THE UNIVERSITY of ADELAIDE

SA Merino Sire Evaluation

2021 Drop Carcase Outcomes

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DAVIES LIVESTOCK RESEARCH CENTRE

make history.

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1. Summary

The SA Merino Sire Evaluation Site received support from the SA Sheep Industry Fund to collect carcase information on hard-to-measure traits associated with eating quality and lean meat yield from the 2021 drop cohort. A total of 142 wethers from 15 sires were randomly selected (~10 per sire) and processed at JBS, Bordertown on 23rd June, 2022. Chiller assessment for Hot Standard Carcase Weight, GR tissue depth, and pH decline were undertaken. Cold carcase dual x-ray absorptiometry composition estimates for lean, fat, and bone percentage were recorded. Samples from the left side loin were collected for analysis of intramuscular fat and shear force after five days ageing. A sire model was then fit and for each trait the heritability, variance components, and predicted means for each sire reported. Overall, carcases sampled yielded well with moderate to high lean percentage and low GR tissue depth. Eating quality was favourable with over half the cohort exceeding the minimum 4% intramuscular fat sought after for good eating quality, although shear force data indicated samples were on the high side of acceptable. Heritability of traits was higher than expected, which may be a result of the small number of sires sampled. This project has provided information on hard-to-measure traits of critical importance to maintaining lamb eating quality and informing Australian Sheep Breeding Values using a South Australian production system and key rams from SA merino breeders.

2. Introduction

The high price of lamb coupled with high consumer expectation has driven the urgency for the Australian lamb supply to ensure it is able to consistently supply high eating quality product. Good meat eating quality is driven by multiple traits which are influenced by genetic and environmental effects. Two key traits are intramuscular fat (IMF) and shear force after 5 days ageing (SF5).

Lean meat yield refers to the amount of lean in a carcase expressed as a percentage of hot standard carcase weight. Dual x-ray absorptiometry (DXA) is a precise and accurate method used to assess carcase composition, including lean, fat, and bone at chain speed in both the hot and cold carcase. DXA devices provide a lean meat yield estimate (DXA lean), with higher values indicating leaner carcases (akin to lower fat score or GR). Lean meat yield has a high heritability in the range of 51% to 58%.

The percentage of intramuscular fat (IMF%) is a major determinant of eating quality. IMF, visualised as marbling, is a measure of the chemical fat percentage in the lamb loin. An increase in IMF% has been shown to correlate with increased consumer perception of juiciness, tenderness, flavour, and overall liking with a minimum of 4% IMF preferred by consumers. The IMF range is typically between 2% and 7%. This trait is moderately to highly heritable and negatively correlated with SF5.

Shear force (SF5) reflects consumer perception of tenderness and is measured as the force required to cut through a sample of cooked loin after five days ageing to allow for tenderisation from proteolytic ageing. SF5 values less than 3kg or 29.42N are desirable and represent more tender meat. SF5 is a moderately to highly heritable trait with a typical range from 1.1kg to 7.7kg.

Higher, or more positive values for DXA lean% and IMF% are favourable, whereas lower, more negative values are preferred for SF5. A balanced approach to selection for lean meat yield and meat quality is needed to ensure these negatively correlated traits do not work against each other. Balanced selection for carcase yield and meat quality traits can be achieved by incorporation of lean meat yield, IMF%, and SF5 breeding values into decisions when selecting sires to simultaneously improve lean meat yield and eating quality.

3. Project purpose and outcomes

This project contributes to the SA Sire Evaluation Site which has the outcome to provide an independent ram benchmarking service within SA for merino sires. Specifically, the purpose of this project was to enable collection of hard-to-measure meat eating quality phenotypes for IMF and SF5 from 2021 drop progeny of the 15 rams entered at the site. This will enable informed sire selection, increase breeding value accuracy of relatives, and augment the reference populations for these traits. This was achieved through completion of the following activities:

- 2021 Mentara Park drop wether lambs processed at JBS, Bordertown
- Individual animal IMF% and SF5 samples collected and analysed
- Collection of individual animal data for the progeny of 15 rams, including exit weight, HSCW, dressing %, GR tissue depth, pH decline, IMF%, SF5, and DXA carcase composition estimates
- Fitting of a sire model to report on heritability, variance components, and sire predicted means across the sampled traits

