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Economic Values for Dairy Sheep Breeds in Slovakia

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ABSTRACT : Economic values of 14 production and functional traits for two Slovak dairy sheep breeds (Improved Valachian and Tsigai) were calculated. Semi-extensive production systems with one lambing per year were simulated using a bio-economic deterministic computer model. The marginal economic value of a trait was defined as the partial derivative of the profit function with respect to that trait. The relative economic value expressed the percentage proportion of standardized economic value (marginal economic value×genetic standard deviation) of a trait in the sum of the absolute values of the standardized economic values over all traits. Milk yield was of highest relative importance (26% and 32% in Improved Valachian and Tsigai) followed by productive lifetime and conception rate of ewes (16% and 15% in Improved Valachian and Tsigai, in both traits). Conception rate of female lambs and litter size had nearly the same relative economic importance in both breeds (9% to 11%). Survival rate of lambs at lambing and till weaning reached slightly lower economic values (4% to 7%). The economic importance of all remaining traits was less than 4%. (**Key Words :** Dairy Sheep, Economic Weights, Milk Production, Functional Traits, Improved Valachian, Tsigai)

INTRODUCTION

Sheep farming plays a crucial role in Slovak agriculture. From the total number of about 230,000 ewes, 105,000 are milked ewes. The breeding programme for dairy sheep in Slovakia and in other countries has focused mainly on milk yield (Oravcova et al., 2005; Smulders et al., 2007). Recently, functional traits have become important for efficient breeding schemes in the dairy sheep industries, due to increased costs of production relative to milk prices, consumer demand for safe, quality food and societal attention to animal welfare (Barillet, 2007). Next in importance to milk production, lamb production accounts for a substantial part of income for dairy sheep farmers, e.g. 25 to 35% in Slovakia, 30 to 60% in the Mediterranean countries (FAO, 2008). Improving ewe reproductive performance, lamb survival and lamb growth is therefore important for modern breeding programmes in sheep (Legarra et al., 2007a; Fuerst-Waltl and Baumung, 2009).

Current breeding programmes for dairy sheep in Slovakia are based upon a performance test for milk production, reproductive traits and lamb growth. Breeding values are estimated for milk yield, fat and protein content (Oravcova and Peškovičova, 2008) and litter size (Margetin et al., 2006). All breeding sheep are selected on the basis of a simple selection index taking into account milk production and litter size. Growth intensity of lambs till weaning, exterior and fleece weight are also considered in animal selection. The weight of a particular trait in the index was assigned on the basis of a commission assessment of the economic importance of each trait.

To the best of our knowledge, economic values for traits in dairy breeds of sheep have been published in only three papers. Legarra et al. (2007a, b) reported economic values for Spanish breeds (Latxa and Manchega) and Fuerst-Waltl and Baumung (2009) published economic values for Austrian dairy sheep. No economic values for Slovak dairy breeds calculated at the population level have been available until now.

The aim of this study was therefore to calculate the economic importance (economic values) of traits currently included in the breeding objective as well as of further functional traits for the dairy sheep breeds in Slovakia.

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MATERIAL AND METHODS

Basic features of the production system and performance parameters

The most widespread dairy breeds in Slovakia are

Improved Valachian and Tsigai. Improved Valachian (IV) is mostly kept in mountain and foothill areas more than 800 m above sea level in the extensive or semi-extensive so-called Carpathian production system. Tsigai (TS) is one of the oldest native breeds kept in areas from 500 to 800 m above sea level, mostly in semi-extensive mountain farming. Both breeds are multi-purpose breeds. About 28,000 IV ewes including 16,000 ewes from 45 breeding flocks and approximately 19,500 TS ewes including 8,400 ewes from 25 breeding flocks are performance tested (PS SR, 2009).

A production system with winter indoor lambing and summer grazing on pasture is practiced in both breeds. Each breed is handled as a self-reproducing population (breeding and commercial flocks together) with breeding females and males bred for their own replacement. To improve meat production and carcass quality, about 10% of the ewe population is crossed with rams purchased from meat breed populations. There is one breeding season per year lasting from 1 Aug. to 30 Sept. for TS and from 1 Aug. to 15 Oct. for IV. Only natural mating is performed.

Females before the first lambing are called lambs and females after their first lambing are called ewes. Because of extensive rearing of replacement lambs, both female and male lambs are first used for mating at the age of 17 to 19 months (in the second breeding season following their weaning). Conception rate of females at this age is on average 85% for both breeds. Female lambs that did not conceive during their first breeding season are mated in the following year, where a 90% conception rate is achieved. All female lambs that failed to conceive are culled 90 days after this breeding season. Fifty percent of the ewes that did not conceive after first lambing are culled 90 days after this breeding season and 50% are retained to be mated in the next breeding season in the following year. Average lambing date is 10th February for TS and 15th February for IV.

