van Der Werf *et al*., 1998; Szyda, 2001).

Aim of this study was to determine the correlation between breeding value of milk production and persistency traits in incomplete and complete lactation periods. Reduction of generation interval and earlier selection of sirs by incomplete data instead of complete data was applied.

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MATERIALS AND METHODS

In this research, the number of 69724 test-day belong to a herd that collected by Iran breeding genetic center were used from 2002 through 2005 calved at the age of 18-36 months. Each cow was required to have at least 4 test-day yields per lactation. Days in milk (DIM) were limited to those between 5 and 305, therefore, after the edits, first-lactation test-day records remained, 29800 records from test-day milk production which obtained first calving of 2716 Holstein cows. The data structure is shown in Table 1.

These animals are daughter relationship with 167 sir, which were used for data and pedigree files. In this study, calving age, accounted from difference between birthday data and calving data and test day obtained from difference calving date and recording date. Data file obtained from incomplete periods 5-30, 5-60, 5-120, 5-150, 5-180, 5-210 and 5-270 days and also incomplete lactation period with 1 and 2 interval recording in addition complete lactation period 5-305 days were used for analysis the breeding value of incomplete and complete lactation period.

The model used was based on animal model for analysis of data as follow as:

$$Y_{ijklp} = M_i + TD_j + S_k + K_L + \sum_{n=1}^{2} b_n (age_{ijklp})^n + \sum_{n=0}^{K} ß_n \phi_n (dim^*_{ijklp}) + \sum_{n=0}^{ka-1} \alpha_{pn} \phi_n (dim^*_{ijklp}) + \sum_{n=0}^{kp-1} Y_{pn} \phi_n (dim^*_{ijklp}) + \varepsilon_{ijklp}$$

where,

y_{ijklp}	=	Milk production test day data.
m_i	=	Fixed effect of is subgroup of time number of milk flow rate per day.
TD_J	=	Fixed effect of jth recording data.
S_K	=	Fixed effect of kth calving season.
K_l	=	Fixed effect of kth calving year.
b_n	=	nth regression coefficient for calving effect.
Age_{ijklp}	=	Calving age effect (covariate).
dim^*_{ijklp}	=	Standard lactation day (range of values from -1 to +1).
β_n	=	n fixed regression coefficient.
α_{pn}	=	nth random regression coefficient additive genetic related to pth cows.
Y_{pn}	=	nth random regression coefficient environment permanent to pth cows.
K	=	Fit degree of fixed regression.
K_a, k_p	=	Fit degrees of covariance function of additive genetic and environment permanent.

Table 1: The general descriptive data structure for analysis

Item	Recorded value
Number of cows	2716
Number of herds	110
Number of test-day records	29800
Average test-day yield (kg)±S.E.	12.18±2.24
Average age at calving (mo)±S.E.	34.00±4.52

For calculation based on random regression model DXMRR program exist on DFREML software were used and all calculation were carried out based on average information algoritm (AI-REML). Days in milk were standarded with respect to:

$$dim_m = -1 + 2(\frac{dim_i - dim_{min}}{dim_{max} - dim_{min}}) \text{ was calculated as} \quad (1)$$

where,

dim_{min} and dim_{max} : The minimum and maximum DIM (5 and 305, respectively).

Breeding value i_m of animal at n_m day of lactating was determined:

$$U_m = \sum_{j=0}^{ka-1} \phi_j (X^*_m) a_{ij} \quad (2)$$

as: X^*_m, J_m polynomial legendre estimated at standarded time $\phi_j(X^*_m)$, where, a_{ij} j_m : Regression coefficient of additive genetic related to i_m animal (Jamrozik and Schaeffer, 1997).

Hence, with uses of legender polynomial estimated breeding value in all of lactation period for milk production and persistency are affected by regression coefficient of a_0, a_1, respectively and these coefficient for each animal are determined by DXMRR program of DFREML software (Jamrozik *et al*., 2002).

For instance breeding value correlation in incomplelet and compelet lactation period were estimated as:

$$r_{xy} = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{[\sum x^2 - \frac{(\sum x)^2}{n}][\sum y^2 - \frac{(\sum y)^2}{n}]}} = \frac{s\rho_{xy}}{\sqrt{SS_x SS_y}} \quad (3)$$

With respect to a_0 and a_1 where,

Σx : Total of random regression coefficient for milk production (a_0) or lactation persistency (a_1) incomplete lactation period.

Σy : Total of random regression coefficient for milk production (a_0) or lactation persistency (a_1) complete lactation period.

RESULTS AND DISCUSSION

Selection for milk production can be carried out based on part of lactation period. The use of incomplete lactation period in daughters to evaluate sperm generative sirs causes reduction in errors due to elimination of daughter prior to 305 days production. The event led to open-day reduction (Strabel and Misztal, 1999). The use of test day data instead of 305 days, possibility for extending data recording intervals is exist, which led to data-recording costs. In spite of low frequency in data recording for example 2 month interval with probability of increase in predicted error, this method is more favorable. The accuracy of data by test day models has been reported by other investigation.

In this study, breeding value for i_m animal in m lactation day were estimated by follow Eq. (4) which the extended version of Eq. (3):

$$(3=K_a)\,U_m=0.701a^{\wedge}0_i+1.2247\,dim^{*}_{m}\,a^{\wedge}1_i+(2.3717\,dim^{*2}_{m}-0.7906)\,a^{\wedge}2_i \qquad (4)$$

where,

a_0, a_1, a_2 : Estimated random regression of additive genetic for i_m animal.

