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Genetic parameters for live weight, ultrasound scan traits and muscling scores in Austrian meat sheep

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Abstract

Heritabilities and genetic correlations were estimated for live weight (lw) and average daily gain (adg) (n= 13,634), ultrasound measured eye muscle depth (emd) and back fat depth (fat) as well as muscling scores for shoulder (shoul), back (back) and hindquarters (hind) (n= 6,110) in Austrian meat sheep. An across breed analysis was carried out using performance records of Merinolandschaf, Suffolk, Texel, German Blackheaded Meatsheep and Jura sheep which were routinely tested for meat performance between 2000 and 2010. Genetic parameters were estimated with multivariate mixed animal models including both direct and maternal genetic effects and permanent environmental effects of the dam (pe) as well as fixed effects. Estimated direct heritabilities were 0.07, 0.16, 0.20, 0.21, 0.03, 0.01, and 0.08 for lw, adg, emd, fat, shoul, back and hind, respectively. Maternal genetic heritabilities were very low and significant only for lw and adg, whereas pe was fitted for every trait and explained between 0.05 and 0.10 of the phenotypic variance. Lw showed highly negative genetic correlations with emd (-0.87), fat (-0.57), and hind (-0.81). The genetic correlations are more strongly antagonistic than observed from published estimates. This may be a direct result of the structure of the data used in this study where many of the records were from small herd year season groups and often confounded by sire.

Keywords: meat performance testing, eye muscle depth, back fat thickness, heritabilities, correlations, across breed analysis

1. Introduction

Performance testing for growth and carcass traits has been obligatory in Austria since 2003 for herd book sheep of breeds with a focus on meat production. Two methods, ultrasound and computer tomography (CT) scanning, are currently used for meat performance testing. Approximately 1,800 sheep are scanned for muscle and back fat depth with ultrasound per year. The majority of these are Merinolandschaf, followed in declining order by Suffolk, Texel, German Blackheaded Meatsheep and Jura. So far the selection is based on the phenotypic performance of the individual. Genetic parameters have not been estimated for Austrian sheep populations. The aim of this study was to estimate heritabilities and correlations for live weight, average daily gain, eye muscle and back fat depth, and three muscling scores for Austrian meat sheep.

2. Material and Methods

2.1 Data

Performance records were taken between 2000 and 2010 as part of the routine performance testing for herd book animals of sheep breeds with a meat focus in Austria. The sheep are weighed and then scanned with an ultrasound device lateral of the spine in the area of the 3rd/4th lumbar vertebra. Both fat depth and eye muscle depth are measured twice on the same picture, 2 cm apart laterally and the average of both measures is used. In addition each animal gets conformation scores for shoulder, back and hindquarter, respectively. Conformation scores range from 1-9 with 9 being the best, meaning most muscular. A more detailed description of data recording can be found in Junkuszew and Ringdorfer (2005). The traits examined in this study were: live weight (lw), average daily gain (adg; live weight divided by age in days), eye muscle depth (emd), fat depth (fat), shoulder score (shoul), back score (back), and hindquarter score (hind). Only records where at least dam information was available were analyzed. Furthermore, records of animals outside a weight range of 29-50 kg or an age range of 56-155 days were deleted. Table 1 details the performance data used in this study.

Table 1: Data summary including description of traits, number of records used, units, means, standard deviations (SD) minimum and maximum values

Trait	Description	No. Records	Unit	Mean	SD	Min	Max
lw	liveweight	13,634	kg	39.3	4.0	29.0	50.0
adg	average daily gain	13,634	g/d	384.2	69.0	209.7	745.8
emd	eye muscle depth	6,110	cm	2.14	0.25	1.29	3.43
fat	backfat depth	6,110	cm	0.65	0.17	0.18	1.47
shoul	shoulder score	6,110	score (1-9)	6.2	0.78	2.0	9.0
back	back score	6,110	score (1-9)	6.5	0.73	3.0	9.0
hind	hindquarter score	6,110	score (1-9)	6.4	0.78	3.0	9.0

More records were used for live weight and average daily gain because those traits were available for all animals while animals had either ultrasound or CT carcass records but not both.
Pedigree information was extracted from the SCHAZI database, operated by the Austrian Sheep and Goat Association (ÖBSZ). The 13,634 animals with records come from 252 different flocks and descended from 6,093 dams and 907 sires. The total number of animals in the pedigree was 23,709. The majority of records (9,617) are from Merinolandschaf sheep, the rest are Suffolk, Texel, German Blackheaded Meatsheep, and Jura with 1,755, 871, 701 and 690 records, respectively.

