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Evaluation of test day daily milk yield and persistency of different milking times in primiparous Holstein dairy cows in Iran

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ABSTRACT

Monthly test day records (morning, noon and night milk; 470,829) from 49,675 Iranian Holstein over 603 herds were used to study the characteristics of genetic parameters of milk yield at different milking times and evaluation of persistency in different milking times. According to the results, residual variance is high at the begining of lactation (4.70 kg) and gradually decreases till the end of lactation in different milking times. Also the additive genetic variance increases till the end of lactation (especially morning milk and estimates are lower at the beginning of lactation (0.35 kg). Permanent environmental variance shows moderate increase, with peak value at the end of lactation. The trends of heritability at different milking times are similar but the morning milk has higher heritability during 260 to 290 days. Peak time of milk yield for morning time was 79 days but for noon and night milking curves was at 62 and 90 DIM. Genetic correlations of different milking times between test days as well as permanent environmental correlation of higher value (close to unity) in adjacent period but decreased with increasing period among test day yield. Morning milk yield was higher compared to noon and night milk but night milk curve showed better persistency.

Key words: Different milking times, Genetic parameters, Heritability, Persistency

Milk yield has a great economical impact on dairy cattle industry and on the level of income on small and large farms. The milk recording system is the basis for genetic evaluation and taking management decisions in farm animals. Different milk recording systems were proposed: the A4 method (monthly records of 2 daily milking) have been approved by ICAR as a reference since 1951 (Cattin-Vidal 1990); and alternative AT method (alternating morning and evening milking records at subsequent monthly visits) to reduce recording costs (Candek-Potokar *et al.* 2006). Milking frequency can have a significant impact on milk yield in cattle when viewed from the producers' viewpoint. Mostly cows are milked twice daily or three times daily. Hickson *et al.* (2006) showed that cows milked once daily have less production and less persistency (the rate of milk secretion on each day of lactation after peak) of production than cows milked twice daily. Jamrozik *et al.* (1997) reported that cows with the same lactation production and higher persistency could stand more stress. The stress causes negative effect on reproduction in later lactations and cow longevity. Three times milking per day increased milk revenue via increased milk volume (8.6 kg/cow per day), increased solids production, and potentially lower SCC's (Erdman *et al.* 1995). Liu *et al.* (2000) reported higher mean and large variances for milk yield of morning milking than evening milking. They also found that correlation of morning milking with daily record was higher than evening records in the use of AM/ PM records of dairy cattle. This means that daily yield estimated from evening milking is less accurate than morning milking. Evaluation of persistency within and between lactations in AM/ PM and daily test day milk yield in dairy goats of Turkey showed that morning milk was secreted more while evening milk had higher persistency (Akin Pala *et al.* 2005).

The objectives of this were to evaluate genetic parameters of milk yield at different milking times (morning, noon and night) in primiparous Holstein cows using random regression test day model, calculation of correlation between daily milk yield and different milking times and the ratios and consideration of persistency and its characteristics in different milking times using test day records by milk –milk peak time .

MATERIALS AND METHODS

Original data included 638,071 first lactation test day records of Iranian primiparous Holstein cows. The data were

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based on the following criteria: the number of test day per days in milk were 9 and 10 for all animals (almost complete lactation) age at calving for all animals was between 20 and 30 months and the minimum and maximum daily milk yield was from 3 to 75 kg. the final dataset included 470,829 monthly test day milk yield records from 49,675 Holstein cows calved between 2000 to 2010 were analyzed which were related to 2,147 sires from 603 herds. The summary of descriptive statistics of the final data set is presented in Tables 1 and 2.