4. Methodology

4.1. Animal management

The South Australian Merino Sire Evaluation Site at Mentara Park evaluated 15 rams, each joined to 57 ewes via artificial insemination in December, 2020. Ewes were scanned at day 50 and managed in groups of singles and multiples until just prior to lambing, when they were then separated in to single, twin, and triplet-bearing management groups. Lambing commenced mid-May, 2021. Conception rates were low with only 45% of ewes scanned pregnant for a total of 572 lambs born across all sires. Lambs were marked in mid-June, 2021, weaned mid-August, 2021, shorn September, 2021 and scanned for carcase traits in April, 2022. The wether lamb cohort was sold on 23 June, 2022 with ten progeny per sire selected for meat eating quality evaluation. Low conception rates and missing birth type records resulted in wether lambs (n = 142) born single, twin, and of unknown birth type selected for sampling to total ten lambs per sire. For some sires, avoiding selection of lambs of unknown birth type was not possible. A summary of sire progeny is provided in Table 1.

Table 1 Summary of number of wether progeny per sire by birth type.

Breeders Flock, Sire Number	**Single**	**Multiple**	**Not recorded**	**Total**
Anderson Poll, 160729	3	10	6	19
Callowie Poll, 190055	4	8	4	16
Claypans Poll, 170632	7	9	3	19
Flairdale Poll, 190401	3	5	0	8
Forest Springs Poll, 190193	6	14	0	20
Hazeldean, 002529	2	17	7	26
Kelvale Poll, 191148	5	7	4	16
Lorelmo Poll, 160172	3	11	3	17
Malleetech Poll, 199100	2	9	3	14
Mumblebone, 191150	9	14	0	23
Nantoura Poll, 190061	6	20	7	33
O'Brien Poll, 190455	4	15	5	24
Ridgeway Poll, 190240	2	13	6	21
Wallaloo Park Poll, 172032	4	6	1	11
The Yanko, 190086	5	2	2	9

4.2. Abattoir assessment

All 142 wether lambs selected for meat eating quality evaluation were consigned together and transported from Mentara Park, Malinong to JBS, Bordertown on Wednesday 22nd June 2022. Lambs were rested in lairage overnight then harvested on Thursday 23rd June 2022 and fabricated on Friday 24th June 2022.

Electronic identification was scanned at the point of slaughter and carcases were manually tagged to enable tracking through harvest and fabrication, and subsequent linkage to Sheep Genetics identification. Carcases were trimmed to AUS-MEAT specifications and then weighed to determine Hot Standard

Carcase Weight (HSCW). All carcases were then subjected to electrical stimulation before entering the chiller where they remained overnight at 0-4°C. Approximately two hours after chiller entry tissue depth (mm) was recorded using a GR knife inserted over the 12th rib 110mm from the midline.

Carcase temperature and pH measurements were taken a total of four times and commenced immediately following harvest on entry to the chiller (approximately 30 minutes post slaughter). Subsequent readings were taken when muscle temperature was approximately 18°C and 12°C, followed by a final measurement in the laboratory. Measurements were taken in the caudal (tail) end of the *m. longissimus thoracis et lumborum* (loin) over the lumber-sacral juncture on the left-hand side after sectioning the dorsal surface of the subcutaneous fat and muscle to expose the measurement site. Measurements were made with a pH meter (WP-80M, TPS Pty Ltd., Queensland) fitted with a stab type temperature probe (Stab Temperature Sensor, TPS Pty Ltd., Queensland) and polypropylene spear type gel electrode (1m pH Sensor Intermediate Junction, TPS Pty Ltd., Queensland). Calibration of the pH sensor with pH 4.01 and pH 7.00 buffers at chiller temperature and room temperature was completed prior to measurement in the chiller and laboratory, respectively. Loin temperature and pH measurements were taken simultaneously.

