Estimation of economic values for traits of dairy sheep: II. Model application to a production system with one lambing per year

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ABSTRACT

A bioeconomic model for dairy sheep was applied to a production system with one lambing per year. The classical extensive Carpathian system with indoor winter lambing, traditional weaning, sale of surplus lambs before Easter, and a summer milking period with ewes on pasture was modeled. The economic values of 15 performance and functional traits were calculated for the Slovakian Improved Walachian multi-purpose breed. The economic values per unit increase in the traits were 0.32 €/kg of milk yield during the standardized milking period of 150 d, 0.29 €/0.1% milk fat, 0.42 €/0.1% milk protein, 0.28 €/‰ and 0.56 €/‰ for conception rates of female lambs and ewes, respectively, 0.20 €/0.01 lamb born, 0.0036 €/‰ and 0.0040 €/‰ for lamb survival at birth and until weaning, respectively, 0.65 €/kg of birth weight, 0.032 €/g per d daily gain from birth until weaning, –0.030 €/kg of mature weight, –0.38 €/0.1 and –0.21 €/0.1 conformation quality grade for weaned lambs and adult sheep, respectively, 0.42 €/kg of fleece weight and 11.10 €/year of productive lifetime for ewes.

Key words: dairy sheep, bioeconomic model, economic value

INTRODUCTION

About 35% of the world's sheep milk is produced in the European Union. Products from sheep such as milk, cheese, and lamb meat are in high demand on the national and international markets. To keep dairy sheep farming competitive in the European market, it is imperative that management, husbandry systems, and genetic merit of dairy sheep be improved. In Slovak agriculture, dairy sheep farming has an important role. The breeding program for dairy sheep in Slovakia and in other countries has focused mainly on improving milk yield (Oravcová et al., 2005; Smulders et al., 2007).

Recently, functional traits have become important for efficient breeding schemes in the dairy sheep industries, because of increased costs of production relative to milk prices, consumer demand for safe, quality food, and greater awareness of animal welfare (Barillet, 2007). Next in importance to milk production, lamb production accounts for a substantial part (e.g., 35 to 45% in Slovakia or Austria) of the income for dairy sheep farmers. Improving ewe reproductive performance, lamb survival, and lamb growth is therefore important for modern breeding programs in dairy sheep (Legarra et al., 2007a; Fuerst-Waltl and Baumung, 2009).

Current dairy sheep breeding programs in Slovakia are based upon a performance test for reproduction, lamb growth, and milk production, and breeding values are estimated for milk yield, fat and protein content (Oravcová, 2007), and litter size (Margetín et al., 2006). A breeding value estimation program for weaning weight is in preparation.

Economic values for traits in dairy breeds of sheep have been published only recently. Legarra et al. (2007a, b) reported economic values for the Spanish breeds Latxa and Manchega, and Fuerst-Waltl and Baumung (2009) published economic values for Austrian dairy sheep. No economic values for Slovakian dairy breeds have been available until now.

The objective of this paper was, therefore, to apply and validate a previously described bioeconomic model (Wolfová et al., 2009) and the corresponding computer program (Wolf et al., 2008) to the calculation of economic values for the most important traits in dairy or multi-purpose sheep. The most widespread multi-purpose sheep breed in Slovakia, Improved Walachian, was chosen for the example calculations.

MATERIALS AND METHODS

Description of the Production System for Improved Walachian Sheep

The Improved Walachian sheep breed was developed in 1982 as a multi-purpose breed with emphasis on satisfactory milk, meat, and wool production. It is a

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Table 1. Characteristics specific to reproductive cycles (parities)

Parity	Ewes died or culled as percentage of ewes entering the reproductive cycle			Conception rate (%)	Percentage of singles ¹	Coefficients for milk yield ²
	Ewes died	Ewes culled for health problems	Ewes culled for low milk production			
1	6.0	8	12.1	95.4	89	1.00
2	3.6	7	10.1	95.6	69	1.31
3	2.4	2	5.5	95.8	65	1.15
4	2.4	2	4.4	93.2	66	1.08
5	2.4	9	5.5	91.9	71	0.99
6	3.6	14	10.0	91.0	74	0.90
7	4.5	18	12.1	90.4	71	0.86
8	5.6	20	13.8	87.8	75	0.80
9	5.9	25	16.2	85.9	76	0.77
10	6.4	37	21.0	—	78	0.72

¹The percentage of twins is 100 minus the percentage of singles.

