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Genetic evaluation of dairy cattle based on morning and afternoon milking test day records with fixed regression model

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This study evaluated morning and afternoon test day records for genetic evaluation of dairy cattle. The data were taken form 128,087 test day yield records for the first four lactations of Holstein cows from 2007 to 2017, from Nucleus Breeding Center of dairy cattle in Indonesia. The records consisted of morning and afternoon and total milk yields from 823 cows, resulting from 133 sires and 520 dams; records were restricted to Day Interval Milk (DIM) between 5 and 305 days production. The genetic parameters were estimated with REML by using animal model with fixed regression. Ali and Schaeffer has a good fit for morning, afternoon and total test day yields with the coefficient of determination ranging from 0.980 to 0.995. Estimates of heritability were 0.177, 0.220, and 0.213 for morning, afternoon, and total test day records, respectively. Spearman rank correlations of breeding values between total yield and morning and afternoon yields, for both animals and sires, ranged between 0.953 and 0.968. In conclusion, morning and afternoon yields can be used for genetic evaluation of dairy cattle.

Key words: Genetic parameters, heritability, morning and afternoon yields, fixed regression model, dairy cattle.

INTRODUCTION

Genetic evaluation of milk yield in dairy cattle has now turned to the use of test day records. With this method, the yield is tested and recorded at certain interval time; for instance every week, every two weeks, every month, etc. The use of test day record is cheaper and more flexible than that of cumulative 305 day records, because the yield is not measured and tested every day, and the data are not adjusted to lactation length.

There are two ways to analyze test day records; (1) records treated as different traits with multivariate, and (2) records treated as the same traits with repeated measurements. Repeated measurement models are more popular than multivariate model (Swalve, 2000), and have been widely used for genetic evaluation of milk yield in many countries. Repeated measurement models were firstly introduced by Ptak and Schaeffer (1993) for fixed regression model, and Schaeffer and Dekkers (1994) and Jamrozik et al. (1997a) for random regression model. Both Ptak and Schaeffer (1993) and Jamrozik et al. (1997b) used regression curve, derived by Ali and Schaeffer (1987), and fitted as covariates. Fixed regression was a superior model for genetic evaluation

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Table 1. Data description.

Lactation	n	Yield	Mean (liter)	StDev
1	53,850	Morning	7.31	3.36
		Afternoon	6.49	2.88
		Total	13.80	5.92
2	25,488	Morning	7.80	2.97
		Afternoon	6.57	2.61
		Total	14.37	5.29
3	38,823	Morning	7.76	3.19
		Afternoon	6.76	2.85
		Total	14.51	5.65
4	9,926	Morning	8.77	3.48
		Afternoon	8.25	3.42
		Total	17.01	6.65

n = number of observation, StDev = Standard Deviation.

dairy cattle (Anang et al., 2001a; Indrijani and Anang, 2009) and sufficient for standard genetic evaluation (Liu at al., 2000), as in cases that the random regression might be biased up ward due to insufficient records (Anang et al., 2001b; Anang et al., 2002).

In many countries, milking is conducted twice a day; in which in early morning and afternoon. There is possibility to evaluate the animals based on morning or afternoon yields of test day record, to have the data collection cheaper and in where the recording is difficult to obtain, such as where the evaluation is conducted in small holder farmers. The purpose of this paper is to study the possible use of morning and afternoon for genetic evaluation of milk production in dairy cows.

MATERIALS AND METHODS

The data comprised 128,087 test day yield records for the first four lactation of Holstein cows from 2007 to 2017, taken at Nucleus Breeding Center of dairy cattle in Baturraden, Central Java Indonesia. The records consisted of morning and afternoon milk yield for each individual cow. The morning yield was milked at 4 am, while the afternoon production was milked at 4 pm. Total production was the additional morning and afternoon yields. 823 cows from 133 sires and 520 dams were evaluated, and the records were restricted to Day Interval Milk (DIM) between 5 to 305 days production. The data description is presented in Table 1.

Regression of Ali and Schaeffer (1987) fitted the data to evaluate the accuracy before estimating genetic parameters. The regression of Ali and Schaeffer is as follows:

$$y = a + b\left(\frac{DIM}{305}\right) + c\left(\frac{DIM}{305}\right)^2 + d\left(\ln\frac{305}{DIM}\right) + f\left(\ln\frac{305}{DIM}\right)^2$$

Where, y = test day yields (morning, afternoon, and total) in liter; DIM = Day Interval Milk (5 to 305 day)
$a,b,c,d,$ and f = coefficients of regression

