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GENETIC EVALUATION FOR MILK PRODUCTION TRAITS IN SLOVAKIAN LACAUNE SHEEP

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ABSTRACT

Genetic parameters and covariance components as well as genetic and environmental trends were estimated for milk production traits in purebred Slovakian Lacaune sheep. The traits under study were daily milk yield, fat and protein content. The data from performance testing, gathered by the State Breeding Institute over the period 1999-2005 comprised 2196 test-day records. The pedigree data comprised 438 records. The three-trait animal model was used for the analysis. Genetic and environmental parameters were estimated using Restricted Maximum Likelihood (REML) algorithm as implemented in the VCE-5 package. The heritabilities were 0.15, 0.10 and 0.25 for daily milk yield, fat and protein content. Variance ratios for flock-test day effect as the most important environmental effect were 0.33, 0.47 and 0.21 for the respective traits. Breeding values used as the basis for estimation of genetic trends were calculated using best linear unbiased prediction (BLUP) methodology as implemented in the PEST package. Genetic trends were expressed as changes in averages of breeding values (adjusted for standardised 150-day lactation) across birth years of animals. Cumulative genetic changes over the analysed period were 5.1 kg, -0.16 and -0.12 % for 150-day milk, fat and protein content. Environmental trends were expressed as changes in averages of flock-test day solutions across years and months of the measurement. The maximum change between the two successive year-month periods was 0.47 kg for daily milk yield and 3.26 and 0.66 % for fat and protein content respectively.

Key words: Lacaune, milk yield, fat and protein content, genetic parameters and trends, environmental parameters and trends

INTRODUCTION

Selection for breeding animals as parents of next generation, based on genetic analyses of most important traits, became a standard for selection practices in most of the farm animal species in Slovakia. In this respect, about ten years of experience could be traced in Slovakian dairy cattle (Candrák et al., 1997) and pigs (Groeneveld and Peškovičová, 1999 and Peškovičová et. al., 1999). First estimates of genetic parameters and breeding values for beef cattle (Krupa et al., 2003 and 2006) and sheep (Oravcová et al., 2005a, 2005b and Margetín et al., 2006) were done a few years ago. Thus, the routine genetic evaluation for milk production traits (milk yield, fat and protein content) and litter size of purebred local populations of Tsigai, Improved Valachian and Merino breeds was recently introduced in Slovakian sheep. Moreover, the effectiveness of milk and milk lambs production was studied (Vláčil, 2002 and Vlčková et al., 2006). As Lacaune sheep is also bred in Slovakia for milk production and production of young animals, a need for genetic evaluation of this breed under Slovakian production circumstances arose. Until now, only few analyses of milk production traits for Slovakian Lacaune exist (Čapistrák et al., 1999, 2005, Margetín et al., 2005 and Oravcová et al., 2006, 2007). Taking into account the availability of complex information on ewe's milk and milk composition across Lacaune flocks recorded, a quantification of genetic and environmental effects that affect production level together with the prediction of breeding values can be done and used to improve selection practice of Slovakian Lacaune in the near future.

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The aim of the study was to estimate genetic parameters and covariance components as well as genetic and environmental trends for milk production traits (milk yield, fat and protein content) in purebred Slovakian Lacaune sheep using the animal model based on individual test-day measurements. Also, analyses of cumulative and annual phenotypic, genetic and environmental changes over the studied period were done.

MATERIAL AND METHODS

Data from regular milk recording of purebred Lacaune sheep in Slovakia over the period 1999-2005, available from the State Breeding Institute of the Slovak Republic, were analysed. In total, 2196 test-day records, belonging to 362 purebred ewes from six flocks at first, second or third lactation containing information on daily milk yield, fat and protein content, entered the calculations. The AC method was used to take ewes' milk samples (ICAR, 2003). Fat and protein content were determined using automated infrared method (STN 57 0536, 1995) and the apparatus calibrated against known sample standards. On an average, four test-day measurements were taken during the lactation with first test day measurement taken mostly within 60-90th days after parturition.