After weaning and selling of lambs before Easter (on average at 5th April), ewes are milked twice a day till the end of the breeding season. Milk extracted from lambed ewes without sucking lambs is used for feeding lambs from litters with twins or triplets. From the total milk production, 40% is processed to cheese on farms; the rest is delivered to dairies.

Breeding rams for pure-breeding as well as cross-breeding are kept in the system for five breeding seasons. Survival rates of rams between the subsequent breeding seasons are on average 96%, 94%, 93% and 91%. The ewe-to ram ratio is 40:1 for rams older than two years and 35:1 for young rams which enter the flock at the age of 17 to 19 months.

For ewes, a maximum of nine reproductive cycles was assumed for the calculation. The main characteristics which are specific for reproduction cycles 1 to 9 are summarized in Table 1. On the basis of the given culling and conception

Table 1. Characteristics for ewes specific to reproductive cycles

Reproductive cycle	Death rate[1]	Culling for health problems[1]	Culling for low milk production[1]	Conception rate[1]	Percentage of		Milk adjustment factors[3]
					Singles[2]	Twins[2]	
Improved Valachian							
1	2.0	3.1	3.0	96.4	84.1	15.8	1.00
2	2.3	4.8	4.5	97.5	80.7	19.1	1.06
3	2.6	7.9	6.8	96.8	76.9	22.9	1.09
4	2.8	11.0	7.4	94.1	76.4	23.7	1.07
5	3.1	19.1	9.0	92.8	76.0	23.7	1.01
6	3.3	27.9	12.5	92.0	76.3	23.4	0.96
7	3.5	30.3	13.5	89.6	77.0	22.8	0.89
8	3.8	29.3	12.6	88.4	78.3	21.5	0.85
9	4.1	31.6	11.4	-	78.9	20.9	0.81
Tsigai							
1	2.3	3.6	3.5	95.4	84.1	15.8	1.00
2	2.5	4.1	4.1	96.5	79.1	20.8	1.02
3	2.8	7.6	6.4	95.8	76.1	23.7	1.07
4	3.0	7.5	6.7	93.2	73.9	25.8	1.09
5	3.2	14.6	8.9	91.9	73.1	26.7	1.02
6	3.5	24.6	12.4	91.4	73.3	26.5	0.93
7	3.7	29.5	13.1	90.9	73.6	26.2	0.87
8	4.0	29.9	13.5	90.4	74.2	25.6	0.80
9	4.2	33.5	14.1	-	74.8	25.1	0.76

[1] Expressed as percent of the ewes which entered each reproductive cycle. [2] The percentage of triplets is 100 minus the percentages of singles and twins.
[3] The adjustment factors relate milk yield in higher reproductive cycles to the milk yield predicted from the lactation curve for the first lactation.

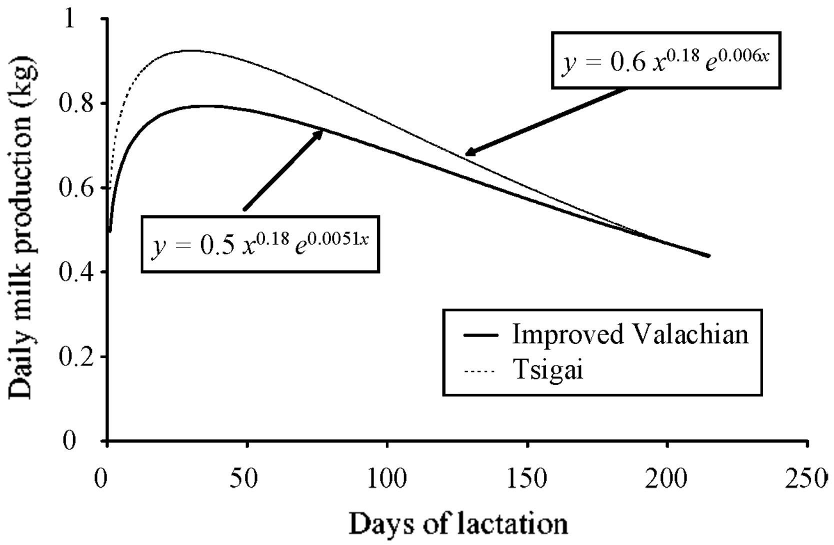

Figure 1. Lactation curves for ewes on the first lactation suckled by a single lamb.

rates, the stationary state of the ewe flock was calculated as described by Wolfová et al. (2009).