²The coefficients relate milk yield in higher parities to predicted milk yield (calculated from the lactation curve) in the first lactation.

mountain sheep belonging to the Zackel group. Recently, the breeding goal for this breed has been to improve milk production and fertility. Improved Walachian is the most widespread breed in Slovakia, with 27,700 ewes and 800 rams in 2006 (PSSR, 2009). It is found mostly in mountain and foothill conditions, more than 800 m above sea level and in both extensive or semi-extensive production systems. For the economic value calculations, the extensive so-called Carpathian production system for Improved Walachian in Slovakia was assumed, with winter lambing indoor and summer grazing on extensive mountain and hill pastures.

As inputs to the model, the average lambing date was February 8, and the milking period started after weaning on April 5 and lasted until November 30. Natural mating of females was performed between September 1 and November 30, during the milking period. Ewes that did not conceive were culled 60 d after the end of the breeding season. As an exception, however, 80% of the ewes that did not conceive following their first lambing and 50% of ewes that did not conceive after their second lambing were retained to be mated in the next breeding season in the following year. All remaining ewes were culled at the end of their tenth reproductive cycle.

All female replacements and 16% of required male replacements were reared on farm, and 84% of required male replacements were purchased. Seventy-two percent of weaned surplus female lambs and 10% of surplus male lambs were sold as breeding animals at about 14 mo of age and therefore were reared with the lambs retained as flock replacements. All remaining surplus female and male lambs were sold for slaughter at weaning.

Female lambs that reached the required proportion of mature weight (75%) were mated at approximately 7 to 8 mo of age in the breeding season following their weaning. Conception rate of female lambs in this breeding season was 70%. The remaining replacements plus

those females that did not conceive during their first breeding season were mated the following year in the second breeding season following their weaning, where an 85% conception rate was achieved. Female lambs that failed to conceive were culled 60 d after this breeding season. Male replacements that reached 75% of breed average mature weight at the start of the breeding season following their weaning were used for breeding at 7 to 8 mo of age. For young rams, the ewe-to-ram ratio was 35:1. Remaining replacement male lambs entered the flock in the second breeding season following their weaning. For these and for adult rams, the ewe-to-ram ratio was 40:1.

The stationary state of the ewe flock was calculated as described by Wolfová et al. (2009) using the parameters given in Table 1. The maximum number of lambings per ewe was set to 10, and the maximum number of breeding seasons for each ram was set to 2. The structure of progeny born in the flock per reproductive cycle and their growth patterns were calculated on the basis of breed average litter size at each lambing, survival and growth rates of lambs within each litter size (see Tables 1 and 2), and growth rates of breeding lambs during rearing (Table 3).

Milk production of Improved Walachian sheep is not high, because the breed was selected not only for milk but for wool and meat production as well. The base lactation curve (first parity lactation with single suckled lamb) is characterized by the equation (Oravcová et al., 2006)

$$y(t) = 0.4t^{0.18}e^{-0.005t}$$

where t is time (days in milk) and $y(t)$ is the milk yield at time t . This lactation curve reaches its maximum (0.68 L) at $t = 35$ d.

Table 2. Characteristics of progeny until weaning

Characteristic	Litter size	
	Singles	Twins
Lambs stillborn or died before 24 h of age, as proportion of lambs born	0.085	0.09
Probability that only one lamb stillborn or died before 24 h of age	0.085	0.06
Probability that two lambs stillborn or died before 24 h of age	—	0.03
Survival rate of lambs until weaning	0.98	0.95
Birth weight female/male (kg)	3.4/3.7	2.8/3.0
Weaning weight female/male (kg)	12.6/14.4	10.1/11.6

Coefficients 0.97 and 1.06 were used to calculate milk yield for ewes without suckled lambs and with twins, respectively, from the milk yield of ewes with singles. Similarly, coefficients from Table 1 were applied to calculate milk yield according to parity number from the milk yield on parity one. Milk extracted from lambed ewes not suckling lambs was used for lambs from litters with twins. After weaning, ewes were milked twice a day using simple milking machines. Average fat and protein contents were 6.60 and 5.99% with phenotypic standard deviations of 0.59 and 0.28%, respectively.

