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Genetic and Environmental Trends for Milk Production Traits in Sheep Estimated with Test-day Model

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ABSTRACT : Data from milk performance testing were used to analyze genetic and environmental trends for purebred Tsigai, Improved Valachian and Lacaune sheep. 103,715 (Tsigai), 212,962 (Improved Valachian) and 2,196 (Lacaune) test-day records gathered by the State Breeding Institute of the Slovak Republic entered the analyses. The respective pedigree data comprised 23,724 (Tsigai), 51,401 (Improved Valachian) and 438 (Lacaune) records. The multiple-trait, mixed model methodology was used to predict the breeding values for daily milk yield, fat and protein content and to estimate the fixed and remaining random effects assumed to affect the above mentioned traits, separately for each breed. The breeding values for daily milk yield were adjusted for 150-day standardized lactation length by multiplying with the constant 150, as the breeding goal of the selection scheme in Slovakian sheep is to increase 150-day milk production and constant heritability throughout the whole lactation is assumed. The genetic trends were expressed as changes in averages of breeding values across birth years of animals. For Tsigai and Lacaune breeds, cumulative genetic changes over the analyzed period were 3.8 and 5.1 kg for 150-day milk, 0 and -0.16% for fat content and 0 and -0.12% for protein content. For Improved Valachian breed, either a low (1.6 kg for 150-day milk yield) or zero (fat and protein content) cumulative genetic change was found. The environmental trends were calculated as averages of solutions for flock-test day effect across years and months in which measurements were taken. A distinctive cyclical pattern which reflected short-time variation in milk production traits was found. Possible explanations for this phenomenon are given and discussed. (**Key Words :** Sheep, Milk Yield, Fat and Protein Content, Animal Model, Genetic and Environmental Trends)

INTRODUCTION

The best linear unbiased prediction (BLUP) and animal model has become the standard for genetic evaluation of milk production traits in sheep (Barillet et al., 1992; 2001a; Legarra and Ugarte, 2004; Jiménez and Jurado, 2006). This methodology enables the phenotypic measurements of the respective traits to be partitioned into genetic and environmental components so that it gives the opportunity for monitoring the proportion of changes caused by genetic and environmental effects over time (Kovac and Groeneveld, 1990; Kominakis et al., 2002; Bai et al., 2006; Krupa, 2006). Apart from assessment of the effectiveness of selection programs, changes in production environment are useful to be known when selection procedures are designed (Peškovičová et al., 1999). The individual contributions of both sires of sires and dams of sires paths to the total genetic progress can also be assessed (Jurado et al., 2006).

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Genetic response for milk production traits in sheep varies over countries and breeds (Barillet et al., 1992, 2001; Astruc et al., 2002; Jiménez and Jurado, 2006). A lower genetic progress is usually considered the result of poor animal identification, small proportion of animals and flocks enrolled in recording system, limited genetic connections amongst flocks when no artificial insemination is applied (Pinelli et al., 2001). Nevertheless, genetic improvement in populations is an important component of the viable sheep industry development.

Genetic trends for milk yield were analyzed for various sheep breeds in the literature. First studies appeared in 1990s (Barillet et al., 1992; Moioli and Pilla, 1994; Serrano et al., 1996). Recent studies could also be found (Astruc et al., 2002; Legarra et al., 2003; Jiménez and Jurado, 2006). The investigations aimed at analyses of genetic trends for fat and protein or fat and protein content occurred less often (Barillet et al., 2001a; Legarra and Ugarte, 2004). The analyses of environmental trends for milk production traits which account for main non-genetic effects caused by variation in management conditions, nutrition regimes, quality of the pastures also occurred less often (Barillet et al., 1992, 2001a; Moioli and Pilla, 1994). Similar to novel developments in dairy cattle research, studies oriented towards applications of random regression models could be found for sheep (Banos et al., 2005; Komprej et al., 2007).

The aim of our work was to estimate genetic and environmental trends for milk yield, fat and protein content in Slovakian purebred sheep populations of Tsigai, Improved Valachian and Lacaune breeds using the animal model based on test-day measurements which was introduced in Slovakia recently (Oravcová et al., 2005). The genetic and the environmental changes over time were quantified and conclusions for optimization of breeding practise were given. The analyses of phenotypic changes for milk production traits were also done.