Milk production of both breeds was described by the Wood's lactation curve (Wood, 1967). Parameters estimated by Oravcová et al. (2006) were applied for the base lactation curves valid for first parity ewes with a single sucking lamb (Figure 1). For estimating milk yield for ewes in different parities, the adjustment factors given in Table 1 were applied. Adjustment factors for litter size were 0.872 and 0.859 for ewes without sucking lambs, 1.073 and 1.078 for ewes with twins, and 1.109 and 1.113 for ewes with three sucking lambs, for IV and TS, respectively.

Survival and growth traits from birth to weaning for lambs in both IV and TS populations are specified in Table 2. Growth pattern of lambs till weaning differed between male and female lambs as well as among litter size classes whereas survival rate till weaning was the same for female and male lambs and differed only among litter size classes. No differences were assumed in survival rates between pure-bred and cross-bred lambs, but birth and weaning weights of cross-bred lambs were on average 8% higher than those of pure-bred lambs. After weaning, differences in growth of replacements were made only between sexes (Table 3).

Economic efficiency of the production systems

The economic efficiency of both populations is expressed as the present value of profit (difference between total revenues and total costs, with addition of the governmental subsidies) per ewe per year. All revenues and costs are discounted to the birth date of each animal group. Therefore difference in time when a trait influences

Table 2. Survival and growth traits from birth to weaning for lambs

Variable	Improved Valachian			Tsigai		
	Singles	Twins	Triplets	Singles	Twins	Triplets
Probability that only one lamb is stillborn or died until 24 h[1]	0.030	0.035	0.041	0.037	0.039	0.045
Probability that two lambs are stillborn or died until 24 h[1]	-	0.006	0.019	-	0.010	0.025
Probability that three lambs are stillborn or died until 24 h[1]	-	-	0.010	-	-	0.011
Survival rate of lambs until weaning[1]	0.90	0.79	0.68	0.88	0.75	0.63
Birth weight of pure-bred lambs (kg)						
Females	3.40	2.80	2.00	3.60	3.00	2.10
Males	3.70	3.00	2.10	3.80	3.20	2.40
Weaning weight of pure-bred lambs (kg)						
Females	13.60	11.10	7.90	14.60	12.10	8.60
Males	15.30	12.90	9.30	16.70	13.90	9.90

[1] Pure-bred and cross-bred lambs together.

Table 3. Growth patterns of breeding animals in different periods

Variable	Improved Valachian		Tsigai	
	Females	Males	Females	Males
Growth rate from weaning till first breeding season after weaning (g/d)	135	162	144	171
Growth rate from first to second breeding season (g/d)	51	66	55	77
Mature weight (kg)	50	70	55	80
Weight gain during flushing (= weight loss during advanced pregnancy) (kg)	3	-	3	-

revenues and costs in the life of an animal is taken into account. Revenues come from sold milk and cheese, from weaned lambs, culled ewes and rams, wool and manure. The average milk price is calculated as a function of milk fat and protein content and somatic cell count (SCC). In Slovakia, a base milk price is paid for milk with at least 5.50% fat, 4.80% protein and with a SCC less than 1.5 million cells/ml of milk. A penalty of 0.40 EUR/kg milk is subtracted from the base price if milk components do not reach the required values. A penalty of 7.3 Eurocents/kg milk is subtracted if SCC lies between 1.5 and 3.0 million cells/ml. For values higher than 3.0 million, the penalty is 0.15 EUR/kg.

Slaughter animals are sold on a live-weight basis. The price for cross-bred lambs sold at weaning is 10% higher than for pure-bred lambs. Wool is sold as greasy wool independent of quality. Manure is gathered and sold only during winter. Input parameters for the calculation of revenues are summarized in Table 4.

Costs included in the calculation were those for feeding, winter housing, labour, health care, milking, cheese production, shearing, purchasing rams for crossing and fixed costs which covered depreciation expenses, energy, repairs, insurance and overhead costs.

Feeding costs were calculated on the basis of the feed needed to meet energy and protein requirements of animals for growth, maintenance, pregnancy, wool and milk production. Milk available for lambs until weaning was insufficient for the growth potential of lambs, so that supplementary concentrates and hay were made available. The base nutrition requirements of all other sheep categories were covered using pasture, hay and straw during summer and hay, grass silage and straw during winter. Compound feedstuffs, oat grain and rape seed were purchased for supplementary feeding of lactating and advanced pregnancy females, for flushing of female replacement stock and for feeding of breeding rams.