Milk available until weaning was not sufficient for the growth potential of lambs, so supplementary concentrates and hay were made available. The base nutrition requirements of all other sheep categories were covered using pasture grass, hay, and straw during the summer and hay, grass silage, and straw during winter. Compounded feedstuffs, wheat and oat grain, and cereal bran were purchased for supplementary feeding of lactating and advanced pregnancy females, for flushing of female replacement stock, and for feeding breeding rams. So as not to exceed the dry matter intake capacity of animals but to meet their net energy and protein requirements (Table 4), feeding rations for particular animal categories were balanced according to their reproductive and productive status. Rations also included mineral additives. Summer and winter water requirements for all categories of animals were determined according to Infascelli et al. (2005).

Calculation of Economic Efficiency and Economic Values of Traits

As described by Wolfová et al. (2009), economic efficiency of the production system was expressed as the present value of the profit per ewe present in the flock at the time of lambing and per year. All revenues and costs were discounted to the birth date of the animals with an annual discount rate of 5%. Revenues came from lambs sold at weaning, culled ewes, rams and breeding lambs, milk, wool, and manure. Animals were sold on a live weight basis. The price per kilogram of live weight depended on the conformation of animals. For lambs sold at weaning and for adult sheep, 2 quality classes were distinguished. Milk obtained during the milking period was sold to dairies for a price which depended on fat and protein content.

Shearing of adult sheep and breeding lambs was done once a year. Wool was sold as greasy wool, with no price differential for quality. Manure could be gathered only in the winter period. Input parameters for the calculation of revenues are summarized in Table 5.

Costs included those for feeding, winter housing, labor, health care, milking, shearing, purchasing breeding animals, and fixed costs, which covered depreciation expenses, energy, repairs, insurance, and overhead costs. A part of the fixed costs directly connected with certain categories of animals (e.g., repairing costs, depreciation costs for buildings, insurance) was allocated only to

Table 3. Growth patterns and other characteristics of breeding animals in different periods

Characteristic	Females	Males
Growth rate from weaning until start of the first breeding season (g/d)	100	150
Growth rate from the first to the second breeding season (g/d)	60	90
Coefficient of variation for the weight at the start of the first breeding season (%)	11	14
Mature weight (kg)	50	70
Weight gain during flushing (kg) ¹	3	—
Survival proportion from weaning to the first breeding season	0.97	0.97
Survival proportion from the first to the second breeding season	0.95	0.95
Survival proportion from mating to lambing	0.99	—

¹It is assumed to be identical to the weight loss during advanced pregnancy in the model.

Table 4. Nutritive values of rations for different groups of animals and feed prices

Feeding ration for	DM content (kg of DM/kg of FM) ¹	Net energy (MJ/kg of DM)	Digestible protein ² (g/kg of DM)	Price ³ (€/100 kg of FM)
Lactating ewes with 1 lamb				
Summer	0.38	6.18	77.4	2.43
Winter	0.74	5.91	73.6	5.24
Lactating ewes with two or more lambs				
Summer	0.38	6.18	77.4	2.43
Winter	0.71	6.11	77.1	5.57
Barren ewes and ewes in early pregnancy				
Summer	0.27	5.32	64.5	0.89
Winter	0.66	5.13	59.9	3.78
Females in advanced pregnancy	0.71	6.72	83.9	4.27
Flushing of females	0.25	5.69	71.3	1.24
Rams in the breeding season	0.71	6.10	66.4	4.97
Rams outside of the breeding season	0.70	5.04	56.7	3.59
Lambs until weaning	0.89	6.49	129.3	18.19
Breeding lambs in rearing				
Summer	0.25	5.36	67.2	0.97
Winter	0.73	5.41	70.1	5.30

¹FM = fresh matter.²Protein digestible in intestine.³Average exchange rate was 37 Slovak Crowns per € for the year 2006.

these categories; the rest of the fixed costs spent for the farming system on the whole (e.g., overhead costs) were allocated to each animal category proportionally to the time period of the presence of the category in the system.

