Strain differences in Merinos for carcase and meat quality

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ABSTRACT

The increased emphasis on the Merino for meat production has heightened the need to quantify the variation across the breed for meat and carcase traits and to produce genetic correlations and heritabilities for these traits. This paper reports on strain effects (broad, medium and fine wool) on carcase and meat quality traits for 1934 rams. Rams (~19 months of age) were slaughtered over 4 years and data on animals from 272 sires were collected. Every year, the rams were fed a formulated pellet at pasture for 5 weeks before slaughter. All animals were slaughtered in commercial abattoirs. Hot carcase weights were recorded and the GR measured using a GR knife. After overnight chilling (4–5°C), carcases were cut between the 12th/13th ribs and the longissimus thoracis et lumborum (LL) was exposed to the air at chiller temperature for 30 min. Meat colour was measured on the cut surface using a Minolta Chromameter set on the *L**, *a**, *b** system. The pH of the LL and the semitendinosus (ST) muscle was also measured. Fine wool rams were the fattest when compared at the same carcase weight. The broad wool strain had the lowest pH in both muscles and there were minimal differences between strains for meat colour. These real differences between Merino strains in meat quality traits require more detailed investigation in order to understand their biological bases and identify if potential markers exist that could be used in Merino breeding programs.

Keywords: sheep; pH; strains; meat quality.

INTRODUCTION

The increased emphasis on the Merino for meat production in Australia has heightened the need to quantify the variation across the breed for meat and carcase traits and to produce genetic correlations and heritabilities for these traits. Fogarty *et al.* (2003) showed differences between broad, medium and fine wool strains for traits such as meat colour, meat pH and carcase fat levels. In terms of meat pH more recently Hopkins *et al.* (2005) reported that superfine strains produced higher levels than broader wool strains. These authors argued that muscle glycogen was potentially limiting in the work of Fogarty *et al.* (2003) and to counter this supplemented their animals on pellets before slaughter. The differences between strains have been further studied using the QPLU$ selection lines. The QPLU$ selection lines are located at Trangie in central western NSW and were established to demonstrate simultaneous improvement in wool weight and reduction in fibre diameter resulting from 10 years of selection using a range of indexes in fine, medium and broad wool strains (Taylor & Atkins, 1997). Rams (~19 months of age) which were the progeny from the last 4 rounds of selection of the Trangie QPLU$ selection lines, were slaughtered and a range of carcase and meat quality traits examined. This paper reports on the analysis of strain effects in this data set.

MATERIALS AND METHODS

Animals and sampling

The data for this paper were recorded on rams born in each of 4 years (2001-2004). The rams were the progeny of Merino sires (8 sires per selection line) that had been single sire mated to Merino ewes within each of 9 selection lines across fine, medium and broad wool types of Merino. Lambs were identified to their sire and dam at lambing and birth type recorded. The lambs were weaned at 2.5 months and run separately in gender groups. The rams were from 272 sire progeny groups (Table 1) and were surplus to the requirements for selected rams in each selection line, with approximately 25% of rams not slaughtered. The rams that were selected as breeding replacements were selected on indexes using estimated breeding values from multiple trait analysis (Taylor & Atkins, 1997).

Table 1: Number of sires used per year to generate the rams slaughtered.

Year	Sires	Rams
2001	68	494
2002	66	505
2003	73	511
2004	65	424
Total	272	1934

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The rams were allocated to 2 slaughter groups in November of each year (2002-2005), balanced for sire. Rams were introduced to grain and then supplementary fed at pasture (a mixture of native grasses and lucerne) for 5 weeks with pellets at 1kg/head.day every second day. In 2002, due to drought the animals were fed grain from July until pellet feeding commenced in December. These animals were handled throughout their life during the collection of production data. The pellets were made on site at Trangie and consisted of 30% lucerne, 20% lupins, 30% wheat and 20% oats with bentonite, salt and lime added. These pellets had an average crude protein level of 19.7%, a ME of 12.1 MJ/kg DM and a digestibility of 77.4%.