Table 1. Descriptive statistics of milk in the morning, noon and night in each test day

Records	Morning milk (kg)		Noon milk (kg) (kg)		Night milk (kg)	
	Mean	std	Mean	std	Mean	std
1	9.341	2.567	8.979	2.538	8.914	2.456
2	10.797	2.559	10.393	2.589	10.353	2.480
3	10.922	2.586	10.476	2.591	10.439	2.450
4	10.840	2.573	10.476	2.591	10.439	2.450
5	10.554	2.529	10.089	2.589	10.032	2.446
6	10.295	2.556	9.819	2.593	9.753	2.481
7	10.012	2.575	9.527	2.572	9.473	2.481
8	9.657	2.557	9.178	2.574	9.122	2.459
9	9.174	2.605	8.708	2.592	8.665	2.459
10	9.016	2.573	8.561	2.547	8.535	2.475
Total	10.060	2.568	9.607	2.577	9.558	2.463

Table 2. Overall description of data set.

Milking time	Mean	Std	Cv (%)
Morning	10.112	2.651	24.224
Noon	9.661	2.662	27.560
Night	9.609	2.549	26.535
Daily	29.383	6.901	23.489

The following random regression model was used for analysis of different milking times and daily milk yield of the cows.

$$Y_{ijk} = HTD_i + \sum_{m=1}^{5} \beta_k X_{km} + \sum_{k=1}^{3} \alpha_k (Z_{km}) + \sum_{k=1}^{4} p_k (Z_{km}) + e_{ijk}$$

In which, Yijk, the morning, noon, night and daily milk yield of cow k on day j within the classes of i; HTDi, fixed effect of herd test date; ß, vector of fixed regression coefficients fitted by Ali and Schaffer function; ák and pk are vectors of random regression coefficients for additive genetics and permanent environmental effects on cow k; eijk is random residual effects associated to Yijk. The orders of Legendre polynomial for additive genetic and permanent environmental effects were k=3 and k=4 respectively.

The PEST software was used for coding the original data and then The VCE 6 software package (Kovac *et al.* 2008) was applied for estimation of covariance components and obtaining solutions (random regression coefficients of additive genetic and permanent environmental effects of each animal) based on restricted maximum likelihood (REML) method. Using IML procedure in SAS package (SAS Inc., 2005) the variance components and the other parameters were calculated for covariance matrices of random regression coefficients. The residual variance was heterogeneous in this study because assumption of constant error variance leads to bias in heritability estimates durnin lactation (Misztal *et al.* 2000, Jensen, 2001, Bignardi *et al.* 2008). Finally, persistency in each milking times was defined as the difference in milk yield between days in milk 280 and peak DIM (milk yield at DIM 280 – peak milk yield). Estimation breeding value of 305 days for the morning, noon and night were calculated with the following function

$$\Gamma = (b0 \times plg0) + (b1 \times plg1) + (b2 \times plg2)$$

Γ, estimation breeding value for morning, noon, night and daily milk yield; plg0, plg1 and plg2, Legendre polynomial coefficients which standardized based on unit of time and; b0, b1and b2, coefficients of Legendre polynomials estimated by VCE6 for each animal in different models.

RESULTS AND DISCUSSION

Parameters and variance components obtained in this analysis show great variability and in values and shapes. Additive genetic, permanent environment and residual variances with estimation of heritability during 305 days in different milking times are shown in Fig. 1. The minimum and maximum genetic variances ranged from 0.33 to 0.93, 0.30 to 0.82 and 0.31 to 0.83 for morning, noon and milking times during lactation respectively. The higher genetic variance was shown in the morning milking time especially at the end of lactation. The behavior of genetic variance in different milking times shows that this variance component tends to be lower in the beginning and greater at the end of lactation period. So, the marked decreases of genetic variance of different milking times suggest that the model is less robust to describe the genetic variance of milk yield during the first 55 days of lactation. The fluctuation of permanent environmental effect in different milking times is higher than additive genetic effect. Increasing permanent environmental variance during lactation suggest that permanent environmental factor had the high influence on test day milk yield during 305 d milk production especially at the end of lactation.

