GENETIC PARAMETERS FOR GROWTH TRAITS OF THE HUNGARIAN MERINO AND MEAT SHEEP BREEDS IN HUNGARY

I. KOMLÓSI

Institute of Animal Science, Debrecen University
H-4032 Debrecen Böszörményi str. 138, Hungary
(phone: +36-52-508-438; fax: +36-52-508-438)

Corresponding author:
e-mail: komlosi@agr.unideb.hu

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Abstract. Heritabilities and genetic correlations between weaning weight (WW) and average daily gain (ADG) for the Hungarian Merino, Ile de France, Charollais, German Mutton Merino, German Blackheaded, Texel, Fleisch Merino and Suffolk were studied. The selection of replacements is based on the two traits. The amount of records provided by the Hungarian Sheep Breeder's Association and by the Hungarian Agriculture Department varied by breeds (462-124680). The general linear model included sex, birth type and age of dam as fixed effects, while maternal permanent environment, the birth flock-year-season and animal genetic effect as random effects. The heritability of WW varied between 0.09±0.02 and 0.62±0.09, for ADG it varied between 0.16±0.01 and 0.28±0.01. The r_g varied between -0.10±0.02 and 0.44±0.09. The permanent environmental variance ratio varied between 0.009±0.007 and 0.06±0.01. The models and parameters calculated by the REML method varied by breeds that necessitates a separate genetic evaluation by breeds.
Keywords: *weaning weight, average daily gain, heritability, genetic correlation, sheep*

Introduction

The present breeding objectives of sheep breeds in Hungary are reproduction, growth, wool and milk traits. Reproduction traits are prolificacy (number of lambs born) and lambing interval; growth traits include weaning weight (in all breeds), average daily gain after weaning (in meat breeds) and yearling weight; milk trait is the milk produced during the lactation period (in dairy breeds); and wool production traits which include greasy fleece weight and fibre diameter (in Merino breeds and Romney). The weighing of these traits in the selection is presented in *Table 1.* The selection for wool traits is based on independent culling level.

Table 1. *The weighing of traits (%) in the index for different breed types*

Breed type	Number of lambs weaned	Lambing interval	Weaning weight	Average daily gain after weaning	Yearling weight	Standard lactation milk production
wool-meat	60 (50*)	0 (10*)	30	0	10	0
meat-wool	60 (50*)	0 (10*)	30	0	10	0
prolific	75 (65*)	0 (10*)	25	0	0	0
meat	40 (30*)	0 (10*)	0	60	0	0
dairy	40 (30*)	0 (10*)	10	0	0	50
local breed	50	0	20	0	30	0

* in flocks where frequent lambing is practiced in the last 5 years

To calculate selection index it is necessary to know the heritability and the correlation between the traits in addition to the economic weight of the traits. The last study on Hungarian Merino genetic parameters was published in 2000 (Nagy, 2000). The population has changed in the last 8 years, and different breeds were also introduced in Hungary. Several estimates have been published for sheep traits (de Vries et al., 1998, Ap Dewi et al., 2002; Safari et al., 2005). The genetic parameters are population specific. It is imperative to calculate these parameters in order to obtain an efficient selection response.

The objective of the present study was to estimate the heritability and genetic correlation for the growth traits (weaning weight and average daily gain) in eight sheep breeds (Hungarian Merino, Ile de France, Charollais, German Mutton Merino, German Blackheaded, Texel, Fleisch Merino and Suffolk), and to test their difference. If no difference is found, the pooling of the breeds within one breeding value evaluation procedure is possible in order to save computer time.

