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The Assessment of Genetic Expression and Nutritional Effects on Lamb Eating Quality

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PART 1: ABSTRACT

Carwell and non-Carwell lambs were finished to slaughter weights (approximately 50 kg live weight) on either wheat/lupin rations (containing protected (starch, protein and lipid) or unprotected nutrients) or at pasture. After processing at a commercial domestic works *M. longissimus lumborum* (LL) of the carcase was assessed for pH, tenderness, cooking loss and colour. The right side of the carcase was cut into six primal joints.

Lambs fed protected and unprotected nutrients had significantly higher ADG's and greater carcase weights and GR than those grown at pasture. Neither ration nor sire type did not significantly effect feed conversion efficiency. There was data to indicate that sire type effected ADG with ADG of non-Carwell sires tending to be greater than that of Carwell sires. Carcase weights were not significantly affected by sire type.

The hindleg primal tended to be heavier for Carwell sire-32 and the eye muscle area greater for Carwell sire-32 and non-Carwell sire-15, when adjusted to a standard carcase weight.

WB shear was found to be greater than 5 kg at 2 days after slaughter in all lambs. Above 5 kg is a level at which Australian consumers consider the meat tough. WB shear was found to be significantly higher in Carwell sire-32 and non-Carwell sire-14 at 2 days after slaughter and remained significantly higher in Carwell sire-32 at 7 days after slaughter. There was no significant difference between sires for tenderness (WB) at 14 days.

Lambs pen-fed protected and unprotected nutrients had significantly higher WB at 2 days than the lambs grown at pasture. There were no significant differences 7 days or 14 days.

Sire type and nutrition had no significant effects on cooking loss of the LL but non-Carwell sires had significantly greater cooking loss in SM two days after slaughter.

The correlation between C, J and GR measurements and pectoral, loin and leg fat were very similar.

The GR measurement was superior to both C and J as an indicator of loin fat. Combining GR and C or GR and J increased correlation only marginally.

The C, J and GR measurements did not give a useful prediction of leg fat.

From the above it is clear that sire differences exist between and within sire types for meat quality. This emphasises the need to closely monitor individual sire effects on meat quality. Nutrition played a role in meat tenderness. Though penned lambs had significantly higher growth rates before slaughter the WB shear was greater for samples from penned lambs than from lambs grown on pasture.

PART 2: EXECUTIVE SUMMARY

1.1 (i) Objectives

Priorities: specific to MLA

1. Determine sire effects on lamb eating quality and provide a benchmark for a lamb eating quality estimated breeding value (EBV).

2. Determine the effects of Carwell genotype on carcass yield and meat quality.

Test the validity of the current GR site measurement for fat on lamb carcasses of a range of weights and seek a superior measurement for heavy lamb carcasses

1.2 (ii) Brief methodology

Sixty-four 12-week-old lambs selected from a group of 190 were placed in single pens for individual feeding. The remaining lambs were maintained on improved pasture. The lambs were from BL x Merino ewes and sired by Poll Dorset rams either from two rams known to express the Carwell gene or from two CPT non-Carwell sires.

The pen-based lambs were weighed weekly and assessed for fat score and subjected to an ultrasound scan for eye muscle depth monthly. Individual feed intake was recorded by weighing the feed offered and the uneaten residues daily. The ration for the pen based lambs was approximately 16% CP and 11 MJ ME/kg DM. Paddock lambs were weighed monthly and assessed for fat score and subjected to an ultrasound scan twice during the trial.

A total of 105 lambs (64 from the pen trial and 41 paddock lambs) were used to represent progeny from the Carwell and non-Carwell sires. They ranged in carcass weights and GR fat measures and after slaughter were used for meat quality (including eye muscle depth, carcass length, loin characteristics, muscle measurements, fat and bone) and retail yield.

Meat Quality measurements included: Warner Bratzler shear force, cooking loss, meat colour, ultimate pH, and aging rate of the LL. In addition to the GR tissue depth measure, measurements of the loin area included: GRb (the amount of muscle at the GR site), C fat (fat over the deepest part of the eye muscle), J fat (thickest layer of fat over the 12th rib), and eye muscle area (length and width at the 12th rib).

1.3 (iii) Main results and conclusions

Carwell and non-Carwell lambs were finished to slaughter weights (approximately 50 kg live weight) on either wheat/lupin rations (containing protected (starch, protein and lipid) or unprotected nutrients) or at pasture. After processing at a commercial domestic works LL of the carcase was assessed for pH, tenderness, cooking loss and colour. The right side of the carcase was cut into six primal joints.
Lambs fed protected and unprotected nutrients had significantly higher ADG's and greater carcase weights and GR than those grown at Pasture. Sire type was not found to significantly affect growth rates or carcase weights.

The hindleg primal, the bone-in loin and loin eye were found to be significantly heavier in Carwell sire-31 and Carwell sire-32, when adjusted to a standard carcase weight.

WB shear was found to be significantly higher in Carwell sire-32 and non-Carwell sire-14 at 2 days after slaughter and remained significantly higher in Carwell sire-32 at 7 days after slaughter. There was no significant difference between sires for tenderness (WB) at 14 days.

Lambs pen-fed protected and unprotected nutrients had significantly higher WB at 2 days than the lambs grown at pasture. There were no significant differences at 7 days or 14 days.

Sire type and nutrition had no significant effects on cooking loss of the LL but non-Carwell sire-14 gave significantly greater cooking loss in the SM.

From this work it is concluded that individual sires can have significant impact on meat quality traits. Nutrition can also significantly affect meat quality. It remains to be determined whether sensory panel work elucidates the differences found using objective measures.