2.2 Statistical analyses

All analyses were performed across breeds. Variance components were estimated using an animal model in ASReml (Gilmour *et al.* 2009). The full model included the fixed effects of contemporary group (defined using herd, year and season of birth - hys), year and month of testing (ym), sex, breed and birth type, as well as the covariates live weight (lw) and age of the animal, and dam age. Dam age was fitted as linear and as quadratic term. Animal, maternal genetic effects and maternal environmental effects (PE dam) were fitted as random effects. A series of univariate analyses were used to find the most appropriate model based on log likelihood ratio tests for each trait and solutions for the effect fitted. Effects that did

not significantly improve the model were removed. Table 2 gives an overview of the effects that were fitted for each trait.
Subsequently, a complete set of bivariate analyses was performed for each trait combination.

Table 2: Effects fitted in the statistical model for each trait

	Random effects			Fixed effects					Covariates			
Trait	**animal**	**dam**	**PE (dam)**	**hys**	**ym**	**sex**	**breed**	**type**	**lw**	**age**	**age (dam)**	**age (dam)** ^{2}
lw	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
adg	✓	✓	✓	✓	✓	✓		✓			✓	✓
emd	✓		✓	✓	✓	✓	✓		✓	✓		
fat	✓		✓	✓	✓	✓		✓	✓	✓	✓	
shoul	✓		✓	✓	✓	✓	✓	✓	✓	✓		
back	✓		✓	✓	✓	✓	✓	✓	✓	✓		
hind	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	

3. Results and Discussion

The model was run with and without maternal genetic effects and permanent environmental effects, respectively, and log likelihoods were compared to determine significance of fit for the model. Maternal genetic effects significantly improved the model for live weight and average daily gain. Maternal permanent environmental effects were significant for all of the traits. Table 3 presents the phenotypic variances and heritabilities.

Table 3: Estimates of phenotypic variance (σ^2_p), direct heritability (h^2), maternal heritability (m^2) and effect of permanent environment of the dam (pe^2_{dam}) with standard errors in parentheses

	lw	**adg**	**emd**	**fat**	**shoul**	**back**	**hind**
σ^2_p	8.69 (0.13)	1843.60 (29.37)	0.03 (0.001)	0.012 (0.0003)	0.26 (0.01)	0.20 (0.004)	0.26 (0.01)
h^2	0.07 (0.02)	0.16 (0.03)	0.20 (0.05)	0.21 (0.05)	0.03 (0.04)	0.01 (0.03)	0.08 (0.04)
m^2	0.05 (0.02)	0.03 (0.02)					
pe^2_{dam}	0.07 (0.02)	0.10 (0.02)	0.06 (0.02)	0.07 (0.02)	0.07 (0.03)	0.06 (0.03)	0.05 (0.02)