The same three-trait animal model with repeated measurements was used to estimate genetic and environmental parameters as well as breeding values for daily milk yield, fat and protein content which served as the basis for estimation of genetic and environmental trends for respective traits in purebred Lacaune sheep. The effects included in the model were the same for all three traits, as given below:

$$y_{ijkl} = \mu + L_i + S_j + b_{1i}\left[\frac{DIM_{ijklm}}{C}\right] + b_{2i}\left[\frac{DIM_{ijklm}}{C}\right]^2 + b_{3i} l n\left[\frac{C}{DIM_{ijklm}}\right] + b_{4i} l n^2\left[\frac{C}{DIM_{ijklm}}\right] + f_k + a_l + p_l + e_{ijkl}$$

where,

y_{ijkl} is the individual observation of daily milk yield (kg), fat and protein content (%)

μ is the intercept

L_i is the fixed effect of lactation number (i =1, 2 and 3)

S_j is the fixed effect of litter size (j = 1 and 2+)

b_{1i}, b_{2i}, b_{3i}, b_{4i} are regression coefficients associated with days in milk (DIM) nested within lactation; the regression according to Ali and Schaeffer (1987) was applied

C is the constant associated with standardised length of milking period in Slovakian sheep (150d.)

f_k is the random effect of flock-test day (k = 1 to 96)

a_l is the random additive genetic value of an individual (l = 1 to 438) with a relationship matrix incorporated

p_{li} is the random permanent environmental effect common for all test days within lactation for each ewe with data (562 levels)

e_{ijkl} is the residual, N(0,δ_e^2)

The pedigree relations, which included information on 438 individuals, were traced three generations back. Only natural mating was applied, thus limited genetic ties were found. On an average, nine daughters per sire were tested. About 75 % of sires had progeny tested in the single flock and proportion of sires with more intensive connections across flocks was low.

VCE-5 software package (Kovač et al., 2002) was used to estimate variance/covariance components for the repective random effects and the three traits. PEST software package (Groeneveld et al., 1993) was used to estimate breeding values (BLUP-predictions) for the respective traits of all individuals involved in the pedigree as well as BLUE-estimates for non-genetic random effects included in the model.

Breeding values for daily milk yield were adjusted for standardised 150-day lactation (multiplying with constant 150 = days). Genetic trends were calculated as averages of the individual breeding values across animals' birth years. Genetic trends were expressed as deviations from base population which consisted of animals born in 1998.

Apart from breeding values, solutions for environmental effects were provided. Solutions for flock-test day effect (BLUE-estimates) were considered when changes in production environment i.e. variation due to management, nutrition, quality of pasture, changes from winter to summer feeding were analysed. Environmental trends were calculated as averages of solutions for flock-test day effect across years and months in which measurements were taken.

Total phenotypic milk yield per lactation used for estimates of phenotypic trends for standardised 150-day milk yield was calculated according to the Fleischmann method using the following formula (STN 46 6213, 1997):

$$Y = I_1 \cdot Y_1 + \sum_{i=1}^{k-1} \frac{Y_i + Y_{i+1}}{2} I_i + Y_k \cdot C$$

where,

Y is the lactation milk yield; I_1 is the interval in days between recording date of suckling period and first test day; Y_i is the milk yield of test day i (i = 1,..., k); I_i is the interval in days between the two successive test days i and $i+1$ and Y_k is the milk yield of the last test-day; C=15 is the standardised length of drying period. Milk yield adjusted for 150-day standardised lactation was calculated using the following formula:

$$Y150 = Y * \frac{150}{L}$$

where,
Y150 is the standardised 150-day milk yield; *Y* is the lactation milk yield; C=150 is standardised length of lactation under Slovakian husbandry system; *L* is the length of lactation considered since the end of suckling period till the end of drying period.

RESULTS AND DISCUSSION

When Lacaune sheep in Slovakia and France are compared, it should be stated that French Lacaune is a specialised dairy sheep breed with about 70 %-proportion of income for milk (Barillet et al., 2001a), whereas Lacaune in Slovakian husbandry system (although individuals of this breed in Slovakia are either continuously imported or they are descendants of imported animals) is a dual-purpose breed with about the same income for milk and lamb production. The difference in average daily milk yield is about 36 % in favour of French Lacaune (1.05 kg vs. 1.5-1.6 l; see Barillet et al., 2001a and 2001b; Berger, 2004 for comparison).