The rams were yarded and held for 1.5–2 hours before weighing the day before slaughter at approximately 19 months of age, then allowed to drink and graze pasture for 2–4 hours before trucking to the abattoir, a trip of 100 km. At the abattoir the animals were held in yards overnight with access to water and slaughtered the next day. For the first year all animals were slaughtered at the same abattoir and in subsequent years a different abattoir was used. The carcases were subject to standard AUS-MEAT trim, which involved removal of kidneys and internal fats (Anon., 1992). Hot carcase weight (HCW) was recorded and fat depth at the GR site (GR; soft tissue depth at the 12th rib, 110 mm from the midline) was measured using a GR knife on the hot carcase. The carcases were held in chillers at <5°C (ambient chiller temperature was recorded using Cox recorders, Belmont, NC, USA) and 24 hours after slaughter they were cut between the 12th and 13th rib and loin muscle (*m. longissimus thoracis et lumborum;* LL) depth (EMD), width (EMW) and fat depth (FATC) over the LL measured. The cross-sectional area (EMA) of the LL was estimated as 80% of the product of EMD and EMW. Meat colour was measured on the cut surface of the LL after at least 30 minutes exposure to the air using a Minolta Chromameter calibrated with a white tile and set on the *L**, *a**, *b** system (where *L** measures relative lightness, *a** relative redness, and *b** relative yellowness). The pH of the LL was also measured using a data recording pH meter (WP-80, TPS Pty. Ltd, Brisbane, QLD) fitted with an intermediate junction electrode (Ionode IJ 44, Tennyson, QLD). The pH of the m. *semitendinosus* (ST) was also measured. Carcases from the 2002-2004 birth years were subjected to electrical stimulation as part of the commercial slaughtering process. For the 2004 born animals, LL samples were also collected at slaughter and held chilled for 3 days and measured again for pH using an iodoacetate method adapted from that described by Dransfield *et al.* (1992).

Statistical analysis

The traits were analysed using a REML procedure (Genstat 9.1, 2006), with the model containing a fixed effect for strain (fine, medium, broad) and year of slaughter, sire identification and ewe identification included as random terms. The term year, represents production and slaughtering variation. For carcase measures, hot carcase weight was included as a covariate while for the colour traits; muscle pH was used as a covariate. The pH at 24 hours in the LL was related to the pH measured after 3 days (for 2004 born animals) using linear regression.

RESULTS

Carcase Measures

The carcase and meat quality characteristics of the animals used in this experiment are summarised in Table 2. There was considerable variation in most traits, with coefficients of variation ranging from around 5% for muscle pH to about 50% for FATC.

Table 2: Mean, standard deviation (s.d.) and range of carcase traits (HCW = hot carcase weight, GR = tissue depth, fat depth over the 12th rib (FATC), depth of the loin muscle (EMD), width of the loin muscle (EMW) and cross-sectional area of the loin muscle (EMA)) and meat quality traits (pH of the longissimus (LL) and semitendinosus (ST) muscles and colour dimensions *L** = lightness, *a** = redness and *b** = yellowness of the LL) for the 1924 hogget rams.

Traits	Mean	S.D.	Range
HCW (kg)	27.3	5.31	11.5 – 45.0
GR depth (mm)	8.8	3.69	0.0 – 20.0
FATC (mm)	2.5	1.28	0.0 – 10.0
EMD (mm)	28.4	3.55	13.0 – 40.0
EMW (mm)	64.7	5.33	50.0 – 86.0
EMA (cm²)	14.8	2.74	5.4 – 24.3
pH (LL)	5.95	0.34	5.50 – 7.16
pH (ST)	6.16	0.31	5.44 – 7.16
Colour characteristics:			
*L**	34.1	2.97	26.0 – 45.8
*a**	19.8	3.24	11.1 – 33.8
*b**	9.2	2.00	4.0 – 20.0

Broad wool carcases were the heaviest, and thus the fattest (GR and FATC) without adjustment for carcase weight, but when carcase weight was used as a covariate the fine wool strain was the fattest (Table 3). Differences for LL dimensions were smaller when carcase weight was used as a covariate, with the medium wool strain exhibiting

a significantly deeper LL ($P < 0.001$), carrying through to a larger EMA. There was no significant difference ($P > 0.05$) between strains for pH of the LL, but there was for the ST with the broad wool strain having a significantly ($P < 0.001$) lower mean (Table 3). Colour of the LL showed minor differences due to strain. There was a significant relationship ($P < 0.001$) between pH of the LL at 24 hours and the pH at 72 hours as measured in 415 carcases from animals born in 2004, with an $R^2 = 0.71$ and an r.s.d = 0.209.