So as not to exceed the dry matter intake capacity of animals and to meet their net energy and protein requirements, feeding rations for particular animal categories were balanced according to their reproductive and productive status. The program Feedman (Petrikovič et al., 2003) was applied for formulating these feeding rations (Table 5). The feeding rations included mineral additives also. The calculated feed requirements were then increased by 10% (IV) and 13% (TS) for the pasture period, and by 6% for winter feeding for both breeds to take into account feed wastage. Feed losses for supplementary feeding of lambs till weaning were assumed to be 5%. Summer and winter water requirements for all categories of animals were determined according to Infascelli et al. (2005).

Compound feedstuffs and concentrates were assumed to be purchased for market prices. These prices were obtained from the Agricultural Paying Agency of Slovakia and our own investigations in the years 2005 to 2007. Hay and grass silage for winter feeding were assumed to be harvested

Table 4. Parameters used for calculating revenues

Parameter (units)	Improved Valachian	Tsigai
Fat content in milk (%)	7.59	7.71
Protein content in milk (%)	5.76	5.83
Phenotypic standard deviation of fat content (%)	0.87	1.03
Phenotypic standard deviation of protein content (%)	0.46	0.49
Somatic cell score	4.95	4.95
Phenotypic standard deviation of somatic cell score	0.23	0.23
Base price for milk (EUR/kg)	0.78	0.78
Cheese price (EUR/kg)	6.57	6.57
Cheese whey price (EUR/kg)	0.73	0.73
Price for wool (EUR/kg)	0.73	0.73
Price for pure-bred lambs sold at weaning (EUR/kg)	2.99	3.00
Price for culled sheep (EUR/kg live weight)	0.74	0.74
Manure price (EUR/100 kg)	0.40	0.40

Table 5. Feeding rations for different animal categories of Improved Valachian (IV) and Tsigai (TS)

Category of animals	Dry matter content (kg/kg fresh matter)		Net energy (MJ/kg dry matter)		Digestible protein (g/kg dry matter)		Price (Eurocents/kg fresh matter)	
	IV	TS	IV	TS	IV	TS	IV	TS
Lactating ewes with one lamb in winter	0.705	0.737	5.94	5.86	85.0	86.2	6.56	5.58
Lactating ewes with more lambs in winter	0.734	0.772	6.10	5.98	93.3	90.6	6.88	6.18
Lactating ewes in summer	0.383	0.383	6.12	6.18	86.0	85.9	2.95	2.57
Barren ewes and low pregnant females								
Summer	0.267	0.307	5.32	5.23	64.5	64.1	1.44	1.20
Winter	0.663	0.763	5.13	4.78	59.9	53.7	4.73	3.17
High pregnant females	0.713	0.781	6.72	6.00	83.9	76.3	5.52	4.41
Flushing of females	0.250	0.280	5.69	6.15	71.3	78.7	1.91	1.82
Rams in breeding period	0.779	0.770	5.25	5.22	58.3	61.6	4.52	3.71
Rams outside of breeding period	0.689	0.870	5.03	5.05	56.4	58.8	4.37	3.42
Lambs till weaning	0.895	0.895	7.20	7.20	165.8	165.8	34.98	34.98
Breeding lambs in rearing								
Summer	0.350	0.387	5.31	5.66	69.4	79.0	2.81	2.51
Winter	0.728	0.700	5.41	5.38	70.1	74.0	6.62	5.58

from pastures and meadows. Prices for these feeds were therefore calculated on the basis of production costs taking into account that IV and TS breeds are kept in different agricultural areas.

Housing costs covered those for bedding material (straw). Labour costs included only general labour costs which were calculated according to the average time needed per animal of each category per year. The specific labour costs were those for shearing, because shearing is done by contract workers. The part of the labour costs depending on milk yield was included in the milking costs. Labour costs connected with cheese processing were included in the costs for cheese production. For 1 kg of cheese, 4.6 litres of milk were assumed to be needed. Milking costs expressed per kg milk were only those costs which depended on milk yield (e.g. costs for energy for cooling, transport, part of labour costs).

Health care costs comprised mainly the costs for drenching against endo-parasites (depending on liveweight) and for treatment against ecto-parasites. Other veterinary costs (drugs and veterinary service except those for parasite treatments) were added. The main input parameters set for cost calculations are listed in Table 6.

The following subsidies from the EU and from the Slovak government were added to the profit: single area payments, support per crops grown on arable land (oat, rape seed, etc.), support for less favourable areas and direct payment per ewe (EC Regulation No 1257/1999). The average subsidies per ewe per year in both breeds were obtained as mean values from the subsidies given to all sheep farms in Slovakia in the year 2006; they were 84.63 EUR per ewe per year for IV and 70.64 EUR per ewe per year for TS.