MATERIAL AND METHODS

Purebred populations of Tsigai, Improved Valachian and Lacaune sheep were analyzed. In the three breeds, considered the dual-purpose in Slovakia with the income equally distributed over milk yield and production of offspring for slaugther as young animals, the same breeding system characterized by seasonal production with lambing in winter months (January to March) is applied. After weaning the lambs, 53-55 days from parturition, ewes are milked since April and are dried off in August-September. Usually, ewes are of pasture availability and are provided with no additional feeding during this period. See Oravcová et al. (2006, 2007) for details on production circumstances and distribution of data over the individual months in milk.

Calculations were based on the data of Slovakia's official milk recording scheme that began in 1995 (Tsigai and Improved Valachian) and 1999 (Lacaune), and included measurements from the nucleus and the multiplier flocks. Daily milk yield was measured using the AC method (ICAR, 2005); fat and protein content were determined using the automated infrared method and apparatus calibrated against known sample standards.

In total, 103,715 (Tsigai), 212,962 (Improved Valachian) and 2,196 (Lacaune) records belonged to 14,577 (Tsigai), 31,148 (Improved Valachian) and 362 (Lacaune) ewes at the first to third lactation were involved in the analyses. On average, four test-day measurements were taken during the lactation. Only records which belonged to individuals with known parents were considered, except for Lacaune as a limited amount of data was available for this imported breed. The relations were traced three generations back. The respective pedigree data comprised 23,724 (Tsigai), 51,401 (Improved Valachian) and 438 (Lacaune) records. Only natural mating was applied, therefore, limited genetic ties were found. On average, 9 (Lacaune) to 13-15 (Tsigai and Improved Valachian) daughters were tested per sire. Most of sires (about 75%) were progeny tested only in the single flock. At the maximum, sires were progeny tested in the three to seven flocks. Proportion of sires with connections within more than four flocks was, however, extremely low.

Genetic merit for daily milk yield, fat and protein content was predicted separately for each breed using the three-trait animal model based on repeated test-day observations and covariance structure included, accounting for mutual associations between the traits. The model equation was the following:

$$y_{ijkl} = \mu + L_i + S_j + b_{1i}\left(\frac{DIM_{ijkl}}{C}\right) + b_{2i}\left(\frac{DIM_{ijkl}}{C}\right)^2$$
$$+ b_{3i}\ln\left(\frac{C}{DIM_{ijkl}}\right) + b_{4i}\ln^2\left(\frac{C}{DIM_{ijkl}}\right) + f_k + a_l + p_{li} + e_{ijkl}$$

Where,

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

μ is intercept

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

S_j is 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 nested within lactation; regression according to Ali and Schaeffer (1987) was applied

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

f_k is random effect of flock-test day (k = 1 to 974 for Tsigai, 1 to 1,567 for Improved Valachian and 1 to 96 for Lacaune)

a_l is random additive genetic value of individual (l = 1 to 23,724 for Tsigai, 1 to 51,401 for Improved Valachian and 1 to 438 for Lacaune) with a relationship matrix incorporated

p_{li} is random permanent environmental effect common for all test days within lactation for each ewe with data (26,344 levels for Tsigai, 53,681 levels for Improved Valachian and 562 levels for Lacaune)

e_{ijkl} is residual

The matrix form of the model was the following:

$$\mathbf{y} = \mathbf{X}\beta + \mathbf{Z}_f\mathbf{f} + \mathbf{Z}_a\mathbf{a} + \mathbf{Z}_p\mathbf{p} + \mathbf{e}$$

where expectation and covariance matrix (V) were the following:

$$\begin{pmatrix}\mathbf{y}\\ \mathbf{e}\\ \mathbf{f}\\ \mathbf{a}\\ \mathbf{p}\end{pmatrix} \sim N\left(\begin{bmatrix}\mathbf{X}\beta\\ 0\\ 0\\ 0\\ 0\end{bmatrix}, \begin{bmatrix}\mathbf{V} & \mathbf{R} & \mathbf{Z}_f\mathbf{G}_f & \mathbf{Z}_a\mathbf{G}_a & \mathbf{Z}_p\mathbf{G}_p\\ \mathbf{R} & \mathbf{R} & 0 & 0 & 0\\ \mathbf{G}_f\mathbf{Z}_f' & 0 & \mathbf{G}_f & 0 & 0\\ \mathbf{G}_a\mathbf{Z}_a' & 0 & 0 & \mathbf{G}_a & 0\\ \mathbf{G}_p\mathbf{Z}_p' & 0 & 0 & 0 & \mathbf{G}_p\end{bmatrix}\right)$$