Carcases were DXA scanned to assess lean, fat and bone composition then fabricated after approximately 24 hours of active chilling. The left-side loin sample was collected following preparation to AUS-MEAT specifications for short loin (H.A.M. item number 4881). Samples were vacuum sealed and refrigerated at approximately 4°C until further preparation. Samples were transported to the laboratory where a final temperature and pH measurement were recorded prior to deboning. This was followed by preparation of a denuded eye of short loin (H.A.M. item number 5150), which was separated into a cranial and caudal piece for intramuscular fat (IMF) and shear force (SF5) testing, respectively. A sample of approximately 45g was diced into 5mm cubes and placed in in 50ml polypropylene tubes (Screw cap tube, Sarstedt, Nümbrecht, Germany), then frozen at -20°C until IMF analysis. Each SF5 sample was prepared with dimensions 60-70mm length, 40-50mm width, and 20-25mm thick to produce a weight of approximately 65g then individually vacuum sealed, aged at 4°C until day 5 post-slaughter, then frozen at -20°C until analysis (Sheep CRC, 2009).

4.3. Intramuscular fat and shear force

Frozen IMF samples were consigned on temperature regulated transport to University of New England, Armidale for analysis. Samples were freeze dried and IMF% was determined using the procedure of near infrared reflectance spectroscopy (NIR). SF5 analysis was conducted following the Sheep CRC method (Sheep CRC, 2009). Briefly, frozen samples were weighed then cooked in a bag in batches using a water bath set at 71°C for 35 mins. Following cooking, samples were cooled in their bag under cold running water for 30 mins then removed from the bag, dried with paper towel, weighed, and stored in the refrigerator at 4°C until testing. Shear force was determined using a Lloyd LRX texture analyser fitted with a Warner-Bratzler blade attachment programmed with a crosshead speed of 100.00mm/min. Samples were cut into 10mm thick pieces that were then sliced parallel to the muscle fibres into pieces approximately 8.3mm by 12mm. Six replicates from each sample were loaded into the Lloyd cutting chamber for testing such that the cutting line was perpendicular to the muscle fibres. Each of the six measurements were recorded (Newtons) and the mean, standard deviation, and coefficient of variation were calculated for each sample. The mean SF5 value was used for analysis unless the coefficient of variation was 24% or greater, in which case the median value was used.

4.4. Statistical analysis

Data were collated in Excel (Microsoft Corporation, 2018) then summarised and visualised in R (R Core Team, 2021) using readxl (Wickham and Bryan, 2019), vtable (Huntington-Klein, 2022) and ggplot2 (Wickham, 2016). GenStat (14th Edition, VSN International Ltd., Hemel Hempstead, UK) was used to fit a sire model to estimate heritability and generate sire predicted means for all carcase traits. Birth type effects could not be fit due to missing records. The standard error is reported for each trait. In this trial only observations on sires were obtained, therefore due to the sire making up ¼ of additive genetic variance the following equation was used to estimate heritability:

$$h^2 = \frac{(4 \text{ x } sire\ variance)}{(sire\ variance \text{ x } residual\ variance)}$$

5. Results and discussion

5.1. Descriptive statistics

Descriptive statistics for the unadjusted live weight, chiller assessment, eating quality, and carcase composition data are provided in Table 2. For each trait, the mean, minimum, maximum, standard deviation, and coefficient of variation (a measure of variability calculated by standard deviation/mean and multiplied by 100) are reported. As expected in a progeny test, there was large variation across the cohort. This is important and demonstrates differences in performance between individuals within the same lifetime management group. Lambs weighed between 44.5kg and 75.0kg at the time of slaughter and on average dressed at 44.7% yielding carcases with HSCW from 18.9kg to 34.9kg. GR tissue depth was highly variable (CV of 49.8%) ranging from 2.0mm (fat score 1) to 25.0mm (fat score 5). Ultimate pH was the least variable trait and ranged from 5.5 to 6.1 with 96% of carcases achieving pH 6.0 or below which is desirable for eating quality. Coefficient of variation indicated intramuscular fat and shear force were highly variable, ranging from 1.9% to 9.7%, and 26.7N to 104.5N, respectively, which are similar to values reported elsewhere (Mortimer *et al.*, 2014). An IMF above 4% is considered preferable by consumers and 52.8% of lambs exceeded this level. However, only 7% of lambs had a shear force below 29.42N (3kg), which is sought after to achieve tenderness. DXA lean averaged 55.6% with a range from 48.2% to 62.4%. Of the carcase composition estimates, fat was the most variable with CV of 14.7% and range 21.0% to 41.4%, which is consistent with the large variation also recorded for GR tissue depth. An average 13.6% was recorded for DXA bone with standard deviation of 1.4.