The fluctuation of residual variance was high in first lactation (before 60 days) and was gardually decreasing in mid and the end of lactation (Fig. 1). Some studies (Strabel and misztal 1999. Cobuci *et al.* 2005) proposed that the residual variance should be homogenous across days in milk (DIM) due to limitation of program, reducing the number of parameters and dimension of the likelihood but it is better to allow residual variance to vary than to fix it in RRM because

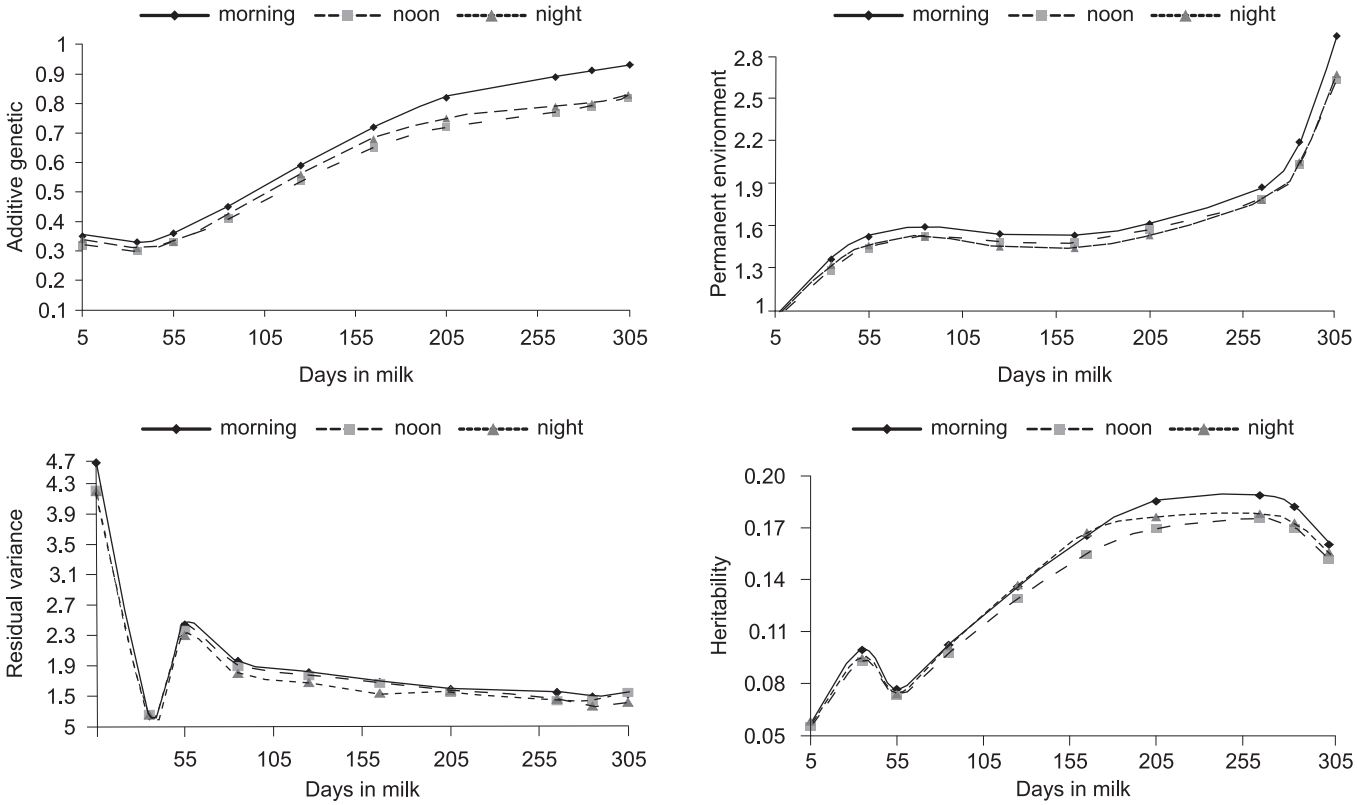

Fig. 1. Additive genetic, permanent environmental, residual variances and heritability of test day milk yield in the morning, noon and night milking times.

assumption of constant error variance leads to bias in heritability estimates (Misztal *et al.* 2000, Jensen, 2001, Bignardi *et al.* 2008). High variability of variance component estimates in this study suggesting that residual should not be assumed constant during lactation. The trend of residual variance among morning, noon and night milking times are almost similar. The daily heritability of different milking times across lactation increases steadily till 35 days then drops till 55 days and after that increases till the end of lactation but a decrease was obtained after 290 days. The relatively low heritability at the end of lactation could be the result of small number of records.