The accuracy was indicated with coefficient of determination (R^2) and standard error of prediction (se) and the calculation using proc nonlin within SAS 9.0. (SAS, 2002).
Genetic parameters were predicted with Restricted Maximum Likelihood (REML) with fixed regression model. The model is as follows:

$$y_{ijkl} = YS_i + L_l + \sum_{m=1}^{4} b_{lm}x_m + a_j + pe_j + e_{ijkl}$$

Where, y_{ijkl} = Test day yields (morning, afternoon, and total), YS_i= Year-Season (Year from 2007 to 2017, season was rain and dry) and L_l= Lactation (1 to 4)

$\sum_{m=1}^{4} b_{lm}x_m$ = four covariates from regression of Ali and Schaeffer (1987) and nested within lactation

Where, x_1= $DIM/305$, x_2 = $(DIM/305)^2$, x_3 = $ln(305/DIM)$, and x_4 = $ln^2(305/DIM)$
a_j = additive genetic effect; pe_j = permanent environmental effect; e_{ijkl} = residual

The genetic parameters were estimated with VCE 6 (Groeneveld et al., 2010) and breeding values were predicted with PEST (Groeneveld, 1999). In addition, Spearman correlation of breeding values for animals and sires were estimated with proc corr within SAS 9.0. (SAS, 2002)

RESULTS AND DISCUSSION

Fitting regression of Ali and Schaeffer

Parameters of regression, R^2 and se by fitting regression of Ali and Schaeffer are presented in Table 2 and Figure 1. The coefficients of determination (R^2) ranged from 0.980 to 0.995, while the standard errors of prediction

Table 2. Regression Parameters, Coefficients of Determination (R^2), and Standard Errors of Prediction (*se*).

Parameters	First Lactation			Second Lactation			Third Lactation			Fourth Lactation		
	Morning	Afternoon	Total	Morning	Afternoon	Total	Morning	Afternoon	Total	Morning	Afternoon	Total
a	-7.096	-6.314	-13.417	18.826	13.144	31.990	2.985	4.294	7.246	-4.260	-10.788	-15.064
b	14.217	12.787	27.019	-26.106	-17.518	-43.635	2.305	-1.138	1.220	12.682	23.541	36.243
c	-1.614	-1.519	-3.141	13.772	10.278	24.031	-0.149	1.165	0.994	-1.995	-7.064	-9.063
d	11.143	9.786	20.932	-3.149	-1.009	-4.175	5.422	3.517	8.958	10.540	13.613	24.164
f	-1.847	-1.597	-3.443	0.116	-0.124	-0.004	-1.031	-0.671	-1.705	-1.873	-2.286	-4.160
R^2	0.992	0.993	0.995	0.993	0.993	0.995	0.994	0.995	0.996	0.980	0.980	0.984
se	0.142	0.124	0.211	0.101	0.085	0.157	0.130	0.099	0.205	0.227	0.218	0.390

ranged between 0.099 and 0.390 liter. High R^2 indicated that regression of Ali and Schaeffer has a good fit for morning, afternoon, and total yields. The computations of lactation curve for genetic evaluation have been conducted by Ali and Schaeffer (1987) (Jamrozik et al., 1997a; Indrijani et al., 2011). The results showed that regression of Ali and Schaeffer resulted in the best fit for genetic evaluation of dairy cattle with test day records.

Figure 1 shows that the yields increased from day 5 to reach the peak at day 35 and then decreased gradually. Morning yield was higher than afternoon yield. The results are in the line with the studies of Everet and Wandel (1970) and Gilbert et al. (1973). The reason might due to environmental factors, such as temperature, activities of the cows, ruminal processes.

Genetic parameters

Variance components, including estimate of additive genetic (Va), permanent environmental (Vp), residual (Ve) variances and estimates of heritability are presented in Table 3.

The estimates of heritability were 0.177, 0.220, and 0.213 for morning, afternoon, and total test day records, respectively. The estimate of heritability at afternoon was higher than morning yield. The estimate of heritability for total yield with fixed regression model was in the line with those estimated by Reents et al. (1995) using Gibbs Sampling, Swalve (1995), Strabel and Swaczkowski (1997), and Indrijani and Anang (2009) as well as REML. However, there was no study in estimating heritability based on morning and afternoon yield. Moderate heritabilities indicated that genetic evaluation based on test day records will result in good response for genetic evaluation of milk yield in dairy cattle.

Correlations of breeding values

Spearman correlation of breeding values between morning, afternoon, and total yield for all animals and sire are presented in Table 4.

There were high correlations of breeding values between total yield with morning and afternoon yield, for both animals and sire, ranging between 0.953 and 0.968.

The correlations between morning and afternoon yields were lower, 0.874 and 0.855 for both animal and sire, respectively. High correlation of breeding values between total production indicated that genetic evaluation of dairy cattle can be conducted based on morning or afternoon records as alternative of total record.