Table 2 Summary statistics for unadjusted weight, carcase, eating quality, and composition measurements including mean, minimum, maximum, standard deviation (SD), and coefficient of variation (CV).

	Mean	Minimum	Maximum	SD	CV (%)
Exit weight (kg)	59.6	44.5	75.00	5.9	9.8
HSCW (kg)	26.7	18.9	34.9	3.3	12.3
Dressing %	44.7	37.8	50.2	2.3	5.2
GR (mm)	9.8	2.0	25.0	4.9	49.8
pH_u	5.7	5.5	6.1	0.1	2.0
IMF (%)	4.1	1.9	9.7	1.2	29.5
SF5 (N)	41.0	26.7	104.5	13.5	32.9
DXA lean (%)	55.6	48.2	62.4	3.2	5.7
DXA fat (%)	30.8	21.0	41.4	4.5	14.7
DXA bone (%)	13.6	10.4	16.6	1.4	10.0

Boxplot summaries showing the unadjusted mean, interquartile range, and outliers by sire for the traits HSCW, dressing%, GR tissue depth, ultimate pH, IMF%, SF5, and DXA lean% are presented in Figure 1. Figure 2 shows the relationship between traits, including HSCW, GR, DXA lean, IMF%, and SF5 with all relationships following trends as expected and reported in other literature. There was a positive relationship between HSCW and GR, with heavier carcases having the greatest GR tissue depth. As DXA lean% increased, indicating carcases with less fat, GR tissue depth and IMF% decreased. The opposite was true for shear force where the lowest SF5 values, indicating more tender meat, were recorded for lambs with the lowest DXA lean, although this relationship was not as strong. There was also a weak relationship between IMF% and SF5 such that as IMF% increased, SF5 decreased.