The maximum amount of heritability (0.18) which is related to morning milking times was obtained between 260 to 285 days. It is obvious that heritability estimates of morning, noon and night times are less than other studies which were calculated based on daily milk yield. This indicates that heritability could have been reduced due to lower milk yield and fluctuation of residual during days in milk. The genetic correlation of different milking times is shown in Table 3, 4 and Fig. 2. Additive genetic Correlations among milk yield in the morning, noon and night ranged

Table 3. Genetic correlation (above the diagonal) and permanent environment correlation (below the diagonal) between milk days at day 5, 35, 55, 85, 125, 165, 205, 265, 285 and 305 in morning milking time

DIM	5	35	55	85	125	165	205	265	285	305
5		0.934	0.842	0.698	0.556	0.471	0.428	0.414	0.418	0.424
35	0.990		0.979	0.908	0.814	0.749	0.708	0.667	0.653	0.635
55	0.987	0.999		0.974	0.915	0.865	0.829	0.778	0.75	0.726
85	0.983	0.989	0.994		0.982	0.954	0.926	0.870	0.840	0.800
125	0.949	0.934	0.943	0.973		0.993	0.976	0.925	0.893	0.850
165	0.858	0.812	0.823	0.876	0.962		0.994	0.955	0.927	0.886
205	0.751	0.673	0.680	0.741	0.866	0.966		0.979	0.958	0.925
265	0.679	0.571	0.557	0.587	0.683	0.794	0.893		0.99	0.982
285	0.666	0.560	0.536	0.541	0.595	0.67	0.774	0.972		0.995
305	0.636	0.543	0.510	0.487	0.487	0.519	0.604	0.880	0.967	

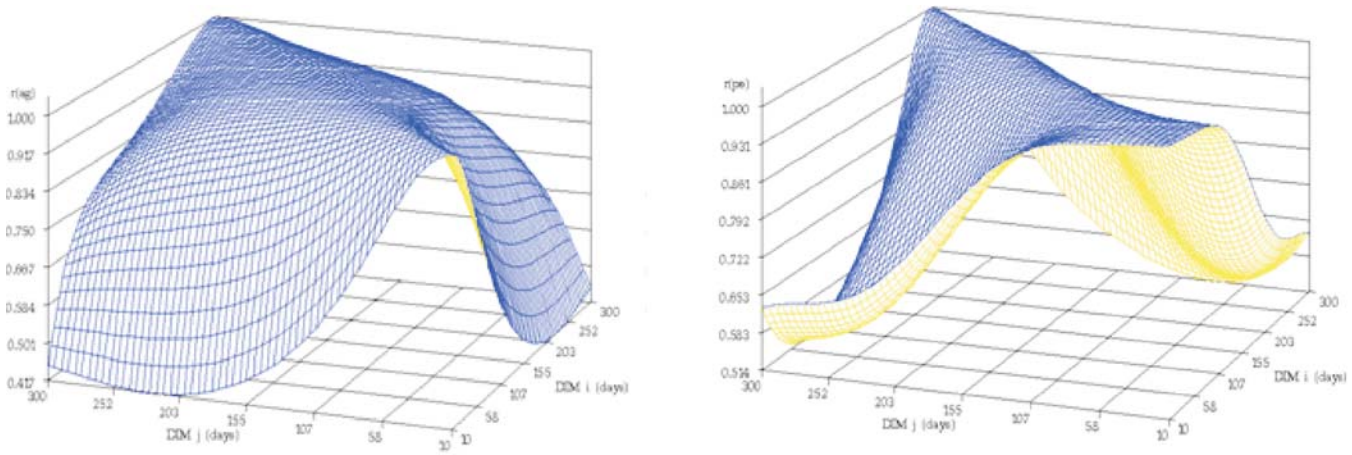

Fig. 2. Additive genetic (left) and permanent environmental (right) correlations at night milking time.