Table 1. Variance ratios and correlations for additive genetic, flock-test day and permanent environmental effects

	Heritabilities/variance ratios				Correlations (genetic/flock-test day/permanent environmental)		
	Tsigai	Improved Valachian	Lacaune		Tsigai	Improved Valachian	Lacaune
Additive genetic							
DMY[1]	0.19	0.10	0.15	DMY- FC	-0.23	-0.29	-0.46
FC[2]	0.12	0.06	0.10	DMY- PC	-0.27	-0.30	-0.36
PC[3]	0.17	0.07	0.25	FC-PC	0.57	0.58	0.68
Flock-test day							
DMY	0.34	0.41	0.33	DMY- FC	-0.23	-0.31	-0.21
FC	0.39	0.48	0.47	DMY- PC	0.05	-0.01	-0.11
PC	0.39	0.46	0.21	FC-PC	0.25	0.39	0.10
Permanent environmental							
DMY	0.11	0.14	0.19	DMY- FC	0.05	0.01	-0.04
FC	0.04	0.02	0.05	DMY- PC	-0.13	-0.08	-0.22
PC	0.04	0.04	0.12	FC-PC	0.36	0.45	0.48

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

$$\mathbf{V} = \mathbf{R} + \mathbf{Z_f G_f Z_f'} + \mathbf{Z_a G_a Z_a'} + \mathbf{Z_p G_p Z_p'}$$

$$\mathbf{R} = \oplus_{j=1}^{n} \mathbf{R}_{0j}$$

$$\mathbf{G_f} = \mathbf{I_f} \otimes \mathbf{G}_{f0}$$

$$\mathbf{G_a} = \mathbf{A} \otimes \mathbf{G}_0$$

$$\mathbf{G_p} = \mathbf{I_p} \otimes \mathbf{G}_{p0}$$

Where,

y is vector of observations for daily milk yield, fat and protein content

X, Z_f, Z_a, Z_p are incidence matrices for fixed and random flock-test day (f), animal (a), and permanent environmental (p) effects

β, f, a, p are vectors of unknown parameters for the above effects

e is residual vector

A is additive genetic relationship matrix

R_0 is residual covariance matrix between traits of order 3

G_{f0}, G_0, G_{p0} are covariance matrices for flock-test day, animal and permanent environmental effects

I_f, I_p are identity matrices of order equal to number of levels in random flock-test day (f) and permanent environmental (p) effects

⊗, $\oplus^{n}_{j=1}$ are Kronecker product and direct sum (j denotes a test-day record)

Genetic parameters and covariance components (G_a, G_f, G_p and R) needed for breeding values predictions were simultaneously calculated using the above model. The variance ratios and correlations for additive genetic, flock-test day and permanent environmental effects are given in Table 1. Flock-test day effect was preferred to be modelled as random i.e. individual flock-test day classes were viewed as random samples from larger populations. Many levels and less numerous classes were identified, therefore, knowledge on the influence of flock-test day effect on traits' variability was of high interest. With Tsigai and Improved Valachian, a research study on estimates of covariance components was previously published (see Oravcová et al., 2005 for details). With Slovakian Lacaune, covariance structure was estimated under the presented resesearch.

PEST software package - direct solutions of mixed model equations (see the above model) from sparse matrix package solver (Groeneveld et al., 1993) were used for prediction of breeding values and estimation of individual levels of fixed and remaining random effects assumed to affect the above traits. As breeding goal of the selection scheme is to increase 150-day milk production and constant heritability is assumed throughout the whole lactation, breeding values for daily milk yield were multiplyied with constant 150 (= days). The fixed lactation length enables a comparison between animals and facilitates flock management (Basdagianni et al., 2004). Apart from breeding values, solutions for environmental effects were provided, of which solutions for flock-test day effect were taken into account when changes in production environment, i.e. variation due to management, nutrition, quality of pasture, changes from winter to summer feeding were analyzed.

Genetic trends were calculated as averages of predicted breeding values across birth years of animals and were expressed as deviations from the base populations which consisted of animals born in 1998. Environmental trends were calculated as averages of solutions for flock-test day effect across years and months in which measurements were taken. Phenotypic trends were calculated as averages of 150-day mik yield across birth years of animals. 150-day milk yield was calculated using the two-step procedure.