Economic values of traits

The traits which influenced revenues and costs in the described production systems in both breeds were milk yield, milk fat and protein content, birth weight of lambs, growth rate of lambs from birth to weaning, growth rate of breeding lambs, fleece weight, conception rate of female lambs and ewes, average litter size (total number of lambs born) per lambed ewe, survival rate of lambs to 24 h of age and from 24 h until weaning, and productive lifetime of ewes.

The definition of traits and a detailed description of the assumptions made for the calculation of economic values for these traits can be found in Wolfová et al. (2009); for that reason, only some important points are emphasized here.

The economic value for milk yield was expressed per kg milk in the standardized milking period (150 days). When changing litter size, the survival rates of lambs within each litter size were held constant and *vice versa* to avoid double counting, as both litter size and survival rates of lambs were evaluated. Productive lifetime of ewes was defined as functional lifetime, i.e. only involuntary culling for health and the death rate of ewes were changed when calculating the economic value of this trait.

The marginal economic value of trait i (ev_i) was defined as the partial derivative of the profit function with respect to that trait (Wolfová et al., 2005) and approximated by the difference quotient because of the high complexity of the profit function. An annual discount rate of 1.5% estimated as the difference between investment rate and inflation rate

Table 6. Main input parameters used to calculate costs (The parameters are equal for both breeds)

Parameter	Ewes[1]	Rams	Breeding lambs from	
			Weaning to 1st breeding	1st to 2nd breeding
Number of treatments against endo-parasites[2]	1	1	1	1
Number of treatments against ecto-parasites[2]	1	1	1	1
Other veterinary costs[2] (service+drugs)	8.36	3.69	1.20	3.69
Number of man-hours per animal per year[3]	7	3	3	3
Number of shearings per animal per year	1	1	1	1
Fixed costs per stable place (EUR/d)	0.110	0.077	0.080	0.080
Cost per shearing (EUR/animal)	2.48	3.65	0.00	1.90
Amount of bedding material in winter (kg per animal per d)	0.50	0.50	0.40	0.40
Costs for milking (EUR/kg milk)	0.20	-	-	-
Cost for cheese production (EUR/kg cheese)	1.83	-	-	-
Price for breeding rams for crossing (EUR/ram)	-	460	-	-
Price for drugs against endo-parasites (EUR per 10 kg live weight per treatment)			0.199	
Price for drugs against ecto-parasites (EUR/animal per treatment)			0.593	
Price for bedding material (EUR/100 kg)			1.83	
Costs for removing and rendering dead animals (EUR/kg live weight)			0.427	
Price for water (EUR/100 L)			0.110	

[1] Including lambs till weaning.
[2] These items are given per animal and per year for ewes and rams and per individual periods (from weaning till the 1st breeding season, from the 1st to the 2nd breeding season) for breeding lambs.
[3] For ewes this time included treatment of lambs till weaning and excluded milking and cheese production.

in the Slovak Republic in the evaluated time period was used in the calculations.

To compare the economic importance of different traits, the marginal economic values were standardized by multiplying them with the genetic standard deviations (σ_{gi}) of the corresponding traits: $evs_i = ev_i\sigma_{gi}$ where evs_i is the standardized economic value of trait i. The absolute values of the standardized economic values were then expressed as percentages of their sum resulting in relative economic values (evr_i):

$$evr_i = 100 \times |evs_i| / \sum_i |evs_i|$$

Values of genetic standard deviations unavailable for the local sheep populations were estimated using the phenotypic standard deviations of these populations and literature values for the heritabilities (the median of the estimates published for milk sheep by Safari & Fogarty, 2003). All calculations were carried out using the ECOWEIGHT package program for sheep (Wolf et al., 2008).

RESULTS

The structure of the ewe flock at the stationary state for both breeds is given in Figure 2 and the corresponding structure of progeny in Table 7. The structures generated by the model agreed well with the real structures of the modelled populations. The numbers of lambs till weaning given in Table 7 include both pure-bred and cross-bred progeny whereas the proportion of cross-bred lambs was approximately 10% in both breeds. There were 79.2 singles, 41.2 twins and 0.7 triplets born in total per hundred lambings per year for IV. The corresponding numbers for Tsigai were 77.6, 44.6 and 0.5, respectively.