Materials and methods

Animals and traits

Performance data were collected by the Hungarian Sheep Breeder's Association in nucleus flocks in the period of 1984 and 2007. The performance testing procedure is regulated by the Sheep Breeding Codex (Radnóczi et al., 2007), which is updated every year. Lambs were born throughout the year with a peak in spring and were weighed at weaning (WW) (between 30 and 80 days of age) on a scale with 0.1 kg precision. The lambs consumed hay and concentrates in addition to the mothers' milk. For meat breeds a fattening test was carried out. Only those healthy lambs were put on test which reached at least 16 kg live weight, and were not over 80 days old in both sexes. Male and female lambs were fattened separately for 38-45 days. The group size was below 50, in 0.7-1.0 m^2 /boxes. Commercially available concentrates were fed ad. lib. with a maximum of 0.1-0.3 kg of hay consumption. The lambs were measured at the beginning and at the end of the test, and their average daily gain was calculated (ADG). The number of records and averages are given in *Table 2*. The total number of individuals with records ranged from 462 (Charollais) to 124680 (Hungarian Merino). Animals with missing data on environmental effects or having record only on one of the traits (other than Hungarian Merino) were excluded from the analysis. The pedigree links were considered for the animals with records, and all the pedigree information was utilised in the prediction of parameters.

Statistical analysis

The WW was adjusted for 60 days. An univariate procedure of SAS (SAS, 1996) was used to edit data and check for normality. The significance of fixed effects for sex, birth type (single or twin), age of dam, and random effect for flock-year-season was tested on each trait separately by using the SAS MIXED procedure (SAS, 1996). Three dam age groups were formed, dams younger than 3 years, dam age between years 3 and 6, and dams older than 6 years. Preliminary analyses showed that these three age groups affect growth traits differently.

Heritabilities and genetic correlations were estimated by the VCE5 software package (Kovac-Groeneveld, 2003) which applies restricted maximum likelihood procedure (REML) in the estimation.

Table 2. *Number of observation and mean values (phenotypic with standard deviation) for weaning weight and average daily gain for the breeds*

Breed	Number of flocks	Years	Total number of individuals (in the pedigree)	Number of individuals with records	Weaning weight (kg)		Average daily gain (g)	
					mean	st. dev.	mean	st. dev.
Hungarian Merino	957	1984-2007	510268	124680	18.7	3.84	-	-
Ile de France	159	1989-2007	34020	6153	19.7	4.31	294.7	62.10
Fleisch Merino	26	1990-2007	5708	1016	23.3	4.30	307.5	77.38
German Blackheaded	87	1987-2007	18848	2063	23.1	4.53	337.6	85.73
German Mutton Merino	474	1986-2007	106343	14933	20.1	3.40	319.8	72.0
Suffolk	120	1988-2007	18052	2829	22.4	4.58	321.4	73.4
Texel	38	1994-2007	4455	860	22.1	4.88	307.6	89.46
Charollais	33	1998-2007	2357	462	23.2	4.45	313.3	81.46

A single-trait (WW) model was applied for the Hungarian Merino, and two-trait models (WW, ADG) were applied for all the other breeds. The models included all the above-mentioned effects if they were found significant for the relevant trait and breed, with the random animal and permanent maternal environment effects included. Maternal ability represents the dam's milk production and mothering ability that is supposedly effect all of her progenies to the same extent. The genetic relationship between direct and maternal effects was not investigated, partly due to the controversial opinion in the literature on the matter (Nasholm and Danell, 1994; Matika et al, 2003), partly due to the lack of a long pedigree on the dam's side in many breeds that is required for accurate parameter estimation.

Heritability is considered as an intraclass correlation, and a test of homogeneity for correlation coefficients (on Z transformed correlations) was conducted (Steel and Torrie, 1987). When the test criterion Chi^2 was significant ($P<0.05$) a pairwise comparison for heritability estimates amongst breeds was carried out by two-sample z-tests since the number of individuals was above 30. Performing two-sample tests instead of multiple comparisons, however, increases type error I, incorrectly rejecting the null hypothesis.

Results and discussion

The significance of factors

The sex significantly affected WW in all breeds (*Table 3*). The birth type also affected significantly the trait except for the Fleisch Merino and German Balckheaded. Single lambs generally weighed more at weaning than twins in the breeds (e.g.