Live weight and the muscling scores for shoulder, back and hindquarters had low direct and maternal heritabilities with values of 0.07, 0.03, 0.01 and 0.08, respectively. Especially the scores for shoulder and back (h^2 of 0.03 and 0.01 and high standard errors) appear not to be heritable in these data. Those values are smaller than the estimates found in literature. De Vries *et al.* (2004) reported a heritability of 0.13 for muscling scores in German meat sheep. These results could indicate that the scoring system in Austria is less accurate.
The discrepancy with literature results is even bigger for the heritability of live weight (h^2 of 0.07). In their review Safari *et al.* (2005) list a range of 0.18-0.21 for live weight in meat sheep. Other studies report values of 0.30 to 0.38 for other sheep populations (Clarke *et al.* 2003; Jones *et al.* 2004), but those studies did not fit maternal effects. Poor data structure with confounding of genetic and fixed effects is likely to be another reason of the lower heritabilities found in this analysis.
The estimated direct heritabilities for average daily gain, eye muscle depth and fat depth were 0.16, 0.20 and 0.21, respectively. These values correspond better with literature. Safari *et al.* (2005) report that in 21 studies the estimated heritability of daily gain averaged at 0.17. The same review lists mean values for eye muscle and fat depth (corrected for live weight as in this study) of 0.22 and 0.25. However, the range

of estimates for emd and fat found in literature is very wide. Maxa *et al.* (2007) estimated 0.16 (emd) and 0.08 (fat) in Czech Suffolk using a comparable model that fitted maternal genetic and environmental effects whereas Kvame and Vangen (2007) present 0.40 for emd and 0.54 for fat in Norwegian meat sheep (without fitting maternal effects).

Genetic and phenotypic correlations are presented in table 4. The muscling scores for shoulder and back were not included in the bivariate analysis because of their low heritabilities with comparable high standard errors.

Table 4: Genetic correlations (below diagonal) and phenotypic correlations (above diagonal) with standard errors in parentheses

	lw	**adg**	**emd**	**fat**	**hind**
lw		0.96 (<0.01)	-0.001 (0.02)	-0.10 (0.02)	-0.01 (0.02)
adg	0.96 (0.01)		0.004 (0.02)	0.16 (0.02)	0.01 (0.02)
emd	-0.87 (0.21)	-0.53 (0.16)		0.06 (0.02)	0.15 (0.02)
fat	-0.57 (0.19)	0.22 (0.15)	0.15 (0.16)		0.10 (0.02)
hind	-0.81 (0.28)	-0.57 (0.23)	0.17 (0.23)	0.43 (0.23)	

Eye muscle depth, fat depth and hindquarter score (all adjusted for live weight) showed strong negative genetic correlations with live weight of -0.57 (fat) to -0.87 (emd). Average daily gain (adg), which is a direct function of lw, is genetically the same trait (0.96). Therefore as would be expected the genetic correlations of adg with emd and hind are also quite negative (-0.53 and -0.57). Fat shows a moderate positive correlation with adg and emd, although both not significantly different from zero. The highest positive genetic correlation (besides lw and adg) is 0.43 and is observed between fat depth and hindquarter score, though again not significantly different from zero. The phenotypic correlations are all very low, with the exception of lw and adg (0.96).

The results of comparable studies in literature vary widely. Jones *et al.* 2004 report a positive genetic correlation of 0.25 for eye muscle and fat depth which is in line with the mean of 0.33 presented in the Safari *et al.* (2005) review. The results listed in that review for those two traits range between -0.28 to 0.76 though. The ranges of estimated genetic correlations for live weight and fat depth and live weight and eye muscle depth presented in Safari *et al.* (2005) are similar wide.

However, the genetic correlations of live weight (and average daily gain) with the other traits are more strongly antagonistic than observed from published estimates. This may be a direct result of the structure of the data used in this study where 42 % of the records were from herd year season groups with less than 10 animals and 60 % of the data were in single sire herd year seasons.

4. Conclusion

A maternal genetic effect was included for both growth traits (live weight and average daily gain). The permanent environment due to the dam was included for all 7 traits. Lowest heritabilities were found for muscling scores and live weight, and highest heritabilities were found for eye muscle and fat depth. Live weight and average daily gain as a direct function of live weight are genetically the same trait. They were strongly negatively correlated with eye muscle and fat depth and hind quarter score. Some of the estimates were not in good agreement with literature results. Poor data structure could be at least part of the reason. Further research will be conducted to try to evaluate data issues. If the results of this study will be confirmed that would imply that simultaneous selection on growth traits (lw and adg) and more muscled animals (emd, hind) is very difficult.

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