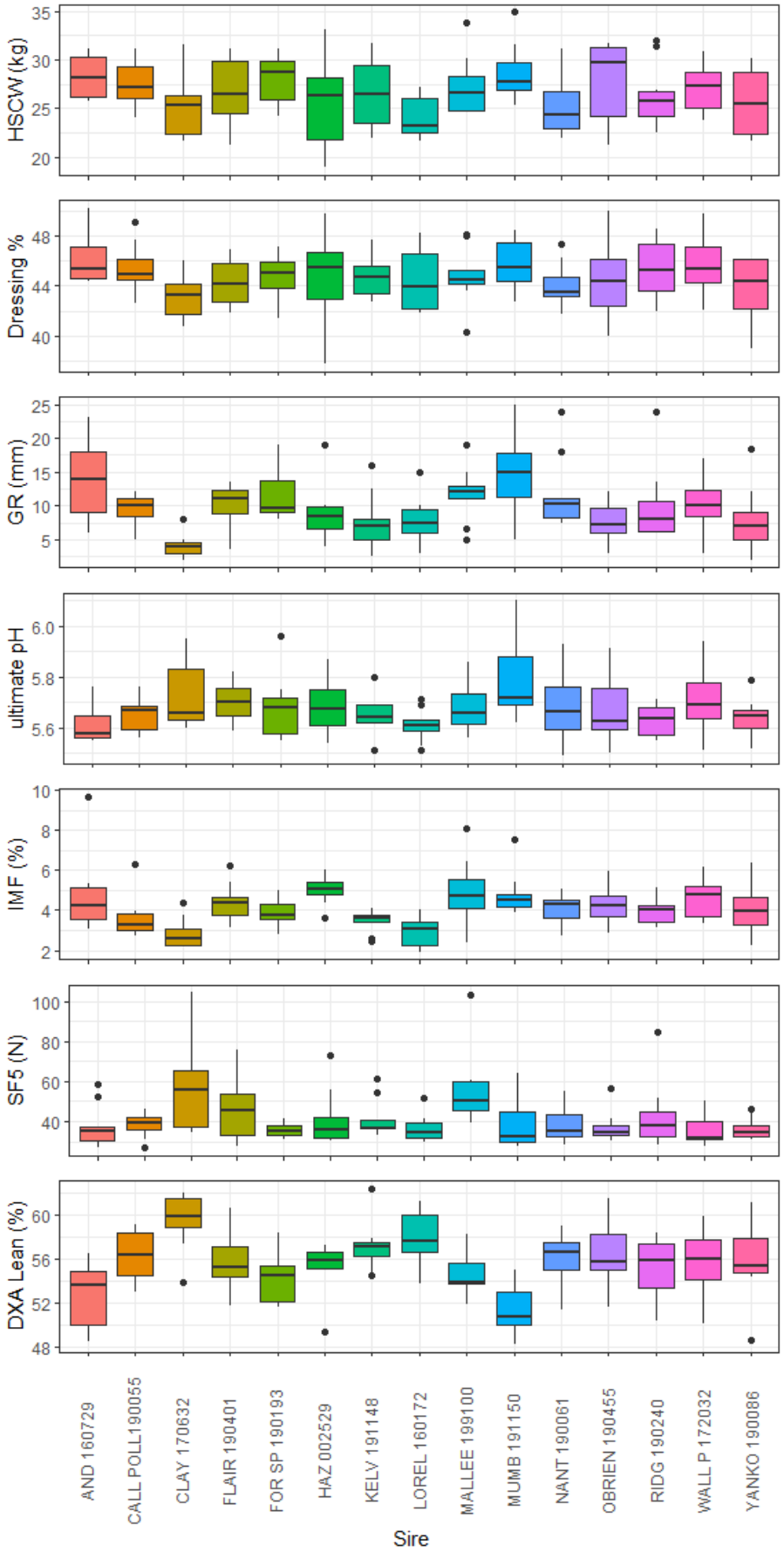

Figure 1 Boxplot summary of unadjusted traits including hot standard carcase weight (HSCW), dressing %, GR tissue depth (GR), ultimate pH, intramuscular fat (IMF), shear force (SF5), and DXA lean, separated by sire.