Mavrogenis, 1988; Yilmaz et al., 2007), due to the restrained uterine capacity and the mother's milking ability. This was also found in our study. The exception for Fleisch Merino and German Balckheaded might indicate that twin lambs' growth are not constrained by their mothers's capacity in these two breeds. This needs to be further investigated in physiological studies. The age of dam significantly affected WW in all breeds with the exception of Charollais and Fleish Merino. This could indicate persistent mothering ability for these two breeds. The phenotype of an individual is influenced by genetic and environmental factors. The fixed and random environmental effects in the model explained from 18% (Hungarian Merino) to 46% (Texel) of the variation on WW. The Hungarian Merino is kept in the most distinct environment in the largest number of flocks and there could be other environmental factors that are not controlled by the breeder, or available but not included in the model. Such grouping factors might be the geographic region (that could explain food availability during a year), nutritional strategy of the breeder (e.g. flushing or no flushing before mating, separation of twin bearing pregnant ewes or no separation).

The sex influenced ADG after weaning for all breeds. The birth type had effect on daily gain only in German Mutton Merino. The lack of influence of birth type on this trait in other breeds is not in agreement with the finding of others (Mavrogenis, 1988; Ceyhan et al, 2008). One explanation for the phenomenon is the compensatory growth during the fattening period. Compensatory growth is referred to as the rapid weight gain that follows a period of reduced nutrient intake of an animal, when it is placed on a high quality diet. Before weaning twin lambs' nutrient requirement is usually not met, but ad libitum access to nutrients during the fattening period makes fast growth for twin possible. The age of dam effected ADG (P<0.05) for Charollais, Fleisch Merino, German Blackheaded and Suffolk. The fixed and random environmental effects in the model explained from 26% (Suffolk) to 48% (Fleisch Merino) of the variation on daily gain.

Table 3. *The level of significance for the fixed effects and the R^2 for the models*[†] *tested by breeds*

Breed	**Hungarian Merino**		**Texel**		**Ile de France**		**German Mutton Merino**	
Traits/Effects	**WW**[§]		**WW**	**ADG**[#]	**WW**	**ADG**	**WW**	**ADG**
Sex	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Birth type	<0.0001		<0.0001	0.5159	<0.0001	0.6800	<0.0001	0.0002
Age of dam	<0.0001		<0.0001	0.2552	<0.0001	0.1121	<0.0001	0.3467
R^2	0.18		0.46	0.48	0.41	0.33	0.28	0.39
	Charollais		**Fleisch Merino**		**German Blackheaded**		**Suffolk**	
Traits/Effects	**WW**[§]	**ADG**	**WW**	**ADG**	**WW**	**ADG**	**WW**	**ADG**
Sex	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Birth type	<0.0001	0.0998	0.1404	0.4485	0.6944	0.2084	<0.0001	0.1414
Age of dam	0.0998	<0.0001	0.5966	0.0173	<0.0001	0.0021	<0.0001	0.0004
R^2	0.29	0.42	0.27	0.48	0.36	0.34	0.34	0.26

[†] The models included the random effect of flock-year-season in addition to the fixed effects.
[§], Weaning weight, # Average daily gain.

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Table 4. *Estimated genetic parameters with standard errors for growth traits by breeds*