The heritabilities, variance ratios and genetic and environmental correlations for daily milk yield, fat and protein content estimated for Slovakian Lacaune are given in Table 1. The heritabilities were 0.15, 0.10 and 0.25 for daily milk yield, fat and protein content. The genetic correlations were -0.46 (between daily milk yield and fat content), -0.36 (between daily milk yield and protein content) and 0.68 (between fat and protein content). The estimates of genetic correlations for Slovakian Lacaune were comparable and similar in magnitude and sign with Tsigai and Improved Valachian (Oravcová et al., 2005a) and did not differ more than 25 %, except for differences in genetic correlations between milk and fat content (differences 37 and 50 % in favour of Slovakian Lacaune). On the contrary, the heritabilities for Slovakian Lacaune were lower than those estimated for French Lacaune (Barillet et al., 2001b) and differed by 37, 62 and 36 % for daily milk yield, fat and protein content. The genetic correlations between daily milk yield and milk components estimated for Slovakian and French Lacaune differed to a smaller extent. The correlations were higher for French Lacaune (12 and 30 %). The heritability estimated for daily milk yield in Slovakian Lacaune was comparable with the heritability reported

Table 1: Heritabilities (on diagonal) and genetic correlations (above diagonal) with standard errors in parentheses for additive genetic effect and variance ratios (on diagonal) and correlations (above diagonal) with standard errors in parentheses for non-genetic random effects

Additive genetic	DMY	FC	PC
DMY[1]	0.15 (0.024)	-0.46 (0.078)	-0.36 (0.061)
FC[2]		0.10 (0.011)	0.68 (0.079)
PC[3]			0.25 (0.018)
Flock-test day	**DMY**	**FC**	**PC**
DMY	0.33 (0.024)	-0.21 (0.106)	-0. 11 (0.061)
FC		0.47 (0.034)	0.10 (0.079)
PC			0.21 (0.018)
Permanent environmental	**DMY**	**FC**	**PC**
DMY	0.19 (0.023)	-0.04 (0.117)	-0.22 (0.104)
FC		0.05 (0.011)	0.48 (0.079)
PC			0.12 (0.024)
Residual	**DMY**	**FC**	**PC**
DMY	0.33 (0.017)	-0.13 (0.023)	-0.14 (0.025)
FC		0.39 (0.026)	0.29 (0.012)
PC			0.42 (0.020)

[1]Daily milk yield, [2]Fat content, [3]Protein content

by Brežnik (1999) for Bovec (0.16), El-Saied et al. (1998a, 1998b) for Churra (0.18 and 0.14) and Horstick (2001) for East Friesian (0.17). The only exceptions were Chios with a heritability of 0.35 reported by Ligda et al. (2002) and Improved Bovec with a heritability of 0.22 as reported by Brežnik (1999). The heritabilities for fat and protein content (for the breeds mentioned above) were comparable with those estimated for Slovakian Lacaune and ranged from 0.08 to 0.31. The genetic correlations between daily milk yield and milk components reported for breeds mentioned above were in agreement with genetic correlations found for Slovakian Lacaune in sign, however, the values were lower and ranged from -0.06 to -0.35. Similarly, the genetic correlation between fat and protein content was in accordance in sign; however, it was lower and ranged from 0.13 to 0.61 for breeds mentioned above.

A large proportion of variability of the respective traits was caused by the environmental effect (flock-test day effect), indicating the need for this effect to be included in the model used for genetic evaluation. The variance ratios were 0.33 for daily milk yield, 0.47 for fat content and 0.21 for protein content (Table 1). The variance ratios for flock-test day effect in Slovakian Lacaune were comparable with those found for Tsigai and Improved Valachian (Oravcová et al., 2005a) and reflected the situation common for sheep in Slovakia: variability due to different production environments across flocks is high and needs to be taken into account.