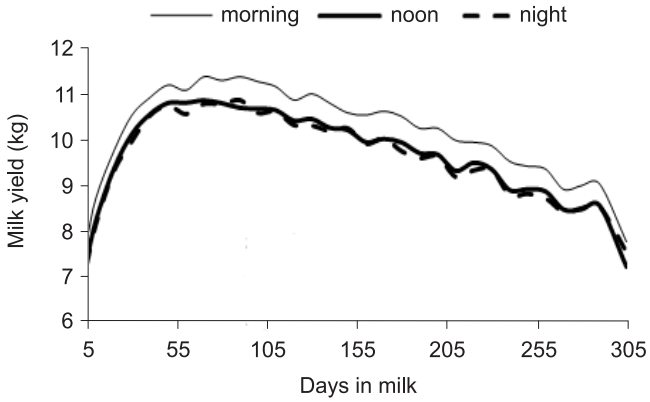

Fig. 3. Lactation curve of cows in the morning, noon and night times.

from 0.414 to 0.995, 0.392 to 0.993 and 0.40 to 0.995 respectively. Genetic correlation among test days is higher when periods are closer to each others. Moreover, the maximum genetic correlation between the first and the end of lactation was observed in the morning milking time. This means that selection for milk yield using morning milk has positive effects on higher morning milk at the end of lactation.

Permanent environmental correlation between different test days followed a similar pattern as the additive genetic correlations. As test days became more apart, the correlation between additive genetic effects decreased much faster than compared to permanent environmental effects in all milking times. The reason is related to high residual variance during lactation. This means that the effect of residual variance during DIM is considerable and it should not assume fixed during lactation.

Phenotypic lactation curve of the primiparous cows in the morning, noon and night is presented in the Fig. 3. Evaluation of milk production in each times show that milk mean of the morning is higher that two other times (10.112 vs. 9.661 and 9.609, Table 2). This result shows that 34.41% of daily milk yields is related to the morning milk time and while this ratio for noon and night milk times are 32.87% and 32.72% respectively.

This means that probably, daily milk yield estimated from noon and nights milking are less accurate than those from morning milking. Evaluation of milk yield using AM-PM recording system by Liu *et al.* (2000) showed that milk

Table 4. Genetic correlation (above the diagonal) and permanent environment correlation (below the diagonal) between milk days at day 5, 35, 55, 85, 125, 165, 205, 265, 285 and 305 in noon milking time

DIM	5	35	55	85	125	165	205	265	285	305
5		0.924	0.818	0.661	0.512	0.429	0.392	0.392	0.40	0.408
35	0.991		0.976	0.897	0.799	0.734	0.693	0.645	0.623	0.594
55	0.987	0.999		0.972	0.910	0.860	0.821	0.753	0.717	0.669
85	0.980	0.987	0.993		0.982	0.953	0.921	0.840	0.792	0.729
125	0.940	0.929	0.941	0.973		0.992	0.972	0.894	0.843	0.775
165	0.843	0.804	0.819	0.875	0.962		0.993	0.931	0.885	0.821
205	0.731	0.663	0.675	0.740	0.867	0.967		0.967	0.932	0.878
265	0.666	0.563	0.554	0.590	0.693	0.806	0.903		0.993	0.971
285	0.663	0.558	0.537	0.549	0.611	0.695	0.792	0.973		0.992
305	0.646	0.548	0.517	0.499	0.509	0.547	0.629	0.884	0.967	

Table 5. Correlations among morning, noon, night and daily records (above diagonal) and among EBV in different milking times (below diagonal) in dairy cows