The estimated profit per ewe present in the flock at lambing time and per year was 36 EUR, i.e. the same with

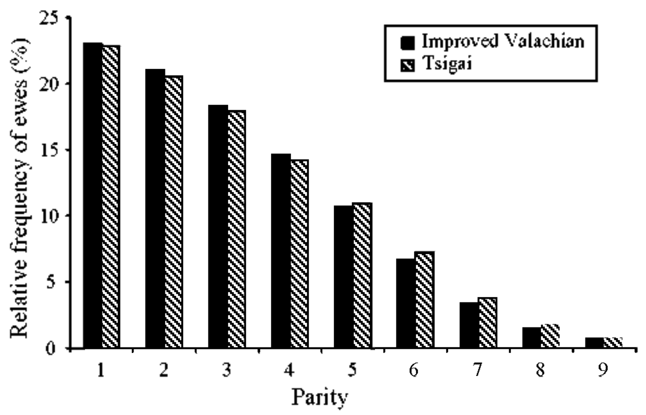

Figure 2. Distribution of the ewes across the parities at the stationary state of the flock.

Table 7. Structure of progeny per 100 ewes which occurred in the flock at time of lambing and per year

Parameter	Improved Valachian	Tsigai
Rams for pure-breeding	2.23	2.23
Rams for cross-breeding	0.27	0.27
Total number of lambs born[1]	120	121
Lambs weaned[1]	114	114
Female lambs sold at weaning for slaughter[1]	29.5	29.8
Male lambs sold at weaning for slaughter[1]	56.6	56.6
Female breeding lambs from weaning to the 1st breeding season	26.8	26.6
Female breeding lambs from the 1st to the 2nd breeding season	25.4	25.2
Male breeding lambs from weaning to the 1st breeding season	0.50	0.50
Male breeding lambs from the 1st to the 2nd breeding season	0.45	0.45

[1] Values include pure-bred and cross-bred lambs.

the IV as well as with the TS breed. The profit for IV resulted from 142 EUR of revenues, 191 EUR of costs and 85 EUR of subsidies. The corresponding numbers for TS were 148 EUR, 182 EUR and 70 EUR. The profitability (calculated as ratio of profit and costs and expressed as percentage) of the modelled systems (18.4% for IV and 20.0% for TS) was positive only when including subsidies in the economic results. Without subsidies, the production systems with IV and TS would operate with losses of 49 EUR and 34 EUR per ewe per year. The subsidies were relevant only for profit; they did not influence the economic values of traits as they did not depend on animal performance.

The revenues from lambs sold at weaning contributed 24% and 25% of the total revenues in IV and TS, respectively. The revenues from milk and from cheese accounted for 24% and 41% of the total revenues in both breeds.

The marginal economic values for all evaluated traits together with means and genetic standard deviations for both breeds are summarized in Table 8. These economic values express the change in profit per ewe per year when increasing the mean of the evaluated traits by one unit.

The economic values of most traits were similar for both breeds. The differences obtained in birth weight, mature weight and fat content are probably caused by the different levels of these traits in both breeds. Fat and protein content in milk reached relatively low economic values

Table 8. Means $\bar{x}$, genetic standard deviations (σ_g) and marginal economic values (*ev*, in EUR per unit of the trait, per ewe and per year) for all traits

Trait (units)	Improved Valachian			Tsigai		
	$\bar{x}$	σ_g	*ev*	$\bar{x}$	σ_g	*ev*
Milk yield in the standardized milking period of 150 d (kg)	68.6	9.64	0.898	75.5	13.98	0.862
Fat content in milk (%)	7.59	0.315	-0.073	7.71	0.426	0.197
Protein content in milk (%)	5.76	0.172	1.41	5.83	0.207	1.32
Birth weight (kg)	3.40[1]	0.140	1.79	3.60[1]	0.148	1.21
Growth rate from birth to weaning (g/d)	0.208[1]	14.18	0.0803	0.204[1]	13.91	0.0882
Mature weight (kg)	50[1]	2.8	-0.492	55[1]	3.06	-0.317
Growth rate in rearing of breeding animals (g/d)	135[2]	6.3	-0.0488	144[2]	6.7	-0.0421
Fleece weight (kg)	5.0[3]	0.48	0.487	4.4[3]	0.49	0.484
Conception rate of female lambs (%)	92.8[4]	6.83	0.478	91.2[4]	7.51	0.447
Conception rate of ewes (%)	95.3[5]	5.60	0.946	94.5[5]	6.06	0.901
Average litter size per lambed ewe (lambs)	1.21[5]	0.136	26.14	1.23[5]	0.139	27.98
Survival rate of lambs at lambing (%)	95.9[6]	5.23	0.387	95.0[6]	5.79	0.427
Survival rate of lambs from 24 h after birth till weaning (%)	98.4[6]	3.32	0.445	98.1[6]	3.67	0.486
Length of productive life of ewes (years)	3.07	0.327	16.49	3.13	0.338	16.28

[1] Females. [2] Female lambs from weaning till the 1st breeding period following their weaning. [3] Rams.

[4] Averaged over all breeding seasons for female lambs. [5] Averaged over all reproductive cycles.