First, total milk yield over particular lactation length was calculated according to the Fleischmann method (ICAR, 2005) using the following formula (STN 46 6213, 1997):

$$y = i_1 \cdot y_1 + \sum_{i=1}^{k-1} \tfrac{y_i + y_{i+1}}{2} \cdot i_t + y_k \cdot 15$$

Where,

y is milk yield over particular lactation of length l

i_1 is number of days between the date of finishing the suckling period and the date of the first test-day meaurement

y_i is test-day milk yield (i = 1, ..., k)

i_t is number of days between the two succesive test days i and i+1

c = 15 is standardized length of drying period

Second, 150-day milk yield was calculated as follows (Anonymous, 1999):

$$y150 = y \cdot \frac{150}{l}$$

Where,

$y150$ is total milk yield calculated for 150-day lactation length

y is total milk yield calculated over lactation of length l

c = 150 is standardised length of lactation of ewes in Slovakia (150 d)

l is particular lactation length which begins after the end of suckling period.

RESULTS

The distribution of annual genetic and phenotypic changes for 150-day milk yield, fat and protein content for Tsigai and Improved Valachian ewes born in 1995-2003 and Lacaune ewes born in 1997-2003 is given in Tables 2, 3 and 4. An overall increase in 150-day milk yield was found for the three breeds. For fat and protein content, a low decrease in phenotypic values was found, probably associated with negative correlations between milk yield and milk composites (see Oravcová et al., 2005 and 2007 for genetic and phenotypic correlations) and selection oriented towards the increase in milk yield. Genetic changes for milk composites were negligible, except for Lacaune breed.

With phenotypic trends, the two different time periods could be identified for 150-day milk yield. The first period until 1999 (Tsigai and Improved Valachian) or 2000 (Lacaune) showed an increase by 9.5, 7.6 and 30.3 kg. The second period showed a stagnation (Tsigai and Improved Valachian) or even a decrease (Lacaune) in 150-day milk yield. The changes between the successive years found for Lacaune were less smooth, probably due to a smaller population size and a higher variation in number of ewes tested over the particular years. The cumulative phenotypic changes were about 6, 4 and 15 kg for Tsigai, Improved Valachian and Lacaune 150-day milk yield. A decrease between 2002 and 2003 was due to the fact that only ewes

Table 2. Genetic and phenotypic trend for 150-day milk yield (kg)

Birth year	Tsigai		Improved Valachian		Lacaune	
	Genetic	Phenotypic	Genetic	Phenotypic	Genetic	Phenotypic
1995	-0.53	88.8	-0.04	87.2		
1996	-0.06	92.2	+0.45	93.3		
1997	-0.67	95.5	+0.38	97.0	-3.60	158.9
1998	0	97.0	0	95.0	0	156.0
1999	+0.98	98.3	+0.44	94.8	+5.43	174.9
2000	+1.71	96.4	+0.27	92.8	+3.58	189.2
2001	+1.29	97.6	+0.66	93.7	-1.97	159.4
2002	+2.26	96.9	+0.65	94.7	+2.19	174.8
2003	+3.29	94.8	+1.6	91.0	+1.52	156.8

Table 3. Genetic and phenotypic trend for fat content (%)

Birth year	Tsigai		Improved Valachian		Lacaune	
	Genetic	Phenotypic	Genetic	Phenotypic	Genetic	Phenotypic
1995	+0.023	8.04	+0.005	7.62		
1996	+0.002	7.90	+0.008	7.67		
1997	+0.012	7.75	+0.005	7.46	-0.09	7.85
1998	0	7.65	0	7.26	0	7.76
1999	-0.014	7.46	+0.001	7.23	-0.17	7.19
2000	-0.008	7.38	-0.008	7.16	-0.27	6.7
2001	-0.012	7.22	+0.003	7.29	-0.25	6.47
2002	-0.005	7.34	+0.006	7.34	-0.31	6.54
2003	-0.007	7.17	-0.003	7.38	-0.25	6.58

Table 4. Genetic and phenotypic trend for protein content (%)

Birth year	Tsigai		Improved Valachian		Lacaune	
	Genetic	Phenotypic	Genetic	Phenotypic	Genetic	Phenotypic
1995	+0.002	5.86	-0.001	5.74		
1996	-0.002	5.83	0	5.79		
1997	+0.010	5.85	-0.002	5.78	+0.059	5.85
1998	0	5.83	0	5.75	0	5.57
1999	0	5.88	0	5.78	-0.019	5.50
2000	-0.005	5.84	-0.002	5.82	-0.087	5.60
2001	-0.001	5.86	-0.002	5.84	-0.045	5.46
2002	-0.008	5.84	+0.003	5.83	-0.077	5.47
2003	+0.002	5.80	-0.004	5.83	-0.059	5.6

at the first lactation were assigned to the latter year. The phenotypic trends for fat content showed a continual decrease for Tsigai (-0.87%) and Lacaune (-1.27%). For Improved Valachian, an initial decrease (-0.46%) was found until 2000. Afterwards, a low increase (+0.22%) was found. Negligible phenotypic changes for protein content for Tsigai and Improved Valachian were found. For Lacaune, an overall decrease (-0.25%) was found.

