Estimation of the Genetic Parameters for Test-Day Milk Yield in Holstein Cattle

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Abstract

The objective of this study was to determine the genetic parameters represented by heritability for test-day milk yield, the genetic correlations between test-days milk yield and the breeding value for Holstein cows. The model used was random regression test-day animal model. The data set consists of 216 test day records from 30 cows. The average number of test day per lactation was seven. The heritability estimates for test-day milk yield ranged from 0.43 at 250th day in milk, to 0.60 at 10th day in milk. Genetic correlations between individual test days milk yield were high and positive.

Keywords: breeding value, random regression test-day model, test day milk yield

1. Introduction

Holstein cattle breed is important dairy breed in Romania. In recent years, more attention has been placed on milk quality traits in breeding programmes. The milk production can included milk yield, fat and protein percentages, fat and protein yields and somatic cell scores [1]. New traits are frequently being studied and are included in milk recording programs, or in breed association recording programs [1]. Test-day milk production records are used in many countries for the genetic evaluation of dairy cattle. The genetic evaluation of cattle using test-day random regression models presents the advantages: it reduces the generation interval, decreasing economical costs and makes possible the selection for persistent lactation [2]. The use of test day models allows a more accurate definition of contemporary groups and associated environmental effects, thus offering a more specific definition of the effects of the lactation stage and reproduction of dairy cows [3], [4]. Random regression models allow the modelling of the covariance structure among test day yields [4].
Many authors used the random regression models for genetic evaluation of the cattle: [4-12].
The Legendre polynomials were used as basic functions in many analyses by random regression models [13-15].
The aim of this study was to determine the genetic parameters for test day milk yield using random regression test-day model.

2. Materials and methods

The 216 test-day milk records from 30 Holstein cows from experimental farm of National Research-Development Institute for Animal Biology and Nutrition in the period 2014-2015 were used in this study.
Analysis of test day record was performed using the restricted maximum likelihood (REML)

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method procedure in R software with script built by Grosu and Rotar [2].

$$y_{tijk} = HTD_i + \sum_{m=0}^{3}(\beta_m \cdot z_{tm}) + \sum_{m=0}^{3}(\alpha_{jm} \cdot z_{tm}) + \sum_{m=0}^{3}(\alpha_{jm} \cdot z_{tm}) + \sum_{m=0}^{3}(\gamma_{jm} \cdot z_{tm}) + e_{t\,ijk}$$

y_{tijk} = test day (TD) milk yield record "***k***" of cow "***j***" in the lactation measured at time "***t***";
HTD_i =HTD effect "***i***"';
β_m = fixed regression coefficient;
α_{jm} = random regression coefficients for the breeding value;
γ_{jm} = random regression coefficients for the permanent environmental effect;
z_{tm} = Legendre Polynomials at time "***t***";
et_{ijk} = residual error.

Legendre polynomials [13] of order 3 were used for additive genetic and permanent environmental effect as random regression.
The model is:

$$y=X_1b+X_2\beta+Z_1\alpha+Z_2\gamma+e$$

where: y = vector of TD milk yield record;
X_1=incidence matrix for fixed effect
b=vector of fixed effect for test-day;
X_2 =covariates matrix for fixed effect
β=fixed regression coefficients
Z_1= covariates matrix for all animals
α=random regression coefficients for the breeding value
Z_2 =covariates matrix for cows with records
γ=random regression coefficients for the permanent environmental effect
e=vector of residual effects

The (co)variance structure was assumed for random effects of model:

$$V=\begin{bmatrix} A\otimes G & 0 & 0 \\ 0 & I\otimes P & 0 \\ 0 & 0 & I\sigma_e^2 \end{bmatrix}$$

Where:

Var (a) =A ⊗ G;
Var (a) = additive variance;

Where ⊗ is Kronecker product function;

Linear model is described as follows [2]:

Var (p)=I ⊗ P;
Var (p)=environmental variance;
G and P are the matrices of genetic and permanent environmental variances and covariances between random regression coefficients.

I=represents the identity matrix with the size equal with the number of cows with records;
σ_e^2=esidual variance for lactation assumed to be constant throughout the lactation;
The estimates of heritability for milk yield during days in milk t were obtained by:

$$h_t^2 = \frac{g_{tt}}{(g_{tt} + p_{tt} + \sigma_e^2)}$$

where:

h_t^2=heritability for milk yield during days in milk t;
g_{tt}=genetic variance for milk yield during any days in milk t;

$$g_{tt} = z_t' * G * z_t$$
$$p_{tt} = z_t' * P * z_t$$

p_{tt}=permanent environmental variance for milk yield during any days in milk t;
z_t=co(variables) related to a specific test day l measured during days in milk t;
σ_e^2=residual variance;
The estimates of genetic correlations between test-day t' and t milk yields were calculated by:

$$r_{g\,t't} = \frac{g_{t't}}{\sqrt{g_{t't} * g_{tt}}}$$

where:
$r_{g\,t't}$=genetic correlations between test-day t` and t milk yields;
$g_{t't}$=genetic covariance between two test days during days in milk;

$$g_{t't} = z_{t'}' * G * z_t$$

$z_{t'}'$=transpose of z;
The breeding value estimate (EBV) was calculated with the formula:

$$EBV_{305} = \sum_{m=0}^{q}(\alpha_{jm} \cdot z_{tm})$$

3. Results and discussion

Table 1 gives the breeding value for 305 days for the best 10 cows for daily milk yield. Table 2 shows the heritability for test-day milk yield. The high heritability estimates for test-day milk yield in our study ranged from 0.43 at 250th day in milk, to 0.60 at 10th day in milk. The average high daily heritability for milk (0.45) was observed by Bohmanova et al. [14], in first lactation of Canadian Holstein cows and De Ross and al. [16] (0.44) in dairy cattle in Netherlands. Zaabza et al. [17] reported lower heritability for milk from the REML procedure 0.21. Cho et al. [9] reported lower test–day heritability estimates ranged from 0.08 to 0.15 for milk, according to days in milk. Kheirabadi and Razmkabir [18] observed heritability for milk 0.204 to Holstein cattle. The heritability obtained by Yazgan and Kiyici [19] was 0.29 for milk yield.

Table 1. The breeding value of the best Holstein cows from our study

No.	Estimate breeding value for daily milk yield
1	1649.57
2	1071.07
3	1059.34
4	962.01
5	941.79
6	903.00
7	487.98
8	354.28
9	315.77
10	254.88

Table 2. The heritability for daily milk yields

Days in milk	Heritability for daily milk yield
10	0.60
40	0.57
70	0.55
100	0.53
130	0.52
160	0.50
190	0.48
220	0.45
250	0.43
280	0.45
305	0.49

Hammami et al. [20] obtained estimates of 305 days heritabilities for milk in Tunisian Holstein 0.25. Melo et al. [4] obtained heritability for test day milk yields ranging from 0.28 to 0.42. Gebreyohannes et al. [10] reported test-day heritability estimates for milk ranged from 0.17 for the first test-day recorded 30 days after calving to 0.42 for the last test-day recorded 300 days after calving. Peixoto et al. [15] reported the heritability estimates for test-day milk yield records varied from 0.19 to 0.32. Takma et al. [21] obtained heritability estimates for test day milk yield ranged from 0.07 to 0.32. The genetic correlations between test-day milk yields during the selected lactation periods obtained by random regression model are shown in Table 3. The correlations between test-day milk yields were positive ranging from 0.46 to 1.

Table 3. Genetic correlation estimates between selected days in milk (DIM) of daily yields

DIM	10	40	70	100	130	160	190	220	250	280	305
10	1	0.98	0.93	0.87	0.81	0.77	0.75	0.75	0.74	0.69	0.62
40	0.98	1	0.98	0.95	0.91	0.87	0.85	0.83	0.79	0.70	0.57
70	0.93	0.99	1	0.99	0.97	0.94	0.92	0.88	0.82	0.68	0.52
100	0.88	0.95	0.99	1	0.99	0.98	0.96	0.92	0.84	0.67	0.48
130	0.82	0.91	0.97	0.99	1	0.99	0.98	0.95	0.85	0.67	0.46
160	0.77	0.87	0.94	0.98	0.99	1	0.99	0.97	0.88	0.69	0.48
190	0.75	0.85	0.92	0.96	0.98	0.99	1	0.99	0.92	0.75	0.55
220	0.75	0.83	0.89	0.92	0.96	0.97	0.99	1	0.97	0.84	0.67
250	0.74	0.79	0.82	0.84	0.85	0.88	0.91	0.97	1	0.95	0.83
280	0.70	0.69	0.68	0.67	0.67	0.69	0.75	0.84	0.95	1	0.96
305	0.62	0.57	0.52	0.48	0.46	0.48	0.54	0.67	0.83	0.94	1

4. Conclusions

Genetic parameters were more precise estimated by the random regression model. The heritability estimates for test-day milk yield were high, ranging from 0.43 at 250th day in milk, to 0.60 at 10th day in milk. Genetic correlations between individual test days milk yield were high and positive.