Breed	**Hungarian Merino**		**Texel**		**Ile de France**		**German Mutton Merino**	
Traits/Effects	**WW[§]**		**WW**	**ADG[#]**	**WW**	**ADG**	**WW**	**ADG**
h^2	0.09 ± 0.02		0.29 ± 0.04	0.28 ± 0.01	0.11 ± 0.01	0.16 ± 0.01	0.07 ± 0.01	0.19 ±0.03
r_g				0.31 ± 0.07		0.17 ± 0.02		0.11 ± 0.02
c^2	0.02 ± 0.001		0.04 ± 0.01	0.01 ± 0.003	0.02 ± 0.003	0.01 ± 0.001	0.03 ± 0.01	0.005 ±0.002
v^2	0.34 ± 0.07		0.29 ± 0.09	0.31 ± 0.11	0.42 ± 0.02	0.21 ± 0.007	0.39 ±0.08	0.35 ±0.09
e^2	0.53 ± 0.08		0.37 ± 0.09	0.39 ± 0.07	0.45 ± 0.01	0.62 ± 0.001	0.49 ±0.07	0.44 ±0.11
	Charollais		**Fleisch Merino**		**German Blackheaded**		**Suffolk**	
Traits/Effects	**WW**	**ADG**	**WW**	**ADG**	**WW**	**ADG**	**WW**	**ADG**
h^2	0.62 ± 0.09	0.25 ± 0.07	0.09 ± 0.02	0.16 ± 0.01	0.24 ± 0.02	0.20 ±0.03	0.14 ± 0.02	0.24 ±0.02
r_g		-0.01 ± 0.31		0.28 ± 0.14		-0.10 ±0.02		0.10 ±0.10
c^2	0.003 ± 0.001	0.06 ± 0.03	0.06 ± 0.01	0.01 ± 0.01	0.03 ± 0.01	0.001 ± 0.001	0.009 ±0.007	0.004 ±0.006
v^2	0.21 ± 0.09	0.62 ± 0.09	0.50 ± 0.04	0.50 ± 0.04	0.32 ± 0.08	0.27 ± 0.06	0.32 ±0.02	0.25 ±0.02
e^2	0.30 ± 0.08	0.48 ± 0.05	0.34 ± 0.04	0.32 ± 0.01	0.40 ±0.07	0.52 ± 0.08	0.52 ±0.02	0.50 ±0.02

[§,] Weaning weight, # Average daily gain.
h^2 is the heritability of the trait, r_g is the genetic correlation between the weaning weight and the average daily gain, c^2 the variance proportion of the maternal permanent environment effect; v^2 the variance proportion of the flock-year-season effect, e^2.is the error variance proportion.

Heritabilities, variance ratios

Models including only significant factors were used in parameter estimation for the breeds. The parameters were estimated by a single-trait model for the Hungarian Merino, and a two-trait model for all the other breeds. The heritability of WW ranged from 0.07 to 0.62, its value was lower in Merino breeds and higher in meat breeds (*Table 4*). The heritability is a ratio of additive genetic and phenotypic variance. The low value for Merinos reflects the wide range of environment in which these breeds are kept. The meat breeds are used for terminal crossing, and the high market value of breeding males requires better nutrition and management, which decreases the environmental variance component. These heritabilities are in the range of those presented by Janssens et al. (2000) and Safari et al. (2005). The ratio of maternal permanent environment variance to the total phenotypic variance was below 0.06 for the two traits in all breeds. Irrespective of the low ratio, studies showed that the inclusion of permanent maternal effect significantly improve the model fit (Matika et al, 2003;

Miraei-Asthiai et al, 2007). The flock-year-season variance ratio exceeded the size of heritability for all breeds except for the Charollais. This large variation of environmental factors shows the exposure of the species to environmental changes by flock, by year and by season.

Genetic correlations

Parameter estimates varied in magnitude between breeds (*Table 4*), ranged from -0.10 to 0.31. These correlations were only different from zero for Texel, Ile de France, German Mutton Merino and German Blackheaded. Weaning weight is the most important factor in determining postweaning liveweight, growth rates and survival of Merino lambs (Hatcher, 2008). This positive relationship was also proved in this study, except for the German Blackheaded. Lambs of this breed with low WW gain more after weaning and vice versa, that could be a sign of compensatory growth. The most important environmental factor that causes this phenomenon is the twin status. In this breed though the birth type had no significant effect on WW and ADG. Further studies are needed to explain the fact. A safe solution in a two trait model in breeding value evaluation for this breed is to use zero correlation between the two traits.

