DIRECT AND MATERNAL GENETIC RELATIONSHIPS BETWEEN LAMB LIVE WEIGHT AND CARCASS TRAITS IN SWEDISH SHEEP BREEDS

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INTRODUCTION

In Sweden, when not including subsidies, meat production accounts for 60 - 90 % of income from the sheep enterprise. Sheep farmers are paid for weight of carcass and according to carcass fleshiness and fatness grades. In the Swedish Sheep Recording Scheme (SSRS) selection of ewes and rams is based on a selection index considering lamb live weight at around four months, ewe fertility and for Gotland lambs also fleece quality. Furthermore, rams used as sires are evaluated using a BLUP animal model (Näsholm, 1999). Until recently, only 4-month weight (4MW) and fleece quality were included in the BLUP-evaluations. For an efficient and profitable production it is also important to breed for improved carcass quality. Both in Denmark and Norway carcass data from commercial slaughterhouses are included in the genetic evalutations of sheep (Pedersen, 1993 ; Olesen *et al*., 1995). To include carcass traits also in the Swedish BLUP-evaluations information on genetic parameters for these traits and their genetic relationships with 4MW are needed. In this study data from the BLUP-evaluations in SSRS and commercial slaughterhouses were used. Heritabilities for carcass weight (CW), fleshiness (FLESH), and fatness (FAT) were estimated. Furthermore, genetic correlations between these traits and also the correlations with 4MW were calculated.

MATERIAL AND METHODS

Two datasets with observations on 4MW, CW, FAT, and FLESH for Gotland sheep and for the so-called "white" breeds were analysed separately. The "White" breeds consist of sheep of the Swedish white landrace breeds, the heavier meat breeds including Texel, Dorset, and East Friesian milk sheep, and crosses between those two groups of breeds. In Table 1 structure of the data is described**.** Since year 1999, 15 grades for degree of fattening (1- to 5+) and 15 carcass fleshiness grades (P- to E+) are used in Sweden. In this study, the observed grades were transformed into numbers so that the lowest fat and fleshiness grades were denoted 1 and the highest grades were denoted 15.

Estimation of genetic parameters. (Co)variance components were estimated simultaneously for 4MW, CW, FAT, and FLESH with use of a multiple trait animal model. The model included the additive relationship matrix (A) with information about sires and dams and for the weights the maternal relationship matrix (A_m) with information about maternal grandsires and granddams. Fixed effects included were the combination of herd and year, the combination of sex of lamb, litter size at birth and weaning, and dam age, and for the "white" breeds also the combination of dam and sire breeds. For 4MW and CW random effects included were the effect of dam a certain year (variance=σ_c^2), the direct additive genetic effect (variance= $A\sigma_a^2$), the maternal additive genetic effect (variance=$A_m\ \sigma_m^2$), and the random residual effect (variance=σ_e^2). For FAT and FLESH the random effects included were only the direct genetic effect and the random residual effect. All random effects were assumed normally distributed with mean zero. For all traits the models also included both a linear and a quadratic regression of the weight/carcass trait on age at weighing/slaughter. Phenotypic variance was $\sigma_p^2 = \sigma_c^2 + \sigma_a^2 + \sigma_m^2 + \sigma_{am} + \sigma_e^2$. The (co)variance components were estimated using the average information algorithm for restricted maximum likelihood included in the DMU-package of Jensen and Madsen (1994).

Table 1. Description of data used for analysis of 4-month weight (in kg), carcass weight (in kg), carcass fatness (in grades), and carcass fleshiness (in grades). Age is in days

	No. of lamb records	Years of birth for lambs	Mean (SD)	Mean age (SD)	No. of sires	No. of dams	Total no. of animals
Gotland sheep							45 901
4MW	35 891	1991-1994	35.4 (6.6)	116 (12)	637	11 262	
CW			18.4 (2.4)				
FAT	3 341	1994-1999	6.2 (1.6)	173 (35)	172	2 193	
FLESH			6.1 (1.2)				
"White" breeds							38 796
4MW	30 698	1991-2001	35.2 (7.8)	114 (14)	710	8 896	
CW			19.1 (2.5)				
FAT	3 814	1994-2000	6.5 (1.5)	173 (35)	217	2 036	
FLESH			6.6 (1.5)				

RESULTS

Heritabilities. In Table 2 estimated genetic parameters are presented. Direct heritabilities of the weights varied between 0.14 and 0.19 and were in the same range for both live and carcass weights. They were higher than the maternal heritabilites, which varied between 0.08 and 0.15. Correlations between direct and maternal genetic effects were all negative and moderate. They were more pronounced for 4MW (-0.38 and –0.39) than for CW (-0.23 and –0.20). Only minor differences between the breed groups were found for the heritabilites and the direct-maternal genetic correlations of the two weights. Relative variance due to common environment of ewe a certain year (σ_c^2 / σ_p^2) is not shown in Table 2 but varied for the weights between 0.05 and 0.12 and was always less than the corresponding maternal heritability. Phenotypic variances (not in a table) for 4MW and CW were higher for the "White" breeds (26.3 and 5.2, respectively) than for Gotland lambs (18.0 and 3.0). Mean weights (Table 1) differed only to a small extent between the two breed groups.

