Contributed paper

GENETIC ASSOCIATIONS BETWEEN ULTRASOUND AND CARCASE MUSCLE DIMENSION MEASURES IN SHEEP

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SUMMARY

This study investigated the genetic relationship between eye muscle width and depth recorded via ultrasound on live animals and on carcases in two populations of Australian and New Zealand sheep. Genetic correlations between ultrasound and carcase muscle dimensions were estimated within populations. Carcase eye muscle dimensions have sufficient genetic variation to be included in sheep breeding programs. Genetic correlations between carcase eye muscle depth (CEMD) and width (CEMW), and between CEMW and ultrasound eye muscle depth (PEMD) in Australian sheep were lower than expected. On the other hand, high genetic correlations were observed between ultrasound depth and width recorded in different ages on New Zealand Merinos. These differences indicate further research about CEMW is required and the implications of current selection practises has on carcase eye muscle dimensions.

INTRODUCTION

Lean meat yield is an important driver of profit for producers, processors and retailers of sheep meat. Ultrasound scanned eye muscle depth is moderately heritable and strongly correlated genetically with eye muscle depth in the carcase. Consequently, the majority of genetic gain in the depth of the eye muscle and in turn lean meat yield has been achieved by seed stock breeders selecting upon the ultrasound trait in the live animal (Brown and Swan 2016). The strong genetic correlations between ultrasound scanned eye muscle depth and width, previously observed in several studies (Safari *et al.* 2005), has meant that Sheep Genetics (Brown *et al.* 2007) has provided breeding values only for muscle depth. This is in part also due to the greater difficulty in measuring eye muscle width via ultrasound.

There are several studies that have reported on the genetic relationship between ultrasound muscle dimensions (Brito *et al.* 2017) and ultrasound and carcase measurements (Safari *et al.* 2005; Greeff *et al.* 2008; Mortimer *et al.* 2010), but often with low records. In the following study the genetic relationship between ultrasound and carcase eye muscle measurements was investigated in two different data sets: > 25,000 Australian Merino and Merino-cross sheep where eye muscle dimensions were measured both with ultrasound post weaning and on the carcase; and >30,000 New Zealand Merinos with ultrasound measurements at different ages. The objective of this study was to update the understanding of the relationship between these measurements and determine the impact selection decisions may have on the dimensions of the eye muscle in the carcase.

MATERIALS AND METHODS

Australian Dataset. Data from Australian Merino and Merino-cross sheep were collected between 2007 and 2019 from 35 commercial flocks, 8 Information Nucleus Flocks and the MLA Resource Flock (van der Werf *et al.* 2010). Ultrasound muscle scanners accredited through Sheep

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Genetics (MLA) scanned eye muscle depth (PEMD) at the C site over the 12th rib, 45 mm from the midline at post weaning age (mean age 213±45 days). Carcase traits were measured using the procedures described in Mortimer *et al.* (2017b). The carcases were cut between the 12th and 13th ribs and eye muscle (*M. longissimus thoracis et lumborum*, LL) depth (CEMD) and eye muscle width (CEMW) were measured with vernier callipers. Mean animal age for carcase traits was 263 (±76) days.

New Zealand Dataset. Data from New Zealand Merinos were collected between 2009 and 2019. Animals were ultrasound scanned at the C site over the 12th rib and measured for eye muscle depth and width at post weaning (7 – 10 months, PEMD, PEMW), yearling (10 – 13 months, YEMD, YEMW) and hogget age (13 – 18 months, HEMD, HEMW). For both data sets live weight was recorded at the time of scanning and was used to adjust the ultrasound measurements for weight. Summaries for each trait are presented on Table 1.