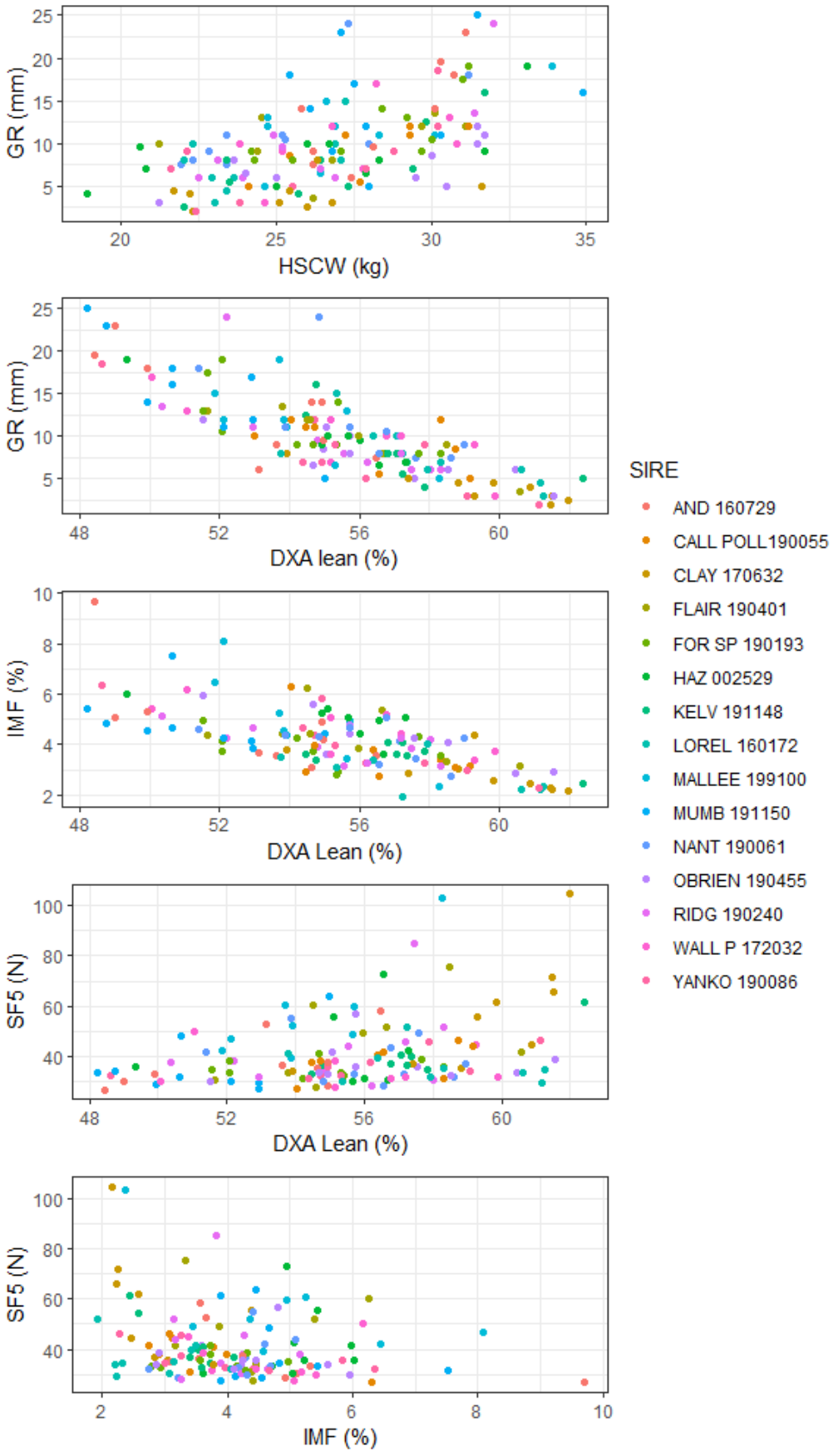

Figure 2 The relationship between recorded traits including hot standard carcase weight (HSCW), GR tissue depth (GR), intramuscular fat (IMF), shear force (SF5) and DXA lean.

5.2. Heritability estimates

Estimated heritability from a sire model was high for GR tissue depth, DXA carcase composition estimates (lean%, fat%, bone%), IMF% and SF5, which was likely a result of the small number of sires sampled (Table 3). Previous studies have reported heritability of GR tissue depth, lean meat yield, IMF% and SF5 at 32%, 35-58%, 48% and 27%, respectively (Jacob and Calnan, 2018; Mortimer *et al.*, 2014; Safari and Fogarty, 2003). Moderate heritability was recorded for exit weight (35%), HSCW (29%) and pH_u (30%), while dressing% had a low heritability with only 3% of the variability in this trait accounted for by genetics (Table 3). All heritability's were higher than expected compared to previously reported values (Jacob and Calnan, 2018; Massender *et al*., 2019; Mortimer *et al*., 2014; Safari and Fogarty, 2003). This variation in heritability from expected values is likely a function of the small size of the data set with only 15 sires sampled.

5.3. Sire predicted means

Variance components and sire predicted means are presented in Table 3 for exit weight, HSCW, dressing% GR tissue depth, DXA carcase composition traits, IMF%, pH_u and SF5. Sire predicted means for dressing% were 44% across the cohort and those for GR tissue depth were within an ideal range for processing, from 5.7mm (fat score 2) to 13.4mm (fat score 3). The sire predicted means for DXA carcase composition estimates were within the range of values observed in industry with DXA lean% predictions at the moderate-high end of the range. The predicted mean for IMF% was greater than the 4% benchmark associated with good eating quality for 10 of the sires. Predicted means for shear force after 5 days ageing were greater than the maximum 29.42N (3kg) sought after to achieve good tenderness across the sire cohort.

Table 3 Variance components and sire predicted means for carcase traits. Heritability of traits with a * were high and could not be accurately calculated due to low sire numbers.