With genetic trends, no genetic response was found until 1997 and 1998 for Tsigai and Improved Valachian 150-day milk yield. Afterwards, positive genetic changes were shown. The cumulative changes were higher for Tsigai in comparison with Improved Valachian (3.8 vs. 1.6 kg), although phenotypic values were almost the same. An increasing genetic response for Lacaune 150-day milk yield was found until 2000. Afterwards, genetic response stagnated over years and changed minimally. The cumulative genetic gain was 5.1 kg. For the three breeds, annual genetic gains were 0.48 (Tsigai), 0.20 (Improved Valachian) and 0.85 kg (Lacaune). The cumulative genetic changes showed an overall decrease (-0.16 and -0.12%) for Lacaune fat and protein content. For the remaining breeds, negligible genetic changes were found for milk composites. Nevertheless, a decreasing tendency in genetic changes for Tsigai fat content was found.

Environmental changes expressed through flock-test day solutions for milk yield averaged over years and months are given in Figures 1, 2 and 3. The graphs are discontinuous to emphasize that ewes are milked only a certain period a year. The characteristic cyclical pattern was found, indicating that milk variability due to short-time changes in environment needs to be taken into account. The positive influence of spring months prevailed; probably reflecting good pasture availability in May and June. With the negative influence shown almost as a rule, a little conflicting appeared the measurements assigned to April. Probably pasture of poor quality and shortage in nutrition, temporarily appeared, are the reasons for this. Since breeding practice do not consider any additional hay or concentrate, improvements in feeding of ewes may be needed. It may also be assumed that the negative influence was not manifested or was negligible when nutrition requirements of ewes were met (compare 2000-2001 and 2003-2004 vs. 1997-1999, 2002 and 2005; Figure 1).

The environmental trends for milk yield were quite inconsistent among the breeds. For Tsigai and Improved Valachian, an overall improvement was found for the period of 1997-2000. Afterwards, the changes tended to stagnate. For Lacaune, an improvement observed until 2003, turned into an unfavourable effect later. It is not easy to identify

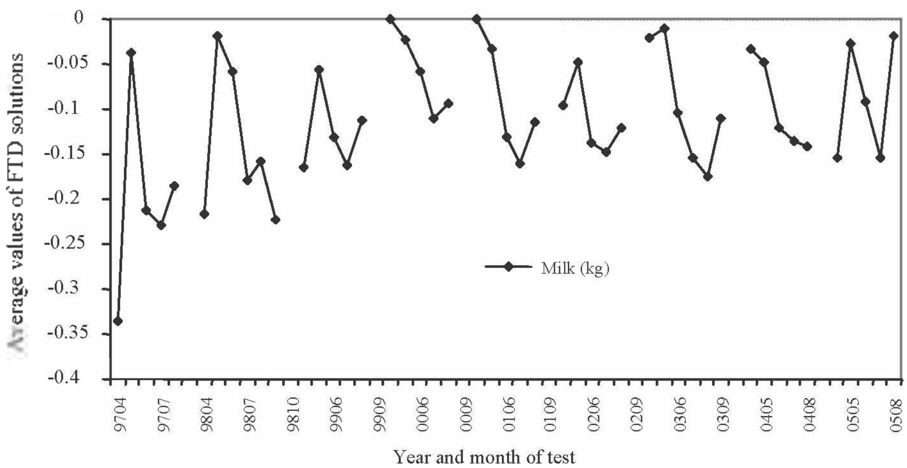

Figure 1. Environmental trend for daily milk yield (Tsigai breed).