Comparison of parameters between breeds

The Z values of the tests conducted for heritabilities are presented in *Table 5*. The Chi^2 value in the homogeneity test was 284.8 for WW, which is significant ($P<0.05$) at 7 degrees of freedom. A pairwise comparison was followed.The heritability of WW for Hungarian Merino was not different from that of the Ile de France and Fleisch Merino. The breeding value evaluation for the latter two breeds though is done for two growth traits, while for the Hungarian Merino only for WW, so possible pooling of the three breeds in one evaluation is not possible. The Chi^2 value in the homogeneity test was 33.08 for the heritability of ADG, which is significant ($P<0.05$) at 6 degrees of freedom.

Despite the fact that the heritability for the two traits was identical for the German Mutton Merino and the Fleisch Merino, the prediction models were different, due to the different significant effects, therefore the combination of the two breeds in one run is not possible. The Chi^2 value in the homogeneity test for correlation between the WW and ADG was 187.72 ($P<0.05$, df 6). According to the genetic correlations between WW and ADG, there were only three cases, where the correlations were not significantly different (Suffolk-German Mutton Merino; Texel-Fleisch Merino; Suffolk-Charollais) (*Table 6*). In heritabilities, however, these breeds differed. The genetic correlation is the correlation between the breeding values of two traits. The correlation is composed of the covariance between breeding values and the standard deviation of breeding values. These components are subjected to selection. Due to the characteristics of the breed the selection intensity for traits is different for different breeds. This can result in different correlations for the breeds.

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Table 5. *Z values (absolute) for pairwise comparisons between estimated heritabilities in different breeds for weaning weight and average daily gain after weaning*

Breed	HME[§]	IDF	FME	GBL	GMM	SUF	TEX	CHA
HME		0.89[#]	0	**5.30**	0.89	1.76	**4.47**	**5.74**
IDF			0.89	**5.81**	**2.82**	1.34	**4.36**	**5.63**
FME		1.26		**5.33**	0.89	1.76	**4.47**	**5.74**
GBL		0.0	1.26		**7.60**	**3.53**	1.11	**4.12**
GMM		**3.57**	0.0	0.94		**3.13**	**5.33**	**6.07**
SUF		**8.48**	**3.57**	1.10	**2.21**		**3.35**	**5.20**
TEX		1.27	**8.48**	**2.52**	**3.79**	1.78		**3.35**
CHA		**16.0**	1.27	0.65	1.18	0.14	0.42	

[§] Breed codes: HME- Hungarian Merino, IDF – Ile de France, FME – Fleisch Merino, GBL – German Blackheaded, GMM – German Mutton Merino, SUF - Suffolk, TEX-Texel, CHA- Charollais.
[#] Z values above diagonal are for weaning weight, below diagonal are for daily gain. Values above 1.96 are significant at P<0.05 level and are in bold.

Table 6. *Z values (absolute) for pairwise comparisons between breeds' weaning weight and average daily gain estimated correlation*

Breed	FME[§]	GBL	GMM	SUF	TEX	CHA
IDF	**3.42**[#]	**10.68**	**4.04**	**3.14**	**4.08**	**3.34**
FME		**10.11**	**5.45**	**5.11**	0.70	**4.93**
GBL			**8.96**	**6.92**	**10.35**	**2.13**
GMM				0.49	**5.98**	**2.11**
SUF					**5.64**	1.79
TEX						**5.37**

[§]Breed codes are the same as in Table 5.
[#] Z values above diagonal are for weaning weight, below diagonal are for daily gain. Values above 1.96 are significant at P<0.05 level and are in bold.

Conclusion

The effects for predicting WW and ADG in the eight breeds were different in some cases. The heritabilities and genetic correlations for the traits were also different in most of the comparisons. They require separate runs for breeding value evaluation in each breed.

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