Table 1. Number of records, mean (standard deviation), coefficient of variation (CV) and number of sires and dams. CEMD: carcase eye muscle depth, CEMW carcase eye muscle width, PEMD and PEMW: post weaning ultrasound eye muscle depth and width, YEMD and YEMW: yearling ultrasound eye muscle depth and width, and HEMD and HEMW: hogget ultrasound eye muscle depth and width

Dataset	Trait	Records	Mean (SD)	CV	Sires	Dams
Australian	**PEMD**	25,628	25.4 (4.8)	18.8	1,651	12,799
	CEMD	26,284	31.0 (4.7)	15.3	1,874	12,747
	CEMW	26,282	60.6 (5.5)	9.0	1,874	12,747
New Zealand	**PEMD**	3,251	26.1 (2.8)	10.7	169	3,251
	YEMD	6,591	27.9 (3.6)	12.8	339	4,038
	HEMD	21,616	27.8 (3.8)	13.5	752	11,118
	PEMW	5,616	68.8 (6.0)	8.8	144	2,760
	YEMW	6,596	71.6 (6.2)	8.7	342	4,040
	HEMW	21,087	71.1 (6.9)	9.7	733	10,629

Statistical analysis. Within each dataset, variance components and genetic parameters for each trait were estimated using a linear mixed model and REML methods with ASReml software (Gilmour *et al.* 2015). Fixed effects included type of birth, contemporary group, sex (male or female) and the age of dam. The quadratic function of live weight (post weaning, yearling, hogget) and hot carcase weight were included to adjust the ultrasound and the carcase traits respectively. All models included the random effects of animal, genetic group (Swan *et al.* 2016) and sire × flock interaction. Maternal effects were not fitted since preliminary analysis showed they were non-significant. For Australian data set age of the animal was included as a fixed effect. For both datasets the animal effect represented the additive genetic variance. Contemporary group was defined by breed, flock, management group, sex, date of measurement and – for carcass data – kill group. Phenotypic variance was calculated as the sum of the additive genetic, sire × site and the residual variance. For each dataset, phenotypic and genetic covariance for all traits and correlations between traits were estimated using bivariate analysis in ASReml.

RESULTS AND DISCUSSION

Variance components and heritability estimates for ultrasound and carcase traits for each of the data sets are shown in Table 2. For the Australian dataset, heritability estimates were moderate for carcase traits ranging from 0.19 (±0.02) for CEMD to 0.27 (±0.02) for CEMW; higher heritability (0.32±0.02) was observed for PEMD. Similar heritabilities for CEMD and CEMW have been

observed in previous studies (Greeff *et al.* 2008; Huisman *et al.* 2016; Mortimer *et al.* 2017b). Heritability for PEMD for both data sets was higher than previously reported (Safari *et al.* 2005; Greeff *et al.* 2008; Mortimer *et al.* 2017a). Higher heritabilities were observed for the New Zealand Merino ultrasound traits: ranging from 0.23 (±0.03, YEMW) to 0.45 (±0.04, PEMD) (Table 2). Increased heritabilities have been observed in the past when live weight was used to adjust measurements (Mortimer *et al.* 2014).

Table 2. Estimates of phenotypic ($\hat{\sigma}_p$), additive ($\hat{\sigma}_a$) and residual ($\hat{\sigma}_\varepsilon$) variance and heritability (h^2) for ultrasound and carcase eye muscle traits. Standard error in parentheses

Dataset	Trait	h^2	$\hat{\sigma}_p$	$\hat{\sigma}_a$	$\hat{\sigma}_\varepsilon$	$\hat{\sigma}_{sire\ x\ site}$
Australian	**PEMD**	0.32 (0.02)	4.95 (0.46)	1.59 (0.1)	3.28 (0.08)	0.08 (0.02)
	CEMD	0.19 (0.02)	10.12 (0.09)	1.92 (0.18)	8.06 (0.16)	0.14 (0.05)
	CEMW	0.27 (0.02)	14.81 (0.14)	3.93 (0.3)	10.55 (0.25)	0.33 (0.08)
New Zealand	**PEMD**	0.45 (0.04)	3.15 (0.07)	1.35 (0.14)	1.76 (0.10)	0.03 (0.02)
	YEMD	0.34 (0.04)	3.42 (0.07)	1.13 (0.18)	2.16 (0.13)	0.13 (0.04)
	HEMD	0.31 (0.02)	3.78 (0.04)	1.16 (0.10)	2.49 (0.07)	0.13 (0.02)
	PEMW	0.29 (0.03)	10.01 (0.22)	2.86 (0.40)	7.09 (0.32)	0.06 (0.04)
	YEMW	0.23 (0.03)	9.48 (0.19)	2.20 (0.42)	7.01 (0.33)	0.27 (0.11)
	HEMW	0.27 (0.02)	10.56 (0.12)	2.82 (0.26)	7.46 (0.20)	0.27 (0.06)