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References

1. Grosu, H., Schaeffer L., Oltenacu P. A., Norman D., Powell R., Kremer V., Banos G., Mrode R., Carvalheira J., Jamrozik J., Draganescu C., and Lungu S., History of genetic evaluation methods in dairy cattle, The Publishing House of the Romanian Academy, Bucharest, 2013.
2. Grosu, H. and Rotar M. C., Estimarea valorii de ameliorare la taurine, pe baza modelelor zilei de control (test day models), Ceres, Bucuresti, 2015.
3. Schaeffer, L. R., Jamrozik L. R., Kistemaker G. J., Van Doormal, B. J., Experience with a test-day model, J. Dairy Sci., 2000, 83, 1135-1144.
4. Melo, C. M. R., Packer I. U., Costa C. N., Machado P.F., Genetic parameters for test day milk yields of first lactation Holstein cows by random regression models, Animal, 2007, 1, 325-334.
5. Herrera, A. C., Munera O. D, Ceron –Munoz M. F., Variance components and genetic parameters for milk production of Holstein cattle in Antioquia (Colombia) using random regression models, Rev. Colomb. Cienc Pecu, 2013, 26, 90-97.
6. Gharahveysi, S., Irani M., Abdullahpour R., Kalashi Z., Use the random regression model for the genetic parameters estimation of milk yield in Holstein cows herd, European Journal of Experimental Biology, 2012, 2(6) 2107-2112.
7. Laureano, M. M. M., Bignardi A. B., Faro L. El., Cardoso V. L., Tonhati H., Albuquerque L. G., Random regression models using different functions to model milk flow in dairy cows, Genetic and Molecular Research, 2014, 13(3), 7528-7541.
8. Tullo, E., Biffani S., Malteca C., Rizzi R., Genetic parameters for milk yield persistency in Carora dairy cattle breed using random regression model, Ital. J. Anim. Sci., 2014, 13, 4, 3484.
9. Cho, C. I., Alam M., Choi T. J., Choy Y. H., Choi J. G., Lee S. S., Cho K.H., Models for estimating genetic parameters of milk production traits using random regression models in Korean Holstein cattle, Asian Australas. J. Anim. Sci., 2016, 29(5), 607-614.
10. Gebreyohannes ,G., Koonawootrittriron S., Elzo M., Suwanasopee T., Estimation of genetic parameters using a random regression monthly test-day model in a Ethiopian dairy cattle population, Agriculture and Natural Resources, 2016, 50, 64-70.
11. Cayo, A. W. C., Lopes P. S., Barbosa da Silva M.V.G., Torres R.A., Martins M. F., Cobuci J. A., Genetic parameters for milk yield and lactation persistency using random regression models in Girolondo cattle, Asian Australas J. Anim. Sci., 2015, 28, 10, 1407-1418.
12. Kheirabadi, K., Alijani S., Zavadilova L., Rafat S.A., Moghaddam G., Estimation of genetic parameters for daily milk yields of promiparous Iranian Holstein cows, Archiv. Tierzucht ., 2013, 56, 44, 455-466
13. Kirkpatrick, M., Lofsvold D., Bulmer M., Analysis of inheritance, selection and evolution of growth trajectories, Genetics, 1990, 124, 979-993
14. Bohmanova, J., Miglior F., Jamrozik J., Misztal I., and Sullivan P. G., Comparison of random regression models with Legendre polynomials and linear splines

for production traits and somatic cell score of Canadian Holstein cows, J. Dairy Sci., 2008, 91, 3627-3638.
15. Peixoto, M. G. C. D., Santes D. J. A., Borquis R. R. A., Bruneli F. A. T., Paneto J. C. C., Tonhati H., Random regression models to estimate genetic parameters for milk production of Guzerat cows using orthogonal Legendre polynomials, Pesq. Agropec. Bras., Brasilia, 2014, 49(5), 373-383.
16. De Ross, A. P.W., Harbes A.G.F., De Jong G., Random herd curves in a test –day model for milk, fat and protein production of dairy cattle in Netherlands. J. Dairy Sci., 2004, 87, 2693-2701.
17. Zaabza, H. B., Gara A. B., Hammami H., Ferchichi M.A., Rekik B., Estimation of variance components of milk, fat and protein yields of Tunisian Holstein dairy cattle using Bayesian and REML methods, Arch. Anim. Breed, 2016, 59, 243-248.
18. Kheirabadi, K., Razmkabir M., Genetic parameters for daily milk somatic cell score and relationship with yield traits of primiparous Holstein cattle in Iran., Journal of Animal Science and Technology, 2016, 58, 38.
19. Yazgan, K., Kiyici J. M., Genetic parameters estimation for some functional milk traits of Brown Swiss dairy cattle, Turkish Journal of Agricultural and Natural Sciences, 2014, 1(3) 301-311.
20. Hammami, H., Rekik B., Soyeurt H., Ben Gara A., Gengler N., Genetic parameters for Tunisian Holsteins using a test-day random regression model, J. Dairy Sci., 2008, 91(5), 2118-2126.
21. Takma, C., Akbas Y., Estimates of genetic parameters for test day milk yield of a Holstein Friesien herd in Turkey with a random regression models, Arch. Tierz., Dummerstorf, 2007, 50(4) 327-336.