DISCUSSION

In agreement with Fogarty *et al.* (2003) and Hopkins *et al.* (2005), fine wool rams were the fattest when compared at the same carcase weight (Table 3). However when no adjustment for carcase weight was applied, the broad rams had the fattest carcases (particularly evident at the GR site), reflective of their much heavier carcases. These effects probably are in part due to differences in mature weights, but it is of interest that when carcase weight was accounted for that the medium wool strain had the largest LL area. This would suggest this strain on average is likely to produce similar amounts of saleable meat to the broad wool strain using the models of Hopkins *et al.* (1995). It appears the medium wool strain has a proportionally deeper LL at the 12th rib which drives the LL area effect (Table 3). Detailed analysis (Hopkins *et al.,* 2006) indicates that the 8% medium wool line was in part responsible for this effect in the medium wool strain, but the reason for this is unclear.

As found by Hopkins *et al.* (2005) for Merino wethers of a similar age, the broad wool strain had the lowest pH in the ST and there were minimal differences between strains for meat colour. The pH for the LL however was not significantly lower in the broad wool strain in contrast to the results of Hopkins *et al.* (2005). Previously, Fogarty *et al.* (2003) reported that in fact the broad wool strain had the highest LL pH when measured in rams of a similar age. In this study, like that of Hopkins *et al.* (2005), but not that of Fogarty *et al.* (2003), the animals were fed pellets for 5 weeks prior to slaughter as an attempt to ensure the animals entered slaughter with adequate glycogen levels given that the level of energy intake impacts on muscle glycogen levels (Pethick *et al.,* 2000). The measurement of ST pH provides more insight into possible effects of strain on muscle pH as this muscle has more type 2B fast glycolytic fibres than the LL (Greenwood *et al.,* 2006). Increasing content of these fibres is linked to increases in the final pH levels (Gardner *et al.,* 2006) and this appears to be driven by a faster rate of glycogen depletion during the pre-slaughter period in the ST (Pethick *et al.,* 2000). This suggests that the broad wool strain was better able to cope with the pre-slaughter stresses. It may also reflect a higher intake of the supplement in the broad wool strain and thus a higher glycogen concentration and explain why Fogarty *et al.,* (2003) found that the broad wool strain had the highest pH since no supplement was provided in their study and the broad wool strain would have the highest maintenance requirement given a larger body weight. It is also feasible that the effect reflects a

Table 3: Predicted means (av.s.e.d) for carcase (HCW = hot carcase weight, GR = tissue depth, fat depth over the 12th rib (FATC), depth of the loin muscle (EMD), width of the loin muscle (EMW) and cross-sectional area of the loin muscle (EMA)) and meat quality traits (pH of the longissimus (LL) and semitendinosus (ST) muscles and colour dimensions L^* = lightness, a^* = redness and b^* = yellowness of the LL) for the 1924 hogget rams according to strain.

Traits	Broad	Medium	Fine	Av. s.e.d.	Significance
HCW (kg)	31.1a	26.7b	25.4c	0.298	***
GR depth (mm)[1]	7.7c	8.9b	9.8a	0.234	***
GR depth (mm)	9.7a	8.7b	8.9b	0.270	***
FATC (mm)[1]	2.1c	2.5b	2.8a	0.098	***
FATC (mm)	2.7a	2.4b	2.6a	0.097	*
EMD (mm)[1]	27.6b	28.7a	28.1b	0.234	***
EMW (mm)[1]	64.4ab	65.1a	64.0b	0.36	***
EMA (cm²)[1]	14.3b	15.0a	14.5b	0.174	***
EMA (cm²)	15.8a	14.8b	13.8c	0.198	***
pH (LL)	5.91a	5.97a	5.95a	0.026	n.s.
pH (ST)	6.09b	6.17a	6.18a	0.026	***
Colour characteristics:					
L^*[2]	34.0b	33.8b	34.6a	0.189	***
a^*[2]	19.7a	19.7a	19.8a	0.173	n.s
b^*[2]	9.2ab	9.1b	9.4a	0.104	*

*P < 0.05; ***P < 0.001; n.s – not significant. [1]Adjusted to a mean carcase weight of 27.6 kg. [2]Adjusted to a pH of 5.95.

difference between strains in the response of muscle glycogen under the same level of intake (Martin *et al.,* 2004).