Feeding costs were calculated on the basis of the feed required to meet energy and protein requirements of animals for growth, maintenance, pregnancy, wool, and milk production. Calculated requirements were then increased by 10% for ewes, rams, and breeding lambs and by 5% for lambs receiving supplementary feed before weaning, to take feed wastage into account.

Housing costs were for bedding material. Labor costs included only general labor costs which were calculated

according to the representative number of hours needed per animal of each category per year. The specific labor costs were those for shearing, because shearing was done by contract workers. A part of labor costs connected with milking which depended on milk yield was included in the milking costs.

Costs for health care comprised mainly the costs for a joint treatment against endo- and ecto-parasites applied twice a year for adult sheep and for replacement stock. Costs for other drugs and veterinary services were added to the health costs.

Costs for milking were estimated by multiplying the amount of milk extracted during the milking period by the costs per kilogram of milk, which included the

Table 5. Parameters used for calculating revenues

Parameter (units)	Value
Lambs sold at weaning	
Quality class 1: price (€/kg)/percentage of animals	2.12/99
Quality class 2: price (€/kg)/percentage of animals	1.60/1
Culled sheep	
Quality class 1: price (€/kg)/percentage of animals	1.38/92
Quality class 2: price (€/kg)/percentage of animals	1.16/8
Wool price (€/kg)	0.54
Amount of wool per shearing (kg/animal)	
Ewes	3.4
Rams	5.0
Breeding female lambs	1.0
Breeding male lambs	1.2
Price per female breeding lamb at an age of 14 mo (€/animal)	64.32
Price per male breeding lamb at an age of 14 mo (€/animal)	443.24
Manure price (€/100 kg)	0.30
Base price for milk with 6.78% fat and 5.87% protein (€/kg)	0.54
Bonus or penalty for fat content greater or less than 6.78% (Euro cents/%)	3.68
Bonus or penalty for protein content greater or less than 5.87% (Euro cents/%)	7.19

Table 6. Main input parameters used to calculate costs

Parameter (units)	Ewes ¹	Rams	Breeding lambs from	
			weaning to first breeding	first to second breeding
Number of treatments against parasites ²	2	2	1	2
Other veterinary costs ² (service + drugs)	6.19	2.73	0.89	2.73
Number of man-hours per year	7	3	3	3
Number of shearings per year	1	1	1	1
Fixed costs per stable place (€/year)	29.79	20.81	21.51	21.51
Amount of bedding material in winter (kg/d)	0.5	0.5	0.4	0.4
Costs for removing and rendering dead animals (€/animal)	14.46	14.46	2.43	2.43
Costs for shearing (€/animal)	1.84	2.70	1.41	1.41
Costs for milking (€/kg milk)	0.15			
Other costs				
Price for farmer hours (€/h)			2.70	
Price for drugs against parasites (€/animal and treatment)			0.44	
Price for bedding material (€/100 kg)			1.35	
Price for water (€/100 l)			0.08	

¹Including lambs until weaning.

²These items are given per year for ewes and rams and per period from weaning until the first breeding season or from the first to the second breeding season for breeding lambs. A joint treatment against endo- and ecto-parasites was applied.

costs for milking facilities, energy for milk cooling, and labor for milking. The main input parameters for the calculation of the costs are listed in Table 6.

Economic values were calculated for the following traits: milk yield, fat and protein content, average daily gain from birth till weaning, mature weight, conformation of animals at slaughter, fleece weight, conception rate of female lambs and ewes, prolificacy (total number of lambs born per lambed ewe), survival rate of lambs to 24 h of age and until weaning, and productive lifetime of ewes.