Variance ratios, found for permanent environmental effects of the animal, accounted for 19, 5 and 12 % of total variance in daily milk yield, fat and protein content (Table 1). The values were slightly higher, but, comparable to those estimated for Tsigai and Improved Valachian (Oravcová et al., 2005a).

The distribution of genetic and phenotypic changes for 150-day milk yield, fat and protein content for Lacaune ewes born in 1997-2003 is given in Table 2. An overall increase in 150-day milk yield was recorded with phenotypic values varying to a greater extent than genetic values. For fat and protein content, a low decrease in phenotypic values was found, probably associated with negative correlations between milk and milk components (either genetic correlations as given in this study or phenotypic correlations as given by Oravcová et. al., 2007) and selection oriented towards the increase in milk yield.

With phenotypic trend, two different time periods could be identified for 150-day milk yield. The first period until 2000 showed an increase by 30.3 kg. The second period showed no trend. The changes varied to a great extent between successive years, probably due to small population size and high variation in number of ewes tested in the particular years. The cumulative change in phenotypic trend for 150-day milk yield was 15 kg. A decrease in 150-day milk yield between ewes born in 2002 and 2003 could be explained by the fact that only ewes at first lactation were tested in the end of the analysed period. Phenotypic trends for fat and protein content showed a continuous decrease (-1.27 and -0.25 %).

The phenotypic values for 150-day milk yield (within the range from 156.0 to 189.2 kg) for Slovakian Lacaune were mostly higher than phenotypic values for standardised milk yield reported by Moioli and Pilla (1994), Ugarte et al. (1995), Sanna et al. (1995, 1997) and Serrano et al. (1996). The values reported by these authors were as follows: 91 kg for Massese breed (70-day partial lactation), 100 to 125 l for Blond-Faced and Black-Faced Latxa (120-day lactation), 160 to 200 l for Sarda (160-day lactation) and 127 l for Manchega (120-day lactation). On the contrary, the values for Slovakian Lacaune were lower than those reported for French Lacaune by Barillet et al. (2001a), who mentioned the phenotypic trend being at around 270 l (165-day lactation) between the years 1995-1999, continuously increasing from the initial value of 80 l (135-day lactation) in 1960. The phenotypic trends for Slovakian and French Lacaune indicate that ewes in Slovakia produce at the lower level than ewes in France. When production levels of milk between Slovakian and French Lacaune are compared, the differences in the length of suckling period (2 months vs. 1 month), length of standardised lactation, nutrition etc. need to be taken into account. From the viewpoint of about 40-year tradition in increasing milk yield of Lacaune in France, Barillet et al. (2001a) suggested that Lacaune importers need to improve the husbandry system (particularly feeding) as the main determinant to account for high milk yield in the country of import.

With genetic trend for 150-day milk yield estimated for Slovakian Lacaune, an increasing genetic response was found until 2000, whereas since 2000, genetic response tended to increase less. Cumulative

Table 2: **Genetic and phenotypic trend for milk production traits**

Birth year	150-day milk yield (kg)		Fat content (%)		Protein content (%)	
	Genetic	Phenotypic	Genetic	Phenotypic	Genetic	Phenotypic
1997	-3.60	158.9	-0.09	7.85	+0.059	5.85
1998	0	156.0	0	7.76	0	5.57
1999	+5.43	174.9	-0.17	7.19	-0.019	5.50
2000	+3.58	189.2	-0.27	6.7	-0.087	5.60
2001	-1.97	159.4	-0.25	6.47	-0.045	5.46
2002	+2.19	174.8	-0.31	6.54	-0.077	5.47
2003	+1.52	156.8	-0.25	6.58	-0.059	5.6

genetic change over the analysed period was 5.1 kg. Respective annual genetic gain was 0.85 kg. With genetic trend estimated for fat and protein content, cumulative genetic change showed an overall decrease (-0.16 and -0.12 %).

There were only few reports on genetic trends for milk production traits in sheep found in the literature. The reports available mostly analysed milk yield, as milk is the economically most important trait in dairy sheep and the selection is oriented towards the increase in milk production. Reports, which analysed the remaining traits, occurred less often.