[6] Averaged over all litter sizes and reproductive cycles.

because of the milk pricing system, in which no bonuses are paid for superior fat and protein percentage. Moreover, the average values of milk fat content were in both populations (7.6 and 7.7% in IV and TS, respectively) already much higher than the threshold value below which penalty was subtracted from the base milk price. The average milk price (77.44 Eurocents/kg for IV, 77.15 Eurocents/kg for TS) was close to the base milk price (78.50 Eurocents/kg). Negative economic values were derived for fat content in the IV breed and for growth rate of breeding lambs and mature weight in both breeds.

Table 9 summarizes the standardized and relative economic values. The results were similar for both breeds. Comparing the relative economic values of all traits, milk yield was the most important trait in both breeds (26% in IV and 32% in TS). Conception rate and length of the productive life of ewes were the next most important traits reaching nearly half of the importance of milk yield. Conception rate of female lambs and litter size contributed to the sum of the absolute values of standardized economic values with 9% to 11% and thus reached about one third of the importance of milk yield. Survival rates of lambs at lambing and till weaning showed an economic importance from 4% to 7% in both breeds.

The complexes of milk production, meat production, functional and wool traits took a share of 27%, 9%, 63% and 1%, respectively, in Improved Valachian and 33%, 7%, 59% and 1%, respectively, in the Tsigai breed in the sum of the absolute values of the standardized economic values.

DISCUSSION

Economic values have been calculated for non-dairy (Amer et al., 1999; Kosgey et al., 2003; Conington et al., 2004) and dairy sheep (Legarra et al., 2007a, b; Fuerst-Waltl and Baumung, 2009). Different methods used for calculation of economic values (reviewed e.g. by Krupová et al., 2008), variability in the production systems and breeds, trait definitions as well as economic and marketing conditions for sheep products make the comparison of published economic values difficult. So the relative share of different sheep products in the total income can have a significant impact on the relative importance of some traits. Furthermore it makes a difference if the whole population is modeled (as it should be for the derivation of economic values for a certain breed) or only a single farm is considered. Nevertheless, some comparisons can be made of the economic values of traits defined in the same way.

The marginal economic values for milk yield calculated for Slovak dairy sheep (0.90 and 0.86 EUR/kg) are within the range of values calculated by Legarra et al. (2007a) for Spanish dairy breeds (0.69-1.44 EUR/L). The value given by Fuerst-Waltl and Baumung (2009) is lower (0.33 EUR/kg) because it refers to milk carrier, and milk yield in Austria is much higher than in Slovakia or Spain. In agreement with Fuerst-Waltl and Baumung (2009), a higher economic value for protein content (yield) was calculated than for fat content (yield) in our study. The economic values for fat and protein content (yield) may be strongly influenced by the milk pricing system. Whereas in Austria the milk price is a linear function of the fat and protein content where the bonus per 1% of protein is 1.67 times higher than for fat content, in Slovakia no bonuses are paid for fat or protein content higher than certain thresholds, but penalties (the same for fat and protein) are subtracted for lower values. A negative value for fat content was obtained

Table 9. Standardized economic values (*evs*, in EUR per genetic standard deviation) and relative economic values of traits (*evr*, in % of the sum of the absolute values of the standardized economic values)

Trait	Improved Valachian		Tsigai	
	evs	*evr*	*evs*	*evr*
Milk yield in the standardized milking period of 150 d	8.66	26.05	12.05	31.90
Fat content in milk	-0.023	0.07	0.0840	0.22
Protein content in milk	0.243	0.73	0.274	0.72
Birth weight	0.250	0.75	0.179	0.47
Growth rate from birth to weaning	1.14	3.42	1.23	3.25
Mature weight	-1.38	4.14	-0.970	2.57
Growth rate in rearing of breeding animals	-0.308	0.93	-0.282	0.75
Fleece weight	0.234	0.70	0.237	0.63
Conception rate of female lambs	3.27	9.82	3.36	8.89
Conception rate of ewes	5.30	15.93	5.46	14.46
Average litter size per lambed ewe	3.56	10.70	3.89	10.30
Survival rate of lambs at lambing	2.02	6.09	2.47	6.55
Survival rate of lambs from 24 h after birth till weaning	1.48	4.45	1.78	4.72
Length of productive life of ewes	5.39	16.22	5.50	14.60
Sum of the absolute values	33.2	100	37.8	100

for IV whereas a positive value was calculated for TS because of the 15% more expensive feeding rations for lactating IV ewes (Table 5).