Economic values for birth weight and average daily gain from birth till weaning were expressed per kilogram or per gram/day, respectively, of change for a female, single-born lamb. Proportional changes in the mean of the same traits in female and male animals born in litters of larger size were included in the calculation of economic values. Similarly, the economic value for mature weight was expressed per kilogram of mature weight of ewes, but the computation accounts for the proportional change in mature weight of rams. Let MW_E and MW_R be the mature weight of ewes and rams, respectively, which are input parameters in the model. The relation k between both weights is $k = MW_R/MW_E$. In the course of the calculation of the economic value of mature weight, the mature weight of ewes is changed twice (by addition or subtraction) by a small value ΔMW_E . To ensure a constant relation between mature weight of rams and of ewes, the corresponding changed mature weight of rams (MW_R^*) is then calculated as $MW_R^* = k \times (MW_E \pm \Delta MW_E)$. Therefore, although the economic value is calculated by relating the change of the profit function to the change of the mature weight

of ewes, the effect of the change of the mature weight of rams on the profit function is also taken into account.

On the other hand, economic values for survival rate of lambs and for quality classes for lambs and adult sheep sold on a live weight basis were expressed per trait values averaged over both sexes. More details on the procedure for the calculation of the economic values are given in the companion paper (Wolfová et al., 2009).

RESULTS

The distribution of the ewes across reproductive cycles at the stationary state of the flock and the corresponding structure of progeny are given in Tables 7 and 8. The average lifetime of ewes resulting from this structure was 3.9 reproductive cycles. The total number of lambs born/ lambed ewe per reproductive cycle was 1.257 where 0.743 lambs were born as singles and 0.514 lambs were born as twins. The structure generated by the model agreed well with the actual structure of the modeled production system. The total revenues, costs, both discounted to the birth date of animals, and governmental subsidies were 115.55 €, 144.76 €, and 74.84 €, respectively, resulting in a present value of profit of 45.63 €/ewe per year. Thus, the system would sustain financial losses without governmental subsidies.

The marginal economic values for all evaluated traits are summarized in Table 9. They express the changes in the present value of profit per ewe present in the flock at lambing and per year that would occur when flock average for the trait was increased by one unit. The economic values for conformation grade of both

Table 7. Structure of the ewe flock: relative frequencies of ewes in each reproductive cycle¹

Item	Reproductive cycle									
	1	2	3	4	5	6	7	8	9	10
Relative frequency (%)	25.5	18.7	14.4	12.5	10.6	8.0	5.2	3.0	1.5	0.6

¹A reproductive cycle is defined as the time period between two lambing seasons. In the given production system, the reproductive cycle has the length of one year.

age classes were negative because of the scoring system; a numerical increase in average quality class meant an economically unfavorable change in the trait. Because of the strongly uneven distribution of the slaughter animals over the grade classes (nearly all animals were in class 1, see Table 5), these traits would be of negligible value in a selection program.

Out of the remaining traits, only mature weight had a negative economic value. The economic value of mature weight was negative because the increase in feed cost for maintenance and growth of heavier ewe population was larger than the increase in revenues from sale of heavier culled ewes and rams, partly because the price for adult sheep was very low (see Table 5). The increase in mature weight also decreased the proportion of female and male breeding lambs heavy enough for mating during the first breeding season after their weaning, resulting in higher costs for rearing replacements. The possible impact of increased mature weight of ewes on birth weight of lambs or on milk production was not taken into account when calculating the economic value of mature weight. This was to avoid double counting because birth weight and milk production were evaluated separately.

The economic value for milk yield seems to be favorable, as it should be possible to increase milk yield during the standardized milking period by several kilograms, thereby increasing profit by several euros/ewe per year. The economic values of milk constituents are also relatively favorable. Among the reproductive traits, litter size seems to have a relatively high economic value. On the other hand, survival rates of lambs at lambing and until weaning have very low economic values.

