Corriedale Eating Quality Genomics Project

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Performance Corriedale Group

The Performance Corriedale Group meets twice per year. The primary meeting is an annual workshop where breeders optimise breeding programs in collaboration with staff from Sheep Genetics. The Group has a group of link sires that are used across all members' flocks. These sires have been chosen to provide links to New Zealand as the Group have been a leader in promoting Trans-Tasman analysis. The Group has developed an excellent culture combining a healthy mix of collaboration and competition which drives genetic progress. The Group provides a good model for strategies to make genetic improvement in breeds of significant, but not dominant number.

At the 2016 annual workshop there was significant discussion about marketing of rams in a way that clients can simply rank them. During the Olympics in August 2016, the new Gold, Silver and Bronze system was launched. Gold rams are top 10% based on the Dual Purpose index, Silver 75-90th percentile and Bronze 40-75th percentile. The system was based on percentiles so that the performance threshold can constantly be increased as the breed makes genetic progress. The system was developed down to the 40th percentile to aid new members where it will take time for their figures to get to Gold and Silver levels. Only Gold rams will be used as link sires in future. Already at ram sales premiums have been paid for Gold rams.

Within the group there is a desire to use the latest genetic tools to maximise genetic progress. Genomics is an area of discussion at every annual workshop and there is a level of frustration that tools are not sufficiently accurate for use by the Group. However, the recent focus of genomics for eating quality provides an opportunity that the Group are prepared to invest in. Most Corriedale breeders believe that Corriedale lamb is superior to other Maternal and Terminal breeds. This project is motivated by a desire to both benchmark current sires against other breeds and develop Genomic tools for ongoing genetic improvement. However, in developing the project it has become clear that it should focus on Corriedale genomics and the benchmarking will come through Sheep CRC and now industry Resource Flocks. The project is funded by Corriedale breeders ($1000/sire=15%), Davies Research Centre (27%), MLA Donor Company (41%) and MLA through the Resource Flock project (17%).

Corriedale progeny test

A progeny testing trial was proposed with the aim of benchmarking Corriedale sires and developing genomic tests for Corriedale breeders. The logic is to slaughter both ewe and wether progeny to maximise the information for carcass and eating quality traits. Reproduction and wool growth data is routinely collected in Group flocks and genomic tests could be developed subsequently without additional phenotyping costs required.

The progeny test is being run at Cressy Research and Demonstration Station in Tasmania. There is a flock of Corriedale ewes currently running on Cressy by one of the Performance Group members, Peter and Claire Blackwood. In the National trials, Corriedale sires have been tested by mating them to Merino ewes. The advantage of using Corriedale ewes in this trial is that there will be more Corriedale haplotypes (segments of DNA) segregating for traits of interest. It is proposed that 45 sires will be tested over 3 years resulting in 900 lambs genotyped. While the project is referred to as a "progeny test", this is really to aid promotion as this is common terminology. Really it is all about characterising the "Corriedale bucket of genes" by describing relationships between genetic variation and phenotypes and the number of sires is really aimed to sample genes across the breed.

Corriedale rams are proposed by breeders and are accepted based on their relationships to sires that have been widely used to ensure a wide range of bloodlines are represented, i.e. we see little point in testing half-brothers. Breeders who supply rams will gain valuable information on a range of performance traits. This is opened up to breeders not currently in the Performance Group as it is a great way to benchmark key sires and to start performance recording. Each year the data will be transferred to SheepGenetics and breeders will receive ASBVs for their rams in this way as it utilises all information available.

Traits measured

The plan is that in each of the three years there will be 15 Corriedale rams tested. Ewes will be synchronised and mated by artificial insemination in April of 2017-2019 inclusive. The aim is for 20 ewes to be inseminated per ram (300 ewes per year) with the aim of achieving 20 lambs per ram (300 lambs per year). Lambs will be slaughtered in April the following year (2018-2020). It is hoped that we can get DEXA measurements of lean meat yield on the lambs in future years.

Lambs are mothered up with the primary aim of recording date of birth and birth type (single vs twin or triplet). Weight is recorded at weaning, post-weaning and pre-slaughter. Fat and muscle depth will be recorded by ultrasound scanning following Sheep Genetics protocols.

While the lambs are alive as many traits as possible are recorded. At this stage this includes wrinkle, face cover, wool colour, wool character, fleece rot, black spots and skin pigment, and structural defects such as shoulders, feet, legs and jaws. The lambs are shorn pre-slaughter to get wool growth and fibre diameter measures.

Carcass weight, GR Fat and lean meat yield will be recorded at the abattoir. Meat samples will be purchased for measurements of intramuscular fat, shear force and fat melting point.