Genetic trends for milk yield estimated for Slovakian Lacaune showed that annual genetic gain was both lower and higher than annual genetic gain reported for sheep in Europe. For Slovakian Lacaune, cumulative genetic change over the period of 1997-2003 was 5.1 kg and respective annual genetic progress was 0.85 kg. Cumulative genetic changes of 9.3 and 6.7 l (annual genetic progress of 1.16 and 0.84 l) were found for Blond-Faced and Black-Faced Latxa over the period of 1985-1993 (Ugarte et al., 1995). Cumulative genetic change of 2.5 l (annual genetic progress of 0.5 l) was found for Manchega over the period of 1987-1992 (Serrano et al., 1996). For French Lacaune, genetic improvement of 100 l was reported over the period of 1980-1997 (Barillet et al., 2001a). Respective annual genetic progress was more than 5 l. Thus, annual genetic change for French Lacaune was the same as the cumulative genetic change for Slovakian Lacaune over the whole period studied.

Slightly decreasing genetic trends for fat and protein content agreed with findings for Black-Faced Latxa (Legarra and Ugarte, 2004), who reported an increase in milk as the main breeding objective, accompanied by a decrease in fat and protein content. When cheese quality is being maintained, worsening of milk components is not required. To avoid a decrease in fat and protein content, selection objective should also include improvements of these traits. For French Lacaune, the revision in selection objective in order to maintain satisfactory cheese-making properties was done in the 1990s (Barillet et al., 2001a). After eight years of selection, the estimated annual genetic gain for fat and protein content was about 0.2 to 0.3 g/l within the period 1992-1997.

Changes in the environmental trend of flock-test day solutions (BLUE-estimates) for daily milk yield over years and months are given in Figure 1. Characteristic cyclical pattern within the years was found, indicating that milk variability due to short-time changes in environment needs to be taken into account. Positive influence of spring months prevailed; probably reflecting good pasture availability (mainly in May). A small conflict appeared in this regard when April showed a negative influence. Probably, pasture of poor quality and shortage in nutrition might be a reason why this phenomenon occurred as breeding practice in Slovakia does not consider any additional ration of hay or concentrate when ewes are grazed. As the analysis has been carried out over a relatively short period, it is difficult to identify why the overall decrease in flock-test day effect since 2003 occurred. Apart from limited adaptation of continuously imported genotype, this may underline the necessity to take an increasing care to nutrition requirements, thus ewes be able to produce

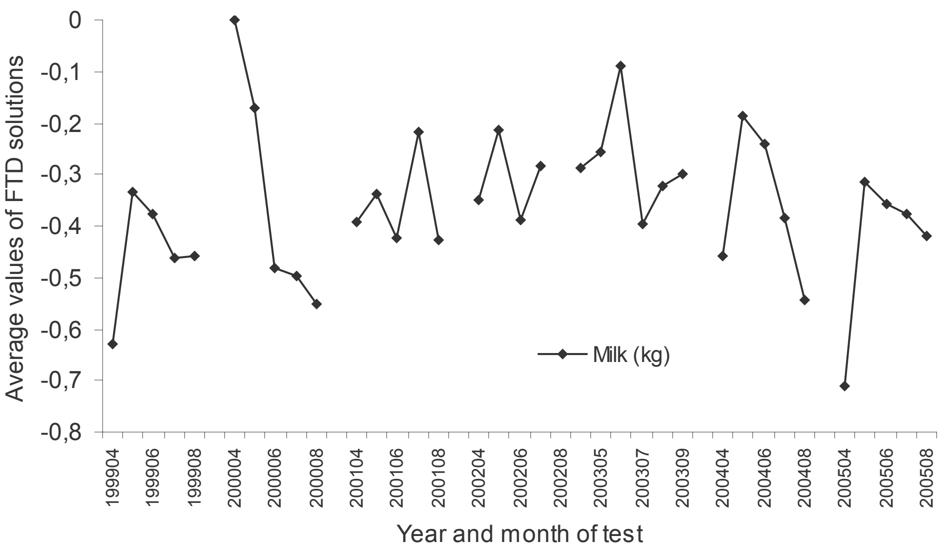

Fig. 1: Environmental trend for daily milk yield

more milk. The maximum environmental change between the two successive year-month periods (Table 3) was 0.47 kg. The maximum phenotypic change between the successive year-month periods was 0.76 kg (data not shown). Obviously, the changes within environmental trends were lower than those within phenotypic trends as changes in the environment were adjusted for all effects included in the model.