DISCUSSION

Most models for the estimation of economic values for traits in sheep have been developed for non-dairy breeds. Very few attempts have been made to model the economic efficiency and economic values for dairy sheep production systems. Economic values for milk production traits were applied to compare efficiency of alternative selection schemes in dairy sheep by Komi-

nakis et al. (1997), but details on the calculation of these values have remained unpublished.

Recently, economic values for milk production as well as for growth and functional traits in dairy sheep have been estimated (Legarra et al., 2007a,b; Fuerst-Waltl and Baumung, 2009). Legarra et al. (2007a,b) used a simple linear profit function for the calculation of economic weights for milk yield, reproductive traits, length of productive life, and somatic cell score. They estimated feed cost from evaluation of farm data using annual expenses for feedstuffs, but did not take pasture cost into account. As mentioned by the authors, this approach might underestimate some costs, especially in extensive pasture systems, and underestimate differences among breeds with different production levels. Similarly, differences in labor costs were not recognized between farms and breeds with different litter sizes and milk production levels. The normative approach used here in which feed requirement is estimated for all animal groups in the flock according to their production status (lactation, pregnancy), body weight, and growth should provide a more accurate accounting of feed costs.

Table 8. Structure of progeny

Category of progeny	Frequency ¹
Total number of lambs born	124
Number of lambs weaned	112
Lambs sold for slaughter at weaning	
Female lambs	7.0
Male lambs	50.2
Female breeding lambs	
From weaning to the first breeding season	47.7
Sold at 14 mo of age	17.5
From the first to the second breeding season	28.7
Died during rearing	3.4
Culled for failure to conceive	2.5
Male breeding lambs	
From weaning to the first breeding season	5.3
Sold at an age of 14 mo	4.9
From the first to the second breeding season	0.3
Died during rearing	0.4
Culled during rearing	2.0

¹All frequencies are given per 100 ewes present in the flock at lambing per year.

Table 9. Marginal economic values in euros per unit of the trait and per ewe/year

Trait (units)	Economic value, €
Milk yield in the standardized milking period of 150 d (kg)	0.32
Fat content in milk (0.1%)	0.29
Protein content in milk (0.1%)	0.42
Birth weight (kg)	0.65
Average daily gain from birth to weaning (g/d)	0.032
Mature weight (kg)	-0.030
Average quality class of weaned lambs sold on a live weight basis (0.1 grade)	-0.38
Average quality class of adult culled sheep paid on a live weight basis (0.1 grade)	-0.21
Fleece weight (kg)	0.42
Conception rate of female lambs (%)	0.28
Conception rate of ewes (%)	0.56
Average litter size per ewe lambing (0.01 lambs)	0.20
Survival rate of lambs at lambing (%)	0.0036
Survival rate of lambs from 24 h after birth until weaning (%)	0.0040
Length of productive life of ewes (years)	11.1

The normative approach was also applied by Fuerst-Waltl and Baumung (2009). They adapted the deterministic computer model written by Miesenberger (1997) and originally developed for dual-purpose dairy beef cattle systems, modifying it to allow the estimation of economic values for growth and carcass traits of dairy sheep as well as those for milk and reproductive traits.

In the papers dealing with the calculation of economic values for dairy sheep (Legarra et al., 2007a,b; Fuerst-Waltl and Baumung, 2009), discounting procedures were not applied to account for variation in the times at which costs and revenues accrued to the system. This is in contrast to Conington et al. (2004), who applied a discounting procedure to computation of economic values in meat sheep. Discounting procedures also are usually applied in cattle (Amer et al., 2001; Wolfová et al., 2005; Berry et al., 2006); therefore, we decided to include a discounting procedure in our model. Discounting increases the relation between the economic values of traits expressed early in an animal's life (e.g., slaughter traits) and the economic values of traits expressed later in the animal's life (e.g., milk yield).

For a comparison of the relative economic importance of the different traits, it would be desirable to multiply each economic value by the genetic standard deviation of the corresponding traits, to obtain values with consistent units of measurement. Unfortunately, reliable estimates of the genetic standard deviations are not available for all of the evaluated traits in Improved Walachian sheep.