Joining

Semen was supplied for 15 rams, and 300 ewes (20 per sire) were mated by artificial insemination in 2017. There were a number of ewes that did not conceive to the AI so, despite high weaning rates, there were just 212 lambs available for subsequent analyses.

The 2nd joining in April 2018 comprised 200 ewes mated by artificial insemination to 10 rams plus 80 ewes naturally mated to 4 rams. Thus, a total of 14 sires and hopefully over 300 lambs. The ewes mated by AI are also naturally mated to the 4 rams as backups.

Laparoscopic insemination of ewes in April 2017

Live measurements

The project has a very committed and active team from New South Wales, Victoria, South Australia and Tasmania. On 14-19th Feb 2018 the group met at Cressy Research Farm, Tasmania, and collected measurements/scores on 28 traits on the 212 lambs that survived to weaning.

DNA samples have been collected. They are currently frozen and stored at University of Adelaide. There has been a delay in sending them for genotyping as we make decisions on the most appropriate timing given likely drop in price in the near future.

We have also secured an Honours students, Hannah Gordon, on the project for 2018. She has written her literature review, been involved in live and carcass measurements and processed the tenderness data.

Pictured from left: Hannah Gordon, Legh Jenkin, Wayne Pitchford, Brenton Lush, Peter Blackwood, John Manchester.

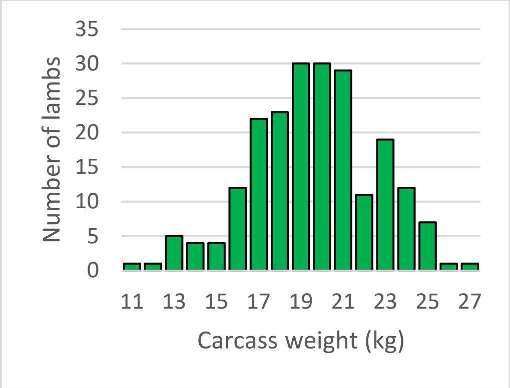
Slaughter measurements

Unfortunately, getting the lambs booked into an abattoir with DEXA measurement of lean meat yield was not possible due to the large number of research kills being conducted. Thus, we killed the lambs at Frewstal, Stawell Victoria 17-19th April 2018. The team of staff at Frewstal were superb which made processing relatively straight forward. Lambs are killed one day, hot standard carcass weight is recorded and they have pH measured at 3 times and then processed the next day. There is quite a lot of work in the boning room on day 2 as the team of 5 people recorded ultimate pH, GR fat depth, collected loin samples, measured fat depth (C-Fat) and muscle depth and width, and meat colour. Three samples were then packed for measurement of fat melting point, intramuscular fat content and shear force. Given the large amount of work in the boning room the 212 lambs were killed over 2 days. Thus, 106 were processed on day 2 and the remaining 106 on day 3. Samples were then transported to University of Adelaide for subsequent testing.

Lambs hanging with research tag numbers shown in green.

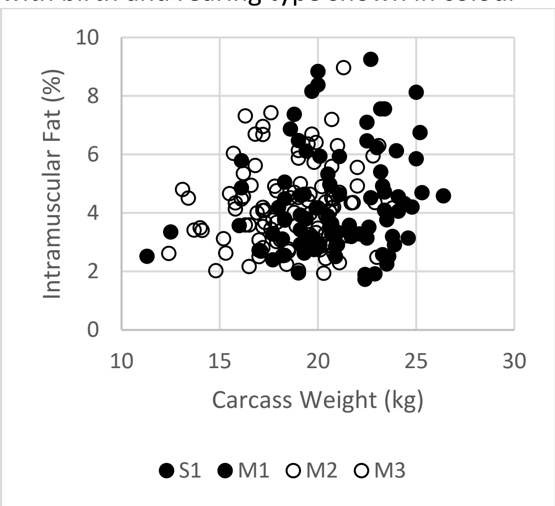
Initially the aim was to have carcasses averaging 24kg and so the plan was to kill lightest half of the lambs a month later to give them time to grow out. However, due to some changes in management at Cressy, it became most sensible to kill all lambs on the same week. The advantage of this is that we have not confounded kill day with carcass weight. However, the disadvantage is that we have a number of lambs that were under the ideal weight (19=9% were <16kg) and the average weight was just under 20kg, thus we thought this would prevent the expression of variation in IMF. A summary of the data collected is presented (Table 1, Figure 1). Many of the light half of lambs were twins and triplets as demonstrated by means presented (Table 2, Figure 2). However, the results demonstrate that there is substantial variation in IMF independent of CWT and the correlation between them was only 0.16 (Figure 2).