The results suggest that there are real differences between Merino strains in meat quality traits, which themselves can impact on factors such as meat shelf life and tenderness. These results require more detailed investigation in order to understand their biological basis and identify if potential markers exist that could be used in Merino breeding programs. To date, only the study of Hopkins *et al.* (2005) has identified differences in enzyme activities between Merino strains, plus speculated on differences in fibre type frequencies between strains, that may underpin the pH effect in Merinos. Validation of their results is needed. Additionally, if traits are identified that could be used as genetic markers for meat quality, these would complement the genetic parameter estimates involving meat and carcase traits that are now becoming available (for example Hopkins *et al.,* 2006) to enhance sheep genetic evaluation and improvement programs in Australian flocks.

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REFERENCES

Anon. 1992: 'AUS-MEAT language.' 4th edn. (Authority for Uniform Specification Meat and Livestock: Sydney).

Dransfield, E.; Etherington, D.J.; Taylor M.A.J. 1992: Modelling post-mortem tenderisation - II: Enzyme changes during storage of electrically stimulated and non-stimulated beef. *Meat Science* **31**: 75-84.

Fogarty, N.M.; Safari, E.; Taylor, P.J.; Murray, W. 2003: Genetic parameters for meat quality and carcass traits and their correlation with wool traits in Australian Merino sheep. *Australian Journal of Agricultural Research* **54**: 715–722.

Gardner, G.E.; Pethick, D.W.; Greenwood, P.L.; Hegarty, R.S. 2006: The effect of genotype and plane of nutrition on the rate of pH decline in lamb carcasses and the expression of metabolic enzymatic markers. *Australian Journal of Agricultural Research* **57**: 661–670.

Genstat 2006: 'Genstat 9 Release 9.1'. 9th edn, for Windows, Lawes Agricultural Trust: Rothamsted Experimental Station.

Greenwood, P.L.; Gardner, G.E.; Hegarty, R.S. 2006: Lamb myofibre characteristics are influenced by sire estimated breeding values and pastoral nutritional system. *Australian Journal of Agricultural Research* **57**: 627–639.

Hopkins, D.L.; Wotton, J.S.A.; Gamble, D.J.; Atkinson, W.R. 1995: Lamb carcass characteristics 2. Estimation of the percentage of saleable cuts for carcasses prepared as trim and traditional cuts using carcass weight, fat depth, eye muscle area, sex and conformation. *Australian Journal of Experimental Agriculture* **35**: 161-169.

Hopkins, D.L.; Hatcher, S.; Pethick, D.W.; Thornberry, K.J. 2005: Carcass traits, meat quality and muscle enzyme activity in strains of Merino hoggets. *Australian Journal of Experimental Agriculture* **45**: 1225-1230.

Hopkins, D.; Greeff, J.; Safari, E.; Brien, F.; Taylor, P. 2006: Genetic parameter estimation for meat traits in Merinos, Final Report for Meat & Livestock Australia, Project SHGEN.014, Sydney Australia.

Martin, K.M.; Gardner, G.E.; Thompson, J.M.; Hopkins, D.L.; 2004: Nutritional impact on muscle glycogen metabolism in lambs selected for muscling. *Journal of Animal and Feed Sciences* **13** (Suppl 1.): 639-642.

Pethick, D.W.; Cummins, L.; Gardner, G.E.; Jacob, R.H.; Knee, B.W.; McDowell, M.; McIntyre, B.L.; Tudor, G.; Walker, P.J.; Warner, R.D. 2000: The regulation of glycogen level in the muscle of ruminants by nutrition. *Proceedings of the New Zealand Society of Animal Production* **60**: 94-98.

Taylor, P.J.; Atkins, K.D. 1997: Genetically improving fleece weight and fibre diameter of the Australian Merino - The Trangie QPLU$ Project. *International Journal of Sheep and Wool Science* **45**: 92-107.