Estimates of genetic and phenotypic correlations between carcase traits and post weaning ultrasound eye muscle depth for the Australian dataset are shown in Table 3. The genetic correlation between PEMD and CEMD was strong (0.77±0.04), but for the same animals CEMD was only moderately correlated with CEMW (0.38±0.05). Moreover, the correlation between CEMW and PEMD was low (0.17±0.04).

In contrast, for the New Zealand dataset, the correlations between ultrasound traits exhibited high genetic correlations between muscle depth and width at the same age (0.92±0.03 to 0.99±0.02) as well as between traits recorded at different ages (0.78±0.15 to 0.90±0.07, Table 4).

Table 3. Estimates of genetic (below diagonal) and phenotypic (above diagonal) correlations and their standard errors (parentheses) between carcase traits and ultrasound post weaning eye muscle depth for Australian dataset (see Table 1 for abbreviations)

	PEMD	CEMD	CEMW
PEMD		0.23 (0.01)	0.06 (0.01)
CEMD	0.77 (0.04)		0.09 (0.01)
CEMW	0.17 (0.04)	0.38 (0.05)	

High correlations between PEMD and CEMD have previously been reported by Greeff *et al.* (2008) (0.77) and Mortimer *et al.* (2010) (0.82). Moderate positive genetic correlations between CEMD and CEMW found in this study were similar to Safari *et al.* (2005) (0.23) and Greeff *et al.* (2008) (0.41). Based on these results, carcase eye muscle depth appears to be a genetically different trait to carcase eye muscle width. These low correlations in carcase measures contradict the New Zealand ultrasound results for corresponding traits as well as previous studies using ultrasound eye muscle dimensions at post weaning age, where correlations between eye muscle depth and width ranged between 0.78 in Australia (Safari *et al.* 2005) and 0.82 in New Zealand (Brito *et al.* 2017). Lower genetic correlations between ultrasound and carcase measurements could be a result of ultrasound limitations to accurately predict muscle dimensions. Hopkins *et al.* (2007) showed that

ultrasound muscle depth measurements are subject to more errors in heavier sheep. Moreover, it would be beneficial for future investigations to include accurate animal age records since limitations might also include potential failure to properly account for age variation.

Table 4. Estimates of genetic and phenotypic correlations between ultrasound eye muscle depth and width for different ages (post weaning, yearling and hogget) for New Zealand Merino (standard error in parentheses)

	Genetic			Phenotypic		
	PEMD	**YEMD**	**HEMD**	**PEMD**	**YEMD**	**HEMD**
PEMW	0.92 (0.03)	0.84 (0.16)	0.88 (0.09)	0.61 (0.01)	0.15 (0.94)	0.64 (0.23)
YEMW	0.78 (0.15)	0.99 (0.02)	0.87 (0.07)	0.57 (0.46)	0.68 (0.01)	0.49 (0.03)
HEMW	0.90 (0.07)	0.80 (0.07)	0.95 (0.01)	0.60 (0.21)	0.48 (0.03)	0.70 (0.01)

CONCLUSIONS

The high genetic correlation between ultrasound PEMD and CEMD means that ultrasound should continue to be used as a selection trait to improve CEMD. However, whilst ultrasound measures of EMD and EMW are strongly correlated with each other, their correlations with carcase measurements are weaker. In particular, further research is required to determine if current selection practices are changing the dimensions of the eye muscle within the carcase and increase the need for a CEMW breeding value.

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