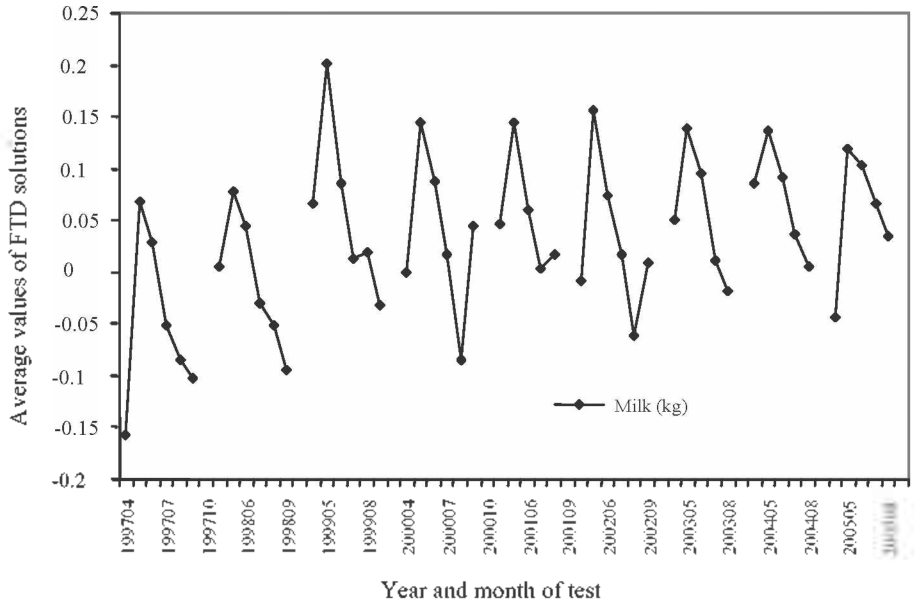

Figure 2. Environmental trend for daily milk yield (Improved Valachian).

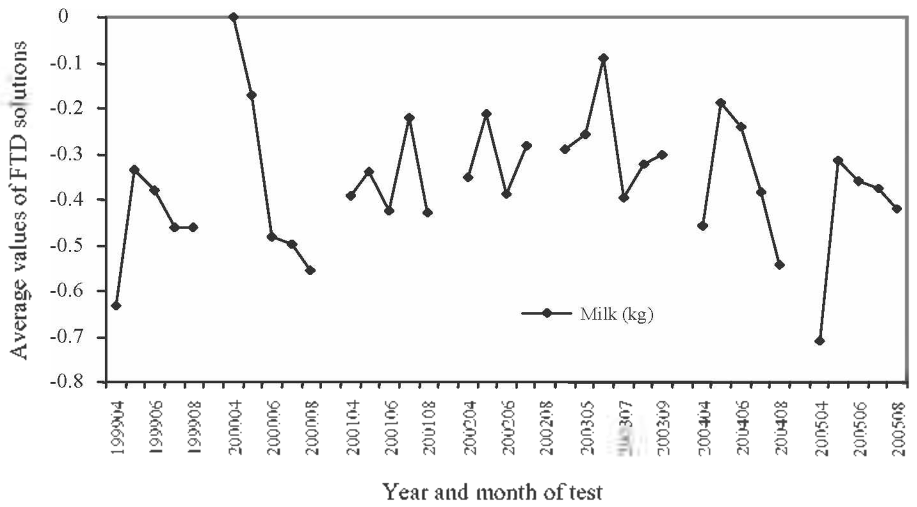

Figure 3. Environmental trend for daily milk yield (Lacaune).

this specific situation as relatively short period and a small population is analyzed. In connection with limited adaptation of imported genotype, this may indicate the necessity to improve the husbandry system and to give much care to ewes' nutrition requirements to be able to manifest genetic potential for high milk yield. The maximum environmental changes between the two successive year-month periods were 0.47, 0.29 and 0.47 kg for Tsigai, Improved Valachian and Lacaune milk yield (Table 5). The maximum phenotypic changes between the successive year-month periods were 0.53, 0.49 and 0.76 kg (data not shown). Being adjusted for the effects included in the evaluation model, environmental changes were lower than phenotypic changes. For fat and protein content, the environmental changes estimated over years and months also followed the characteristic cyclical pattern (not shown). This pattern was opposite to that found for milk yield, probably due to negative correlations between milk yield and milk composites. The maximum environmental changes between the two successive year-month periods were 1.56, 1.76 and 3.26% for Tsigai, Improved Valachian and Lacaune fat content.The maximum environmental changes between the two successive year-month periods were 1.15, 1.12 and 0.66% for Tsigai, Improved Valachian and Lacaune protein content.