The proportion of milk processed to cheese on farm had an important impact on the economic values of milk production traits and productive lifetime of ewes. Selling all milk to dairies while keeping all other input parameters in our calculation constant, the marginal economic value of milk yield and productive lifetime would drop whereas the importance of milk components would rise (results of this calculation are not shown in the paper). It should be mentioned that the relation of fat and protein content to the recovery factor for milk to cheese production has not been included in the present model because of the absence of relevant data. This can cause an underestimation of the economic importance for milk components. As no special breeding programme is running for cheese- and milk-producing farms in Slovakia, our calculation included the joint analysis of milk (60% of farms) and cheese (40% of farms) farms. Legarra et al. (2007a) have shown that the economic values for fertility (conception rate), prolificacy (number of lambs born) and milk yield was higher for cheese-seller farms than for milk-seller farms.

In our calculation which was based on a closed population model, productive lifetime of ewes was an important trait with a high economic value. On the other hand, when considering an open flock model as did Fürst-Waltl et al. (2006) who included the possibility to sell breeding animals, even a negative economic value of the productive lifetime of ewes may be achieved. This value turns to a positive one if the sale of breeding rams is not allowed. The relatively low value (1.9 EUR per year) calculated by Legarra et al. (2007a) may be explained by the fact that these authors assumed only a saving in costs for replacement when increasing productive lifetime of ewes, whereas, next to a change in replacement costs, the impact of prolonged lifetime of ewes on the age structure of the flock was taken into account in our study. This influenced also the total milk and lamb production per ewe per year.

Among the reproduction traits, litter size was found to be an important trait not only in our study but also by Fuerst-Waltl and Baumung (2009) and Legarra et al. (2007a), the marginal economic values being in the range from approximately 30 to 50 EUR/lamb in all papers.

Economic values for meat traits (growth rate of lambs or weaning weight and mature weight) have been published for meat sheep (i.e. Kosgey et al., 2003; Conington et al., 2004) and particularly for dairy sheep (Fuerst-Waltl and Baumung, 2009). Weaning weight or growth rate of lambs has generally a higher economic importance in meat than in dairy sheep as the share of the income from sold lambs in the total revenues for meat sheep is higher than for dairy sheep. Depending on the production system, Conington et al. (2004) estimated a proportion of 32% to 45% of the total revenues, whereas only 22% to 23% were calculated in our study and 11% proportion was estimated by Fuerst-Waltl and Baumung (2009). The estimated economic impact of increased mature weight in sheep, similarly to cattle, was mostly negative (Conington et al., 2004; Morais and Madalena, 2006) which is in agreement with our finding. Higher feed costs for growth and maintenance of heavier animals were not balanced by higher revenues from heavier culled ewes and rams in our study. The negative value for growth rate of replacements was caused by the fact that the great majority of females were mated in the same breeding season (at about 18 months of age). A higher growth rate caused higher feeding costs for replacement per day, but no additional savings (shortening of rearing period, decreasing of total feeding costs in the rearing period, and a lower age of females at first lambing). However, a positive estimate was found by Kosgey et al. (2003) for fixed feed resources.

Fuerst-Waltl and Baumung (2009) estimated next to longevity the lowest relative economic importance for stillbirth, dressing percentage and EUROP grading score. These traits did not reach 3% of the economic importance of the whole trait complex. Amer et al. (1999) also estimated low economic values for survival rate of lambs at lambing and till weaning. In our calculation, the relative importance of lamb survival rate at birth and till weaning (which are in principle the same traits as lamb losses) were nearly the same (from 4% to 7% of the total importance of all traits). The lower economic importance of these traits can be explained by the high level of these traits (the lambs were born and reared in the stall) and by the relatively low share of revenues from lambs in the total revenues (ca. 20%). Economic values for carcass traits could not be calculated for the Slovak dairy populations because all animals were sold on a live-weight basis.

Legarra et al. (2007b) calculated also the economic value for somatic cell score (SCS). Somatic cell count (SCC) has not been routinely recorded for sheep in Slovakia, and was available only from some farms for this study. As all these sample data did not show sufficient variability (all data belonged to the same score), no economic value for SCS could be calculated.

IMPLICATIONS

For dairy sheep breeds kept in semi-extensive production systems, milk yield, conception rate (ewes and female lambs), productive lifetime of ewes and litter size showed the highest economic importance. The main conclusion for both Slovak breeds is that female fertility traits and productive lifetime of ewes should be further investigated for their inclusion in an economic selection index in addition to milk yield and litter size. A very low economic importance was calculated for wool production under the present market prices of wool. Low economic weights for milk components are currently influenced by the milk pricing system and insufficient information on the relationship between milk components and cheese production. After including this relationship into the calculations the economic weight of milk components will probably increase.

The developed model and computer program may be useful for calculating economic values in further sheep populations.

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