With respect to influences of a_0, a_1 regression coefficient on breeding value for milk production and persistency by legendre polynomials applying, therefore, correlation between incomplete and complete lactation based on these coefficients. Breeding value correlation rate for milk production trait between lactation period (5-30 days) and (5-270 days) in comparison to complete lactation period 305 days for all sir cows and daughters were ranged from 0.37-0.79 and 0.38-0.87, respectively, also this value for milk production persistency between lactation period (5-30 days) and (5-270 days) in comparison to complete lactation period 305 day for all sir cows and daughters were ranged from 0.21-0.76 and 0.18-0.84, respectively.

In all cows the breeding value correlation for incomplete lactation period 5-90 days in comparison to complete lactation period (305 days) reached upper than 0.6 and this correlation for incomplete lactation period 5-120 days was higher than 0.7. By increasing during lactation period, this value has been improved and in incomplete lactation period 5-240 days was equal to 0.8. In respect to lactation period persistency the correlation value higher than 0.6 was obtained at incomplete lactation period 5-150 days. As increase in lactation period this value has been increased reached higher than 0.8 in complete lactation period 5-240.

Breeding value for estimated milk production and persistency traits incomplete and complete lactation period for all cow sirs and daughter sirs in evaluated herds are showed in Table 2.

Table 2: Breeding value correlation for milk production and persistency traits in between incomplete and complete lactation period for all sire cows and daughter sir cow in evaluated herds

Complete and incomplete lactation period	The correlation of breeding value milk production and lactation persistency traits r_1	r_2	r_3	r_4
5-30	0.37	0.38	0.21	0.18
5-60	0.65	0.56	0.015	0.048
5-90	0.71	0.67	0.3	0.26
5-120	0.73	0.72	0.49	0.39
5-150	0.75	0.68	0.65	0.68
5-180	0.81	0.79	0.73	0.79
5-210	0.84	0.85	0.78	0.81
5-240	0.85	0.91	0.83	0.91
5-270	0.79	0.87	0.76	0.84
1 month interval	0.87	0.88	0.63	0.59
2 month interval	0.95	0.94	0.90	0.92

Persistency traits in between incomplete and complete lactation period for all sire cows and daughter sir cow in evaluated herds. r_1: Breeding value correlation for predicated milk production trait from incomplete (305 days) and complete lactation periods for all of evaluated sirs in herd; r_2 Breeding value correlation for predicated milk production trait from incomplete (305 days) and complete lactation periods for all of daughters in herd; r_3: Breeding value correlation for predicated persistency milk trait from incomplete; (305 days) and complete lactation periods for all of evaluated sirs in herd; r_4: Breeding value correlation for predicated persistency milk trait from incomplete (305 days) and complete lactation periods for all of daughters in herd

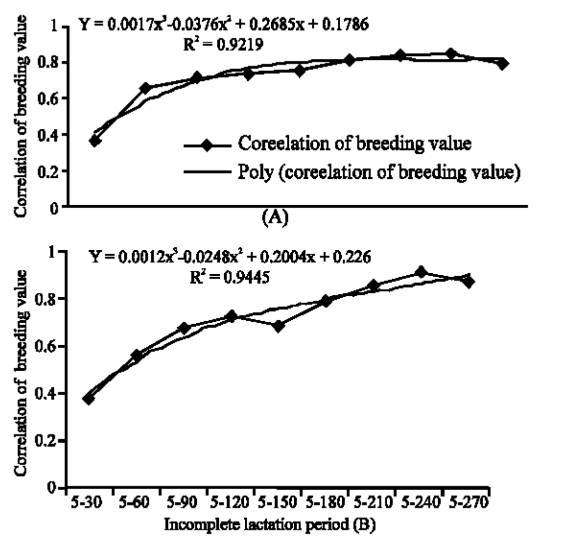

Fig. 1: Breeding value correlation for milk production between incomplete and complete lactation period for all of sirs (A) and for all of daughter sirs (B) in herd by random regression model

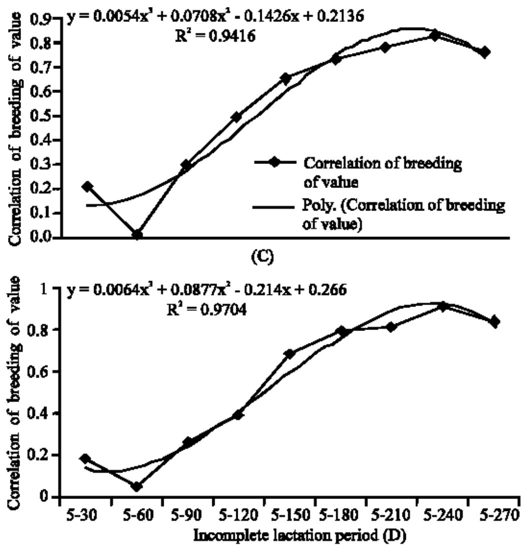

Fig. 2: Breeding value correlation for persistency milk between incomplete and complete lactation period for all sirs (C) and for all of daughter sirs (D) in herd by random regression model

Therefore, selection for milk production and persistency can be done base on part of lactation period due to higher correlation for breeding value between incomplete and complete lactation periods. This correlation for milk production and persistency during 2 months interval recording were higher than 0.8 and 0.6, respectively.

In one month interval recording for milk production and persistency traits was higher than 0.9. with respect to higher correlation for 1 and 2 month interval data for milk production and higher correlation for milk production persistency in 1 month data in comparison to complete lactation period.

Breeding value correlation for milk production and persistency about incomplete lactation period (lower than 305 days) and complete lactation period with correlation variation equation and coefficient of determination can be seen in Fig. 1-2.

CONCLUSION

The results of this study demonstrated that production in recording times or extending interval time between recordings led to reduction in recording cost with out pronounced reduction in accuracy of estimation. Therefore, selection for milk production and persistency can be done base on part of lactation period due to higher correlation for breeding value between incomplete and complete lactation periods.

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