Differences among the models, production systems, and trait definitions, as well as in economic and marketing conditions for sheep products, make the comparison of published economic values very difficult. Nevertheless, some comparisons of the relationships between the economic values of traits defined in the same way

can be made. Although the following text may not appear systematic, its structure is necessitated by the availability of comparative results. Only one literature source was available for comparison with the current study for some pairs of traits.

The ratio of the marginal economic values of milk protein to milk fat in our calculation (1.44:1) was similar to the ratio for these traits estimated for dairy sheep in Austria (1.60:1; Fuerst-Waltl and Baumung, 2009). This ratio is not influenced by discounting, because both traits are realized at the same time. The ratio of the marginal economic importance of ewe conception rate and milk yield was 1.78:1 in our calculation (with discounting). This ratio is strongly influenced by discounting because conception rate is realized much earlier in a ewe's life than milk yield. If we did not take into account discounting of revenues and costs, we would get a ratio of 1.23:1, which is very close to 1.25:1, the ratio calculated from Legarra et al. (2007a).

The 5.4:1 ratio of economic values of litter size and protein yield reported by Fuerst-Waltl and Baumung (2009) was higher than the 3.8:1 ratio (3.2:1 without discounting) in our study (recalculated after converting protein content to protein yield), which could be caused by different assumptions made for the calculation of the economic value of litter size. In our study, a higher litter size was associated with higher total lamb losses at birth and until weaning; whereas Fuerst-Waltl and Baumung (2009) did not consider this effect. Although our model did include lamb losses, there was no double counting for this trait because we assumed a constant death rate of lambs within each litter size as flock average litter size increased.

A similar approach was used by Amer et al. (1999) and Conington et al. (2004) for the estimation of the economic value for litter size at weaning. In their case, increased litter size at weaning was caused by an in-

creased number of lambs born, but with survival rate within each litter size constant. When the effect of litter size on the total losses of lambs is not properly accounted for, the economic value of litter size will be overestimated. On the other hand, Legarra et al. (2007a) calculated a lower economic value for litter size in relation to milk yield compared with the present paper, but they did not account for differences in feeding costs and milk production between ewes suckling one versus more than one lamb.

The greatest difference between studies in the estimated marginal economic value for the same trait was for productive lifetime of ewes. In our study, an increase in ewe productive lifetime of one year increased annual profit per ewe by 11.08 € (9.40 € without discounting); whereas Legarra et al. (2007a) estimated the change in profit for the Latxa and Manchega breeds in Spain from 1.24 to 2.71 €/year increase in productive life. Their economic values resulted only from a decrease in replacement cost; whereas the economic value of productive lifetime calculated in our study was influenced also by the change in milk yield and in litter size caused by an increased proportion of older, more productive ewes in the flock. The inclusion of these effects does not mean a double counting for the traits milk yield or litter size, because the change in productive lifetime does not cause a change in the genetic potential for milk production or prolificacy, but causes only a change in the age structure of the ewe flock. The negative economic value for the productive lifetime of ewes, -0.54 €/year and ewe, reported by Fuerst-Waltl and Baumung (2009) is surprising and cannot be explained without detailed knowledge of the assumptions made in their model and calculations.

A negative economic value for mature weight, as obtained in our study, was also reported in meat sheep (Conington et al., 2004). There is little information about economic values for lamb survival rate. Amer et al. (1999) calculated economic values for survival rate of lambs at lambing and until weaning for meat sheep. Comparing their marginal economic values for litter size (7.43 €/lamb) with the economic values for survival rates (0.11 to 0.17 €/%), the low economic importance of the lamb survival rates is apparent. In our example for dairy sheep, the relative economic importance of lamb survival rate (0.4 euro cents/% at lambing and until weaning) in comparison to litter size (20 €/lamb) was even smaller.

The results presented in this paper demonstrate an application of the model described in the companion paper (Wolfová et al., 2009) for the estimation of the economic efficiency and economic values of productive and functional traits in dairy sheep production systems. Nevertheless, for the accurate evaluation of the relative

importance of traits in selection, genetic parameters for traits in the breeding objective must be first estimated for a given breed and breeding program.

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