Estimation of the Genetic Parameters for Test-Day Milk, in Teleorman Black Head Sheep

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Abstract
The objective of this study was to determine the genetic parameters represented by heritability for test-day milk yield and the genetic correlation between test-days milk yield and the breeding value for Teleorman Black Head sheep. The genetic parameters of daily milk yield during the first three lactations of Teleorman Black Head ewes were estimated with the random regression test-day animal model. Data consisted of 631 test-day records of 81 ewes at first lactation, 351 test-day records of 58 ewes at second lactation and 229 test-day records of 33 ewes at third lactation from experimental farm of INCDBNA Balotesti. Lactations were analysed separately. The heritability estimates for test-day milk yield of ewes at first lactation ranged from 0.015 at 200 day in milk to 0.19 at 10 day in milk. For the ewes at second lactation the heritability estimates ranged from 0.016 at 180th in milk to 0.246 at 10 day in milk. For the ewes at third lactation the heritability estimates for test day milk yield ranged from 0.018 at 180th in milk to 0.249 at 10th day in milk. Genetic correlations between individual test days milk yield were high and positive.

Keywords: breeding value, random regression model, test day milk yield, ewes, genetic parameters

1. Introduction

Genetic improvement of local dairy sheep breeds and populations is an important component of the development of a viable dairy sheep industry [1]. The use of the best method for genetic evaluation of sheep is very important in production. Test-day milk production records are used in many countries for the genetic evaluation of sheep. The genetic evaluation of sheep 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 test-day random regression model improves the accuracy of evaluation. The inclusion of random regression coefficients to describe permanent environmental effects led to a more accurate estimation of the genetic and non-genetic effects that influence milk yield.
Test-day animal models have been widely used for routine evaluations in many countries and by many authors [3-9].
Milk-yield breeding values for sheep are estimated using the test-day model [6, 10] rather than the older lactation model, because the test-day model is more accurate in accounting for the environmental variations associated with lactation.
The objective of this study was to determine the genetic parameters represented by the heritability for test-day milk yield, the genetic correlation between test-days milk yield and the breeding value for Teleorman Black Head ewes using random regression test-day model.

2. Materials and methods

The 631 test-day milk records from 81 Teleorman Black Head sheep at the first lactation, 351 test-day milk records from 58 ewes at second lactation,

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229 test-day milk records from 33 ewes at third lactation from experimental farm of National Research-Development Institute for Animal Biology and Nutrition in the period 2006-2011 were used in this study. The pedigree covered 168 animals - 81 ewes with records at the first lactation, 122 animals - 58 ewes with records at the second lactation, and 79 animals - 33 ewes with records at the third lactation.

Analysis of test day record was performed using the restricted maximum likelihood (REML) method procedure in R software realised by Horia Grosu. Linear model is described as follows:

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

y_{tijk} = test day (TD) milk yield record "***k***" of ewe "***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 [11] of order 3 were used for additive genetic and permanent environmental effect as random regression.

The model is:

$$y = X_1b + X_2\beta + Z1\alpha + Z_2\gamma + e$$

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;
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= residual 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 covariances 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 shows the heritability for test-day milk yield for first three lactations of Teleorman Black Head population sheep. Table 2 gives the breeding value for 200 days for the best 10 ewes for daily milk yield at first, second and third lactation. The lower heritability estimates for test-day milk yield in our study ranged from 0.015 at 200th day in milk, to 0.19 at 10th day in milk for ewes at first lactation. For the ewes at second lactation the heritability estimates ranged from 0.016 at 180th in milk to 0.246 at 10 day in milk. For the ewes at third lactation the heritability estimates for test day milk yield ranged from 0.018 at 180th in milk to 0.249 at 10th day in milk. Cadavez et al. [12] reported that the heritability estimates for daily milk yield ranged from 0.025 at 150th in milk and 0.295 at 30 day in milk for Churra da Terra Quente ewes. Kominakis et al. [13] reported heritability for ewes at the first three lactations; the heritability estimates for daily milk yields for ewes at first lactation ranged from 0.06 at 15 day in milk to 0.25 in 105 day in milk, at second lactation the values ranged from 0.09 at 150 day in milk to 0.17 at 15 day in milk and at third lactation the estimates ranged from 0.05 at 75 day in milk to 0.12 in 15 day in milk. Gutierrez et al. [4] reported the heritability for test-day milk yield to be 0.106. The heritability reported by Bauer (0.28) [14] was higher than that determined by Hamann et al. [5] but lower than the value reported by Baro et al. [15] (0.35). Banos et al. [16] observed that the animal correlation between daily milk yield were higher on adjacent days than days further apart. Tables 3, 4 and 5 show the genetic correlations between test-day milk yields during the selected lactation periods obtained by random regression model. The correlations between test-day milk yields were positive, ranging from 0.64 to 1 at the first lactation, from 0.47 to 1 at second lactation and third lactation.