DISCUSSION

The reports on genetic and environmental trends found in the literature for dairy sheep traits mostly analyzed milk

Table 5. Environmental differences in daily milk yield between the year-month periods

Time period comparisons	Differences		
	Tsigai	Improved Valachian	Lacaune
1997/5-1995/4	+0.30	+0.21	
1997/6-1995/5	-0.17	-0.04	
1997/7-1997/6	-0.02	-0.08	
1997/8-1997/7	+0.04	-0.04	
1997/9-1997/8		-0.01	
1998/5-1998/4	+0.20	+0.07	
1998/6-1998/5	-0.04	-0.03	
1998/7-1998/6	-0.12	-0.07	
1998/8-1998/7	+0.02	-0.02	
1998/9-1998/8	-0.06	-0.04	
1999/5-1999/4	+0.11	+0.13	+0.29
1999/6-1999/5	-0.08	-0.11	-0.05
1999/7-1999/6	-0.03	-0.07	-0.08
1999/8-1999/7	+0.05	0	0
1999/9-1999/8		-0.05	
2000/5-2000/4	-0.02	+0.14	-0.17
2000/6-2000/5	-0.04	-0.06	-0.31
2000/7-2000/6	-0.05	-0.07	-0.02
2000/8-2000/7	-0.02	-0.10	-0.05
2000/9-2000/8		+0.12	
2001/5-2001/4	-0.03	+0.09	+0.05
2001/6-2001/5	-0.10	-0.08	-0.08
2001/7-2001/6	-0.03	-0.06	+0.20
2001/8-2001/7	+0.04	+0.01	-0.21
2002/5-2002/4	+0.05	+0.16	+0.14
2002/6-2002/5	-0.09	-0.08	-0.18
2002/7-2002/6	-0.01	-0.06	+0.10
2002/8-2002/7	-0.03	+0.07	
2003/5-2003/4	+0.01	+0.08	+0.03
2003/6-2003/5	-0.09	-0.04	+0.16
2003/7-2003/6	-0.05	-0.08	-0.31
2003/8-2003/7	-0.02	-0.03	+0.07
2003/9-2003/8	-0.06		+0.02
2004/5-2004/4	-0.01	+0.05	+0.27
2004/6-2004/5	-0.07	-0.04	-0.05
2004/7-2004/6	-0.01	-0.05	-0.14
2004/8-2004/7	-0.01	-0.03	-0.16
2005/5-2005/4	+0.13	+0.16	+0.39
2005/6-2005/5	-0.07	-0.02	-0.04
2005/7-2005/6	-0.06	-0.04	-0.02
2005/8-2005/7	+0.14	-0.03	-0.04

yield, as selection is oriented towards the increase in milk. The reports which analyzed the remaining traits occurred less often. Most of the cited studies considered total milk yield a variable which entered the evaluation model. The adequacy of using total milk yield and methods applied for adjustment of milk yield for certain lactation length might be argued, however, some research based on the experimental data (Keskin and Dag, 2006) showed quite a good consistency beween the Fleischmann method (ICAR, 2005) and the more sophisticated approaches. Contrariwise, Cadavez et al. (2007) reported underestimation of milk yield at high production levels when various mathematical models were compared.

The phenotypic values for 150-day milk yield for Tsigai and Improved Valachian were mostly lower than phenotypic values for standardized milk yield reported by Moili and Pilla (1994), Ugarte et al. (1995), Sanna et al. (1995, 1997) and Serrano et al. (1996). The values 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). The values for Lacaune in Slovakia were lower than those for Lacaune in France. According to Barillet et al. (1992 and 2001a), stable phenotypic values about 270 L (nucleus flocks) and 220 L (commercial flocks) were observed for 165-day lactation over the period of 1995-1999. Contrariwise, the values about 80 L (135-day period) were observed in early 1960s when selection program was launched.

When production levels of milk yield between ewes in Slovakia and European countries are compared, the differences in lengths of suckling period (2 months vs. 1 month), lengths of lactation (90-, 120-, 135-, 150-, 165-day) and nutrition regimes need to be taken into account. Also, the adaptation potential of breeds has to be recognized. This was pointed out by Barillet et al. (2001a) who suggested to verify the adaptation of Lacaune breed to local conditions and/or to improve local husbandry system; particularly feeding. These are the main determinants which may enable Lacaune importers to produce as much as breeders in France.