	Morning	Noon	Night	DMY
Morning		0.646*	0.645	0.883
		<0.0001	<0.0001	<0.0001
Noon	0.278		0.673	0.873
	<0.0001		<0.0001	<0.0001
Night	0.566	0.539		0.872
	<0.0001	<0.0001		<0.0001
DMY	0.677	0.524	0.640	
	<0.0001	<0.0001	<0.0001	

*= P- value, DMY=daily milk yield.

production in the morning time has higher means and larger variances compared to evening milking but Ouweltjes, (1998) showed that morning milk was 6% lower than evening milk yields. Moreover, Erb *et al.* (1952) reported that milk yield of Jersey cows was 7.6% higher during the morning milking than evening. The shape of lactation curve in different times is shown in Fig. 3. The shape and behavior of lactation curve in the noon and night times are similar but different with morning milk curve during DIM. The results indicate that the peak milk yield and peak time in the morning, noon and night times are different. In the morning milking the peak DIM was in 79 days but peak DIM for noon and night milking curves were at 62 and 90 days respectively. So in the lactation curve of first parity, noon milk reaching peak earlier than morning and night times. Moreover, peak milk yield in the morning, noon and night are 11.059, 10.680 and 10.591 kg respectively. This indicates that in different milking curves, the highest milk yield is related to the morning followed by noon and night. Persistency for the morning, noon and night times were –2.104, –2.184 and –2.069 respectively. These values indicate that night milk yield is more persistent than the morning and noon times and persistency of milk yield in the morning and noon are almost the same. This shows that lactation curve of noon and night with lower peak may be more persistent. These results confirm the report of Canadian dairy network (2004) which concluded that higher persistency is mainly due to later and lower peak yields. More persistency of night milk is due to higher flowing of oxygen in the milking gland during the days because of daily activity. Pala and Savas (2006) reported that in Turkish goats the evening milk had a lower persistency than morning milk but morning milk yield was higher than the evening milk yield. The researches show that persistency depends on many factors including body weight, parity, body condition score (BCS), age, health, feed intake, season, stage of lactation and humidity (Togashi *et al.* 2005, Olori *et al.* 1999, Hickson *et al.* 2006).

Correlation between different milk times and daily milk yield and correlation of estimation breeding values of these times with EBV of daily milk yield is in Table 5. Correlation values below diagonal are lower than of upper diagonal. The highest and lowest phenotypic correlation was observed between morning (0.883) and night milk (0.872) with daily milk yield respectively (P<0.01) but among different milking times the highest correlation was obtained between noon and night. Gantner *et al.* (2006) reported that correlation between morning milk and daily milk yield was 96.5% while this amount for evening milk and daily milk production was lower (95.3%). Moreover, the highest correlation of EBV with different milking times was shown between morning and DMY (0.677). This means that the genetic evaluation of cows with the morning milk time produced the similar accuracy and ranking of animals.

Random regression model allowed modeling of the covariance structure among test day yields and the genetic variance and genetic yields for each single day of lactation can be estimated and used to define suitable criteria of persistency. Modeling of test day records in the morning, noon and night was done using a random regression model with orders of Legendre polynomials of 3 and 4 for additive genetic and permanent environmental effects respectively. In different milking times the variance component tended to be lower in the beginning and greater at the end of lactation period. The highest fluctuation of variance components and parameters was observed in the first two months of DMI. The maximum amount of heritability (0.18) which is related to morning milking times was obtained around 260 to 285 DMI. Permanent environmental correlation between different test days followed a similar pattern as the additive genetic correlations. In general, genetic and permanent environmental correlations between close test days are higher and gradually decline as the distance between test days increase. The proportion of morning, noon and night milk from daily milk yield were 34.41%, 32.87% and 32.72% respectively. Based on these results it is obvious that, morning milk time has critical impact on daily milk yield in cow the role of morning milk is important in prediction of daily milk yield which should be evaluated specifically in the future studies in Iranian dairy cows. The highest phenotypic correlation and correlation among EBVs in different times was obtained between morning milk and DMY.

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