Figure 1. Distribution of carcass weights



Hannah Gordon processing tenderness samples after ageing the meat for 5 days

Figure 2. Graph of relationship between intramuscular fat content and carcass weight with birth and rearing type shown in colour



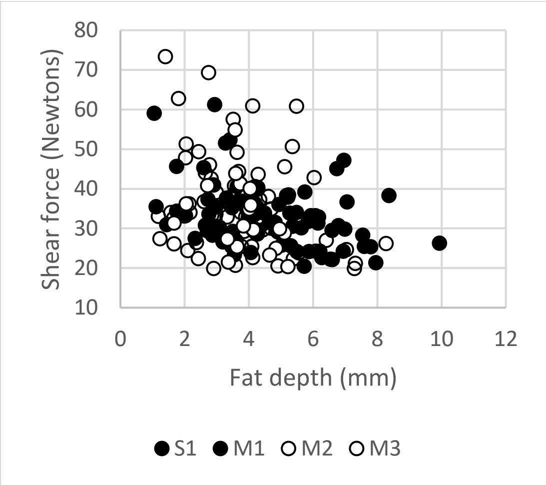
Compared to wethers but adjusted for differences in birth and rearing type, ewe lambs were 5% lighter, 2% shorter, 8% fatter including greater amounts of intramuscular fat and had 8% lower shear force (more tender) meat. The combination of lower shear force and greater IMF% means ewe lambs had significantly better quality meat.

Post-weaning, the lambs gained 210g/d but then from February to April they only gained 66g/d. Lambs were weighed on 4th April at approximately 6.5 months of age and 38% of ewe lambs were greater than 45kg, the target for mating ewe lambs. For a dual purpose breed, this is an important benchmark that needs to be improved. That said, given the low gains from February to April, if they had been on greater supplementary feed then most of the ewe lambs would have reached a 45kg target mating weight at 7 months.

Often in trials such as this, there are insufficient triplets to allow analysis of them as a separate group. However, we had 10 sets and so the effect is measured reasonably accurately. The effect of type of birth will be discussed in two ways as there were four categories: Single born lambs raised as singles (S1), multiple born lambs raised as singles (M1), twins (M2) or triplets (M3). Compared to those born and raised single, twin lambs were 20% lighter at weaning but just 10% lighter at slaughter, grew 18% less wool that was 3% finer, had 6% less muscle depth and 16% lower fat depth although surprisingly no significant difference in IMF or shear force (Table 3). Compared to twins, triplets were 15% lighter at weaning and 8% lighter at slaughter, grew 18% less wool of similar diameter, 4% less muscle depth and 2% less fat depth but 10% less IMF and not significantly greater shear force.

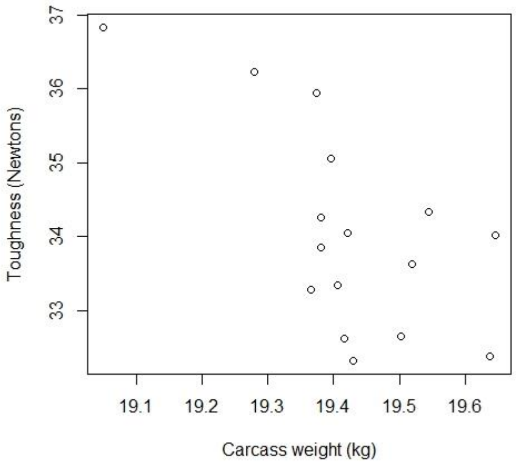
It was no surprise that fat depth was reasonably closely related to carcass weight and shear force was related to fat depth (Figure 3), although not strongly related to carcass weight. The effect is likely caused by those carcasses with having low fat depth (<4mm) cooling too fast in the chiller and the meat becoming "cold shortened". Not all carcasses are affected but being lean increases the risk of cold shortening.

Figure 3. Graph of relationship between shear force and fat depth with different rearing types shown.



The heritabilities estimated herein (Table 2) are from a sire model that only accounts for ¼ of the genetic variance and with low numbers of progeny (only 212). Thus, the heritability estimates are of very low accuracy and should only be taken as an indication that there is high, medium or low variation between sires in the traits measured. As expected, traits of high heritability were fibre diameter, skin pigment and possibly wrinkle. Those of moderate heritability were growth, muscle, fat, fleece weight and meat quality. Those of low heritability were scores like wool character, staple structure, face cover and depth of body.

Figure 4. Sire means for shear force and carcass weight.