Conclusion

Regression Ali and Schaeffer has a good fit for morning, afternoon and total test day yields with the coefficient of determination ranging from 0.980 to 0.995. Estimate of heritabilites was generally moderate with 0.177, 0.220, and 0.213 for morning, afternoon, and total test day records, respectively. Spearman rank correlations of breeding values between total yield with morning and afternoon yields, for both animals and sires, ranging between 0.953 and 0.968. High correlation indicated that genetic evaluation of dairy cattle can be conducted based on morning or afternoon records as alternative of total record.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

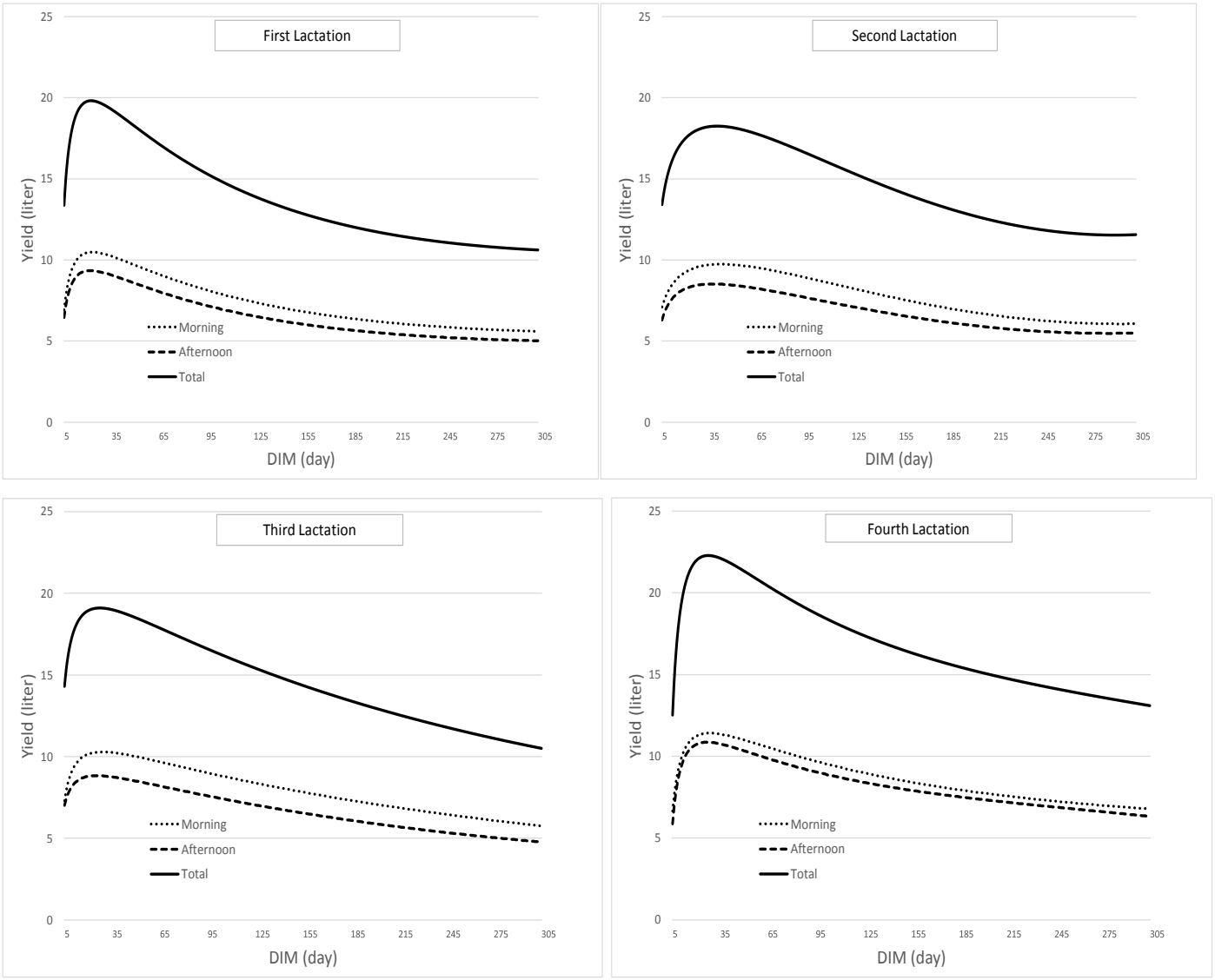

Figure 1. Lactation curves by fitting regression of Ali and Schaeffer (1987).

Table 3. Variance components.

Variance Components	*Va*	*Vp*	*Ve*	h^2 *(se)*
Morning	2.020	1.905	7.505	0.177 (0.006)
Afternoon	1.933	1.071	5.795	0.220 (0.039)
Total	8.178	6.069	24.133	0.213 (0.050)

Table 4. Spearman correlations of breeding values.

Parameter	Animal	Sire
Morning and Total	0.968	0.964
Afternoon and Total	0.959	0.953
Morning and Afternoon	0.874	0.855

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