Table 1. The heritability for daily milk yields in the first three lactations

Days in milk	Heritability for daily milk yield At first lactation	Heritability for daily milk yield at second lactation	Heritability for daily milk yield at third lactation
10	0.190	0.246	0.249
20	0.170	0.212	0.216
40	0.130	0.151	0.159
60	0.096	0.108	0.117
80	0.075	0.079	0.089
100	0.059	0.061	0.069
120	0.047	0.048	0.054
140	0.035	0.035	0.039
160	0.024	0.024	0.026
180	0.017	0.016	0.018
200	0.015	0.018	0.022

Table 2. The breeding value of the best Teleorman Black Head sheep from our study in the first three lactations

No.	Estimate breeding value for daily milk yield (I)	Estimate breeding value for daily milk yield (II)	Estimate breeding value for daily milk yield (III)
1	33.56	10.08	24.34
2	33.28	9.80	16.55
3	31.97	8.27	14.72
4	26.10	7.76	11.87
5	25.44	7.56	8.80
6	25.39	7.34	8.34
7	22.47	4.40	8.28
8	19.26	4.29	6.53
9	14.55	4.23	5.78
10	12.26	3.82	5.19

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

DIM	10	20	40	60	80	100	120	140	160	180	200
10	1	0.99	0.97	0.92	0.84	0.75	0.68	0.64	0.66	0.76	0.84
20	0.99	1	0.98	0.94	0.87	0.80	0.73	0.69	0.71	0.80	0.84
40	0.97	0.98	1	0.98	0.94	0.88	0.82	0.79	0.80	0.86	0.83
60	0.92	0.94	0.98	1	0.98	0.95	0.91	0.88	0.88	0.90	0.79
80	0.84	0.87	0.94	0.98	1	0.98	0.96	0.94	0.94	0.92	0.74
100	0.75	0.80	0.88	0.95	0.98	1	0.99	0.98	0.97	0.92	0.68
120	0.68	0.73	0.82	0.91	0.96	0.99	1	0.99	0.98	0.92	0.64
140	0.64	0.69	0.79	0.88	0.94	0.98	0.99	1	0.99	0.92	0.64
160	0.66	0.71	0.80	0.88	0.94	0.97	0.98	0.99	1	0.96	0.71
180	0.76	0.80	0.86	0.90	0.92	0.92	0.92	0.92	0.96	1	0.87
200	0.84	0.84	0.83	0.79	0.74	0.68	0.64	0.64	0.71	0.87	1

Table 4 Genetic correlation estimates between selected days in milk (DIM) of daily yields (second lactation)

DIM	10	20	40	60	80	100	120	140	160	180	200
10	1	0.99	0.97	0.90	0.79	0.66	0.55	0.49	0.52	0.69	0.82
20	0.99	1	0.98	0.93	0.83	0.71	0.60	0.55	0.58	0.73	0.81
40	0.97	0.98	1	0.98	0.91	0.82	0.73	0.67	0.70	0.80	0.79
60	0.90	0.93	0.98	1	0.97	0.91	0.84	0.80	0.81	0.86	0.73
80	0.79	0.83	0.91	0.97	1	0.98	0.94	0.90	0.90	0.88	0.65
100	0.66	0.71	0.82	0.91	0.98	1	0.98	0.97	0.95	0.88	0.55
120	0.55	0.60	0.73	0.84	0.94	0.98	1	0.99	0.98	0.87	0.48
140	0.49	0.55	0.67	0.80	0.90	0.97	0.99	1	0.99	0.88	0.47
160	0.52	0.58	0.70	0.81	0.90	0.95	0.99	0.99	1	0.93	0.57
180	0.69	0.73	0.80	0.86	0.88	0.88	0.87	0.88	0.93	1	0.82
200	0.82	0.81	0.79	0.73	0.65	0.55	0.48	0.47	0.57	0.82	1

Table 5. Genetic correlation estimates between selected days in milk (DIM) of daily yields (third lactation)

DIM	10	20	40	60	80	100	120	140	160	180	200
10	1	0.99	0.97	0.91	0.82	0.71	0.62	0.58	0.62	0.77	0.83
20	0.99	1	0.98	0.94	0.85	0.76	0.67	0.63	0.67	0.80	0.81
40	0.97	0.98	1	0.98	0.93	0.85	0.78	0.75	0.77	0.85	0.77
60	0.91	0.94	0.98	1	0.98	0.93	0.88	0.85	0.86	0.88	0.71
80	0.82	0.85	0.93	0.98	1	0.98	0.95	0.93	0.93	0.89	0.62
100	0.71	0.76	0.85	0.93	0.98	1	0.99	0.97	0.96	0.87	0.53
120	0.62	0.67	0.78	0.88	0.95	0.99	1	0.99	0.97	0.86	0.47
140	0.58	0.63	0.75	0.85	0.93	0.97	0.99	1	0.98	0.87	0.48
160	0.62	0.67	0.77	0.86	0.93	0.96	0.97	0.98	1	0.93	0.59
180	0.77	0.80	0.85	0.88	0.89	0.87	0.86	0.87	0.93	1	0.82
200	0.83	0.81	0.77	0.71	0.62	0.53	0.47	0.48	0.59	0.84	1

4. Conclusions

The genetic parameters were more precisely estimated by the random regression model. Heritability was highest in the early lactation and in mid lactation, being lower during late lactation. The heritability estimates for test-day milk yield of ewes at first lactation ranged from 0.015 at 200 day in milk to 0.19 at 10 day in milk. For the ewes in second lactation, the heritability estimates ranged from 0.016 at 180th in milk to 0.246 at 10 day in milk. For the ewes at third lactation the heritability estimates for test day milk yield ranged from 0.018 at 180th in milk to 0.249 at 10th day in milk. The genetic correlations between the individual test days milk yield were high and positive.

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