Genetic values estimated for 150-day milk yield showed the lower progress than most of studies reported for sheep in Europe. Cumulative genetic changes 9.3 and 6.7 L (annual genetic gain 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). The recent analyses (Legarra et al., 2003) reported higher genetic improvements with annual genetic changes 2.97 and 2.95 L for Blond-Faced and Black-Faced Latxa over the period of 1985-1999. The annual genetic gain 0.5 L (cumulative genetic change of 2.5 L) was found for Manchega over the period of 1987-1992 (Serrano et al., 1996). The recent analyses of Jurado et al. (2006) showed that selection response for Manchega breed slightly increased (0.82 vs. 0.5 L), however, this value was lower than those reported for most of Spanish breeds. The reasons might partly be a result of the fact that the sires of sires path contributed to the total genetic gain negligibly, while the dams of sires path contributed by 60%. Jiménez and Jurado (2006) reported the annual genetic gain 4.66 L for Assaf that corresponded with cumulative genetic change about 30 L over the period of 1996-2003. For Lacaune in France (male population), genetic improvement 100 L was reported over the period of 1980-1997 (Barillet et al., 1998 and 2001a). The respective annual genetic gain was about 5 L, the same as the cumulative genetic change for Lacaune in Slovakia over the period of 1997-2003.

Astruc et al. (2002) reviewed genetic merits for male populations of various breeds in France. The respective annual changes were 4.33, 3.19, 3.53 and 0.81 L for Red-Faced Manech, Black-Faced Manech (Latxa in Spain), Basco-Béarnaise and Corsican rams. Apart from different lengths of time in which the breeding scheme was applied, the differences in the annual genetic gains might be attributed to the intensity of the artificial insemination in the nucleus flocks. The breeding scheme for Lacaune started in 1960s and the current artificial insemination rate accounts for 85%, whereas the breeding scheme for Corsican started in 1990s and the current artificial insemination rate accounts for 39%.

Serrano et al. (1996) reported the two different periods in genetic trend for Manchega ewes during the initial phase (1987-1992) of routine genetic evaluation. No selection response was observed within the first period, whereas an increase in genetic gain was observed within the second period. The authors explained this phenomenon by positive selection response in the latter period, since daughters of breeding males were selected according to their genetic value predictions. These findings were in accordance with our findingins for Tsigai and Improved Valachian, as both breeds showed the higher genetic responses during the recent years.

The slightly decreasing genetic trends for Lacaune fat and protein content agreed with findings for Black-Faced Latxa fat and protein content (cumulative genetic changes -0.14 and -0.25%) reported by Legarra and Ugarte (2004) who considered this fact being a result of an increasing milk yield. However, under specific circumstances a decrease in fat and protein content is not required. When cheese properties have to be maintained/improved, the increase in qualitative milk traits should be included in the selection scheme. For Lacaune in France, the revision in selection objective was done during 1990s (Barillet et al., 2001a). As a result, the predicted annual genetic gain for fat and protein content was 0.2 to 0.3 g/L over the period of 1992-1997. To avoid a decrease in fat and protein content with implications on cheese quality and farmer's income, the considerations on including the additional traits such as fat and protein content, somatic cell count, udder traits in the selection objective were reported for Spanish sheep (Legarra and Ugarte, 2004).

The positive effect of environment on milk yield was claimed by Barillet et al. (1992) and Moioli and Pilla (1994). Opposite to the former findings, Barillet et al. (2001a) reported a decrease in the positive influence of flock-year effect for Lacaune breed during the second half of 1990s and atributted this phenomenon to a diminution of ewe's feeding level so that farmers were enabled to comply with changes in the selection objective oriented towards maintaining the product quality of Roquefort cheese. A positive influence of spring months with rich pastures and a negative influence of summer months with poor and scarce pastures was reported by Cappio-Borlino et al. (1997). However, no considerations on animal model were employed in their investigations.

IMPLICATIONS

The positive genetic trends which reflected the increasing genetic potential for milk yield were found. The phenotypic trends were improved only in the beginning of the analyzed period, whereas a stagnation in milk yield was observed within the recent years. The possible reasons behind this might be the facts that routine genetic evaluation was introduced only recently and formerly applied selection based on dam's milk yield appeared to be of low efficiency across the whole populations. Although the environmental trends indicated a slight improvement in management of flocks, a stagnation (Tsigai and Improved Valachian) or even a decrease (Lacaune) in positive changes were observed with the time proceeded. Nevertheless, the analyses might be of high relevance when actions needed are to be identified and might be useful for breeding practise in countries searching for improvements in less productive breeds. The findings for Lacaune breed need to be verified when more data are available in the future.

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