The heritabilities will be much more accurately estimated when the genotyping is complete and a genomic relationship matrix (GRM) can be fit in the model rather than simply fitting sire. Our experience with other data sets is that heritabilities from a GRM are higher than from a pedigree due to the improved description of genetic relationship. Certainly in the Corriedale trial where there is no dam pedigree the improvement will be significant. When the genotype data is available and analysed, then phenotypes and genotypes can will sent to Sheep Genetics for inclusion in analysis and this will improve the accuracy of ASBVs.

In future we expect that the genomic testing will be used in three ways:

1. Improve the accuracy of ASBVs on young rams that are in the top 20% of the drop;
2. Obtaining ASBVs on 80% of rams before measurements are taken, replacing the need for ultrasound scanning of muscle and fat; and
3. Obtaining ASBVs on young ewes to both confirm selection of the best and identify candidates for advanced reproductive technologies.

Table 1. Summary of data including variation (standard deviation) and heritability estimates from the preliminary analysis.

Trait	Mean	Min.	Max.	CV (%)	Phenotypic SD	Heritability (%)
Weaning weight 29/11/17 (kg)	24.7	13.6	36.4	19	3.4	28
Post-weaning wt 12/2/18 (kg)	40.6	21.0	55.0	15	4.8	2
Pre-slaughter wt 4/4/18 (kg)	43.9	28.0	55.5	13	4.8	37
Height (mm)	635	530	700	5	26	24
Greasy fleece wt (kg)	1.6	0.6	2.7	21	0.3	33
Fibre diameter (mm)	22.5	18.2	27.3	7	1.6	>100
Wool Colour (score)	2.3	1	5	35	0.7	44
Wool Character (score)	2.8	1	4	23	0.6	8
Staple Structure (score)	2.7	1	4	26	0.7	5
Face Cover (score)	2.5	2	4	22	0.6	6
Body Wrinkle (score)	1.6	1	4	42	0.7	57
Skin Pigment (score)	3.9	1	5	27	1.0	>100
Depth of Body (score)	2.4	1	4	30	0.6	0
Carcass weight (kg)	19.6	11.3	26.7	15	2.5	8
Eye muscle depth (mm)	28.4	21.5	38.4	11	2.9	38
GR Fat (score)	2.3	0.5	4.0	29	0.6	46
C-Fat (mm)	4.1	1.1	9.9	39	1.6	12
Intramuscular fat (%)	4.3	1.4	10.1	37	1.6	37
pH at 12 degrees	6.28	5.47	7.13	5	0.32	11
pH ultimate (Loin)	5.78	5.57	6.40	2	0.13	28
Shear force (Newtons)	34.1	19.9	73.4	27	9.5	23

Table 2. Effect of sex and birth type (singles or multiples raised as single, twin, triplet).

Trait	Male	Female	Single/ single	Multiple/ single	Multiple/ twin	Multiple/ triplet
Weaning weight (kg)	24.9	23.9	28.7	26.3	23.0	19.6
Post-weaning wt (kg)	41.2	39.1	45.0	42.2	39.0	34.4
Pre-slaughter wt (kg)	44.5	42.5	47.1	45.3	43.2	38.6
Height (mm)	641	626	649	641	632	610
Greasy fleece wt (kg)	1.5	1.6	1.9	1.7	1.5	1.2
Fibre diameter (mm)	22.4	22.8	22.9	23.0	22.2	22.4
Wool Colour (score)	2.3	2.3	2.0	2.6	2.3	2.2
Wool Character (score)	2.8	2.8	2.5	2.9	2.8	3.0
Staple Structure (score)	2.7	2.7	2.5	3.0	2.7	2.5
Face Cover (score)	2.5	2.6	2.5	2.4	2.6	2.7
Body Wrinkle (score)	1.6	1.6	1.8	1.7	1.7	1.3
Skin Pigment (score)	3.9	3.9	3.8	3.9	4.2	3.7
Depth of Body (score)	2.5	2.5	2.0	2.5	2.5	2.9
Carcass weight (kg)	19.9	18.9	21.2	20.0	19.0	17.5
Eye muscle depth (mm)	28.5	28.0	29.8	28.3	28.0	27.0
GR Fat (score)	2.2	2.4	2.5	2.4	2.2	2.1
C-Fat (mm)	4.0	4.4	4.5	4.8	3.8	3.7
Intramuscular fat (%)	4.1	4.5	4.2	4.8	4.2	3.8
pH at 12 degrees	6.30	6.29	6.20	6.26	6.29	6.42
pH ultimate (Loin)	5.78	5.77	5.75	5.76	5.79	5.82
Shear force (Newtons)	35.5	32.6	32.8	32.5	34.4	36.5