Table 3: Environmental differences across year-month periods

Time period comparisons	Differences between the successive time periods		
	Daily milk yield (kg)	Fat content (%)	Protein content (%)
1999/5 – 1999/4	+0.29	+0.5	-0.19
1999/6 – 1999/5	-0.05	-0.74	-0.17
1999/7 – 1999/6	-0.08	+0.05	+0.09
1999/8 - 1999/7	0	+0.05	+0.16
2000/5 – 2000/4	-0.17	+1.38	+0.29
2000/6 – 2000/5	-0.31	+0.51	-0.23
2000/7 – 2000/6	-0.02	-0.15	+0.27
2000/8 - 2000/7	-0.05	+1.17	+0.44
2001/5 – 2001/4	+0.05	-0.13	-0.37
2001/6 – 2001/5	-0.08	+0.25	+0.29
2001/7 – 2001/6	+0.20	+0.28	-0.2
2001/8 – 2001/7	-0.21	-0.04	-0.03
2002/5 – 2002/4	+0.14	-0.15	+0.01
2002/6 – 2002/5	-0.18	+0.63	-0.22
2002/7 – 2002/6	+0.10	-0.19	-0.01
2003/5 – 2003/4	+0.03	-0.7	+0.07
2003/6 – 2003/5	+0.16	-0.33	-0.19
2003/7 – 2003/6	-0.31	+0.15	+0.14
2003/8 – 2003/7	+0.07	-1.14	+0.12
2003/9 – 2003/8	+0.02	+2.12	+0.03
2004/5 – 2004/4	+0.27	-1.36	+0.36
2004/6 – 2004/5	-0.05	+1.47	-0.04
2004/7 – 2004/6	-0.14	-0.42	+0.04
2004/8 – 2004/7	-0.16	+0.19	+0.04
2005/5 – 2005/4	+0.39	-0.17	+0.07
2005/6 – 2005/5	-0.04	+0.1	-0.18
2005/7 – 2005/6	-0.02	+0.29	+0.02
2005/8 – 2005/7	-0.04	-0.72	+0.08

Changes in environmental trends of flock-test day solutions for fat and protein content also showed cyclical pattern within the years (not shown). This pattern was opposite to that found for daily milk yield, probably due to negative correlations between milk and milk composites. With fat content, the maximum environmental change between the two successive year-month periods was 3.26 % (Table 3). With protein content, the maximum environmental change between the two successive year-month periods was 0.66 %.

A positive effect of the environment on milk yield modelled through flock-year effect was confirmed by Barillet et al. (1992) and Moioli & Pilla (1994). The latter authors, however, reported difficulties when specific improvements in the environment were identified. Probably due to changes in selection objective, Barillet et al. (2001a) reported a quick decrease in flock-year effect during the second half of 1990s for French Lacaune which contradicted an increase found before 1995. The authors explained this phenomenon by diminution of ewe's feeding level, thus farmers be able to comply with the rules for maintaining the product quality of Roquefort cheese. Similar to our results, positive influence of spring months on milk yield and negative influence of summer months when pastures were scarce and of poor quality was reported by Cappio-Borlino et al. (1997). The authors pointed out the need for this effect to be included in the model although it remained partially confounded with the effect of days in milk due to the fact that ewes which lamb in certain period also produce in certain period.

CONCLUSION

The positive genetic trend for 150-day milk yield was found for purebred Slovakian Lacaune sheep. In contrast, the phenotypic trend was substantially improved only in the beginning of the analysed period and fluctuation in milk production was observed at the second half of the analysed period. The possible reason for this might be the fact that selection based on dam's milk yield appeared to be of low efficiency. The environmental trend for daily milk yield indicated a slight overall improvement in management of flocks, which tended to decrease in the time proceeded. Possible reasons have been identified and remedial measures indicated.

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