Heritabilities of FAT and FLESH were medium high. Phenotypic variances of FAT for the Gotland breed and the " White" breeds (1.8 for both) and also the heritabilities (0.26 and 0.27) were almost the same. For FLESH the values were higher for the "White" breeds than for the Gotland lambs, both for phenotypic variances (1.5 and 1.0, respectively) and for heritabilities (0.29 and 0.19).

Correlations between traits. Genetic correlations between 4MW and CW were high but clearly different from unity both in the Gotland breed (0.73) and in the "White" breeds (0.76). For the "White" breeds the genetic correlations between 4MW and FAT (0.08) and FLESH (0.09), respectively, were both low. For the Gotland lambs the correlation between 4MW and FAT was negative with a value of –0.23. The correlation between 4MW and FLESH was positive (0.13). The genetic correlations between CW and FAT were low in both datasets (0.06 and 0.07), while the correlations between CW and FLESH and between FAT and FLESH were moderate and ranged between 0.37 and 0.59. Genetic correlations between maternal effects of 4MW and CW were high both for the Gotland lambs (0.97) and for the "White"breeds (0.80). Corresponding correlations between common environmental effects (not in a table) were somewhat lower (0.63 and 0.58). Direct-maternal genetic correlations between 4MW and CW were all negative. Genetic correlations between maternal effects on 4MW/CW and FAT/FLESH were moderate and positive (0.23 to 0.38).

Table 2. Heritabilities for (on diagonal) and genetic (above diagonal) and phenotypic correlations (below diagonal) between 4-month live weight and carcass traits of Swedish lambs

		4MW		CW			
		Direct	Maternal	Direct	Maternal	FAT	FLESH
Gotland sheep							
4MW	Direct	**0.19**	- 0.38	0.73	-0.18	-0.23	0.13
	Maternal		**0.15**	-0.36	0.97	0.35	0.36
CW	Direct			**0.14**	-0.23	0.07	0.38
	Maternal	0.68			**0.12**	0.23	0.38
FAT		0.22		0.37		**0.26**	0.37
FLESH		0.33		0.59		0.34	**0.19**
"White" breeds							
4MW	Direct	**0.17**	-0.39	0.76	-0.32	0.08	0.09
	Maternal		**0.12**	-0.09	0.80	0.28	0.25
CW	Direct			**0.16**	-0.20	0.06	0.59
	Maternal	0.73			**0.08**	0.35	0.31
FAT		0.24		0.39		**0.27**	0.40
FLESH		0.32		0.60		0.33	**0.29**

DISCUSSION

The results show that inclusion of carcass traits into the breeding objectives is important and seems feasible. Heritabilities for these traits were almost as large as or larger than those for live weight. Most likely the multi-trait model accounted for the selection of animals being slaughtered and contributed to the achieved level of heritabilities. Direct and maternal heritabilities of 4MW, CW and FAT did not differ between the breeds studied. Only for FLESH there were some differences and the heritability was higher for the "White" breeds. Furthermore there was a higher phenotypic and also genetic variation in 4MW and CW for the "White" breeds. The reason for this might be that the "White" breed group include a number of different breeds, both landrace breeds and meat breeds, which are genetically different.

Estimates of heritabilities for live weight at ages around 4 months presented in the literature vary between breeds (e.g. Tosh & Kemp, 1994 ; Fogarty, 1995), but the estimates in the present study are within the range of earlier published results. Olesen *et al*. (1995) presented heritabilities for carcass traits used in a Norwegian study where the aim was to estimate breeding values for ewes and rams. The heritabilities for carcass weight and carcass grade (0.16 and 0.20, respectively) were close to the results of this study. Also in the genetic evaluation of sheep in Denmark they use a value of 0.20 for classification at slaughter (Pedersen, 1993). In the Norwegian study they used a value of 0.15 for fat % and this is lower than the values presented in this study (0.26 and 0.27).

Genetic correlations between the different traits differed only slightly for the two breed groups studied. Whereas the correlations between the two weights were high, the correlations between 4MW and FAT and FLESH, respectively, and also between CW and FAT were low except the correlation between 4MW and FAT of the “White” breeds that was moderate and negative. Genetic correlations between CW and FLESH and between FAT and FLESH were moderate. The moderate and positive correlations between maternal effects on 4MW/CW and FAT/FLESH indicate that the importance of maternal effects for carcass traits needs to be further studied.

CONCLUSIONS

The results show that carcass traits have at least as large genetic variation as 4MW. The latter has only low correlations with fat content and conformation of the carcasses. The genetic relationships between live weight and carcass traits underline the importance to include all of them into the breeding objectives as they would considerably contribute to the accuracy of breeding values. As carcass traits can only be used after the primary selection of lambs has taken place, it is important to apply multiple trait animal models for genetic evaluations in order to utilize all information in an optimal way. Furthermore it is concluded that there are maternal genetic influences on both weight at around 4 months and on weight after slaughter.

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