	Number of progeny	Exit weight (kg)	HSCW (kg)	Dressing %	GR (mm)	DXA Lean (%)	DXA Fat (%)	DXA Bone (%)	IMF (%)	IMF dry matter (%)	pH_u	SF5 (N)
Variance components												
Heritability		35%	29%	3%	84%	*	*	*	95%	83%	30%	60%
Sire variance		2.69	0.72	0.05	5.07	3.07	6.34	0.57	0.36	0.23	0.00	28.00
Residual variance		27.99	9.40	5.41	19.11	6.85	14.14	1.28	1.16	0.88	0.01	157.80
Sire predicted means												
Anderson Poll, 160729	9	60.90	27.58	44.82	12.4	53.2	34.3	12.6	4.64	26.81	5.65	38.6
Callowie Poll, 190055	9	60.46	27.18	44.76	9.7	55.9	30.4	13.8	3.82	26.39	5.67	38.9
Claypans Poll, 170632	9	59.00	26.09	44.60	5.7	58.8	26.2	15.0	3.17	25.70	5.71	51.1
Flairdale Poll, 190401	8	60.38	26.86	44.68	10.1	55.6	30.8	13.6	4.34	26.48	5.69	43.8
Forest Springs Poll, 190193	10	61.17	27.30	44.71	11.1	54.6	32.2	13.2	3.88	26.14	5.68	38.0
Hazeldean, 002529	10	59.37	26.61	44.70	9.3	55.1	31.6	13.4	4.86	26.91	5.68	40.3
Kelvale Poll, 191148	9	59.45	26.69	44.72	8.3	56.9	29.0	14.2	3.62	25.73	5.67	41.5
Lorelmo Poll, 160172	10	57.44	25.72	44.68	8.4	57.3	28.4	14.4	3.23	25.62	5.65	37.6
Malleetech Poll, 199100	9	60.94	27.20	44.71	11.3	54.4	32.5	13.1	4.75	26.83	5.68	49.3
Missing sire	2	59.93	26.83	44.71	9.9	55.5	31.0	13.6	4.14	26.33	5.68	41.0
Mumblebone, 191150	10	60.50	27.33	44.80	13.4	52.4	35.4	12.3	4.56	26.60	5.73	40.6
Nantoura Poll, 190061	10	58.24	26.00	44.66	11.1	56.1	30.1	13.9	4.09	26.32	5.68	39.5
O'Brien Poll, 190455	10	61.50	27.33	44.67	8.3	56.3	29.8	13.9	4.25	26.33	5.68	38.3
Ridgeway Poll, 190240	10	59.47	26.77	44.75	10.1	55.1	31.6	13.4	4.05	26.30	5.66	41.4
Wallaloo Park Poll, 172032	8	60.03	27.05	44.76	10.1	55.4	31.0	13.6	4.50	26.49	5.69	37.6
The Yanko, 190086	9	60.09	26.66	44.65	9.0	55.3	31.2	13.5	4.28	26.34	5.67	38.4

6. Conclusion

The data collected in this project will inform Australian Sheep Breeding Values for key carcase and eating quality traits. Carcase yield performance was high with consideration for GR tissue depth and DXA lean%. Importantly, average performance for IMF% was favourable and above the threshold for acceptable eating quality, although SF5 performance was not as strong with average values exceeding the upper limits for desirable tenderness. This highlights the importance of informed genetic selection coupled with management of growth path to maximise cohort performance relative to consumer expectations.

7. Acknowledgements

The SA Sheep Industry Fund is gratefully acknowledged for funding the data collection on carcase and eating quality traits for this project. There is a large team and several industry collaborators that made critical contributions to this project. The site is part of the Australian Merino Sire Evaluation Association and is supported through entry fees and in-kind assistance from ram breeders from across Australia. The site committee and Merino SA are critical in helping to establish and run the site. Mentara Park and the Eckert family were instrumental in raising the sheep and achieving the experimental design that enable a single cohort to be maintained to slaughter. JBS is gratefully acknowledged for extensive access to the Bordertown facility for recording and sample collection. Thanks to the University of New England for provision of IMF results and to the large team at the Davies Livestock Research Centre, University of Adelaide for sample collection, processing, and analysis.

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