PART 3: MAIN RESEARCH REPORT

1.4 3.1 Introduction

The Meat Standards Australia (MSA) scheme has been recently developed for the beef industry and provides a consistent product to consumers on the basis of eating quality grade. MSA grading is based on 'critical control factors' including genetics, nutrition, pre- and post-slaughter factors, as well as processing and cooking that can affect meat and eating quality. Since lack of consistency is a key issue identified by consumers and processors for their reluctance to purchase lamb, the sheep meat industry would also benefit from understanding critical control points affecting production of lambs of a consistent quality. Evidence from the MLA supported Branded Lamb Alliances also shows consumers are willing to pay more for branded products ~ products they consider have a guarantee of quality.

Recent consumer panel work (Hopkins & Ferrier, pers comm) has shown that eating quality can be significantly affected by genotype. Previous studies suggest genetic variation in aspects of eating quality and in particular meat tenderness (Speck *et al.,* 1997, Clarke *et al.,* 1997). This has shown that the genetic base and nutrition can influence some meat quality and biochemical attributes. It is important to be able to gain a greater understanding of critical control points in the production and processing pathways that can affect carcass and meat quality.

Ferrier *et al.,* (1998) found that sire type affected the amount of muscle deposited at the GR site. In addition the amount of muscle at the GR site was inversely related to the amount of eye muscle in the loin area. There is a suggestion from scientists and from some processors and wholesalers that the selection for GR may be causing a redistribution of fat rather than a reduction. As the Australian Lamb Industry moves more to Value Based Marketing it become an imperative to ensure the measures used to predict carcass yield in fact provide consistent prediction of characteristics desired by the market place. There has been concern in some of the alliance programs that as they moved to using carcass weight and GR to describe carcasses that for carcasses of similar weight and GR there was still considerable variation in appearance. Variation in yield is also suggested. Alternative sites might provide better prediction of carcass yield. Palsson (1939) examined a large number of fat sites in hogget and lamb up to about 22 kg carcass weight. With lambs of vastly different genetic make-up now capable of growing to weights of 40 kg or more, the reassessment of potential sites is desirable and the examination of variations in predictions of saleable meat and muscle from currently used sites is imperative.

A muscling gene in meat sheep breeds offers the opportunity to improve meat yield and present consumers with a more desirable meat product. In the USA scientists have mapped a major gene (Callipyge gene) using DNA markers. This gene contributes to increased dressing percentage, eye muscle area and meat yield in

the loin and hindquarter. USA studies suggest that the gene may cause adverse meat quality effects such as increased toughness. Koohmaraie *et al.,* (1995) demonstrated that the reduced rate of calpain-mediated postmortem proteolysis in lambs carrying the Callipyge gene is responsible for the reduced rate and extent of postmortem tenderization.

The National Central Progeny Test (CPT) indicates a muscling gene (Carwell gene, M+) exists in the Australian meat sheep industry. The Carwell gene has been described, based on increased eye muscle depth, in the Australian meat sheep industry. Hopkins and Fogarty (1998) reported from a study of the Carwell gene in Australian lambs that the gene was associated with higher shear force values for the *longissimus lumborum* (LL) muscle and significantly increased the weight of the boneless loin when the growth rate the month prior to slaughter was 353 g/d. They suggested that there might be nutrition by genotype interaction such that expression of the gene is masked at low growth rates. These authors reported no increase in muscle dimensions or toughness in progeny from the same sires when the lamb growth rate was 113 g/d prior to slaughter. The samples of meat used in the tenderness test were aged for 7 days before freezing and 13% exceeded 5 kg shear force, a figure above which Australian consumers consider lamb loin to be unacceptably tough. There is an urgent need to determine the effect of the Carwell gene on eating quality before any possible detrimental effects are spread through the industry.

Previous results (Ferrier and Gaunt, pers comm) show that production and processing management can have significant impact on lamb meat quality. Analysis of 1996-7 CPT data show that growth rate at particular stages had a significant effect on lamb meat quality. Low growth rates were associated with tougher meat. Climatic conditions pre-slaughter and post slaughter chilling conditions could also have caused poor meat quality. Aging was not able to reduce Warner Bratzler shear force values to a level that indicated that samples were of acceptable quality to consumers. Lamb meat produced in these production systems was of a standard that could adversely affect consumer satisfaction with product. For the lamb industry, control points in the production-processing pathway need to be examined (or established) to give greater likelihood of consistently producing tender meat.

The environment has a significant impact on final product. As yet we have little or no information on the interaction of genetics and environment (which may include the interactions of genetics, nutrition and pre slaughter handling). It has been demonstrated that some genotypes have a greater propensity to lay down fat following a period of feed restriction. The impact of previous nutritional history on eating quality may also have a genetic interaction.

This study aims to:

- Determine effects of Carwell genotype and nutrition (paddock versus pen) on carcass yield and meat quality

- Test the validity of the current GR site measurement for fat on lamb carcases over a range of weights.

1.5 3.2 Materials and methods

Lamb management and selection

Sixty-four 12-week-old lambs selected on the basis of live weight and sire ID from a group of 190 were placed in single pens for individual feeding. The remaining lambs were maintained as one group on improved pasture. The lambs were from BL x Merino ewes and sired by Poll Dorset rams either from two rams known to express the Carwell gene or from two non-Carwell sires. Sires were known for all lambs.

The lambs in the pens were fed a ration with or without protected nutrients. The ingredients and chemical composition of the two different rations are given in Table 1. The protected starch supplement was prepared from wheat and the Marble Plus™ from canola, soybean and sunflower oilseeds by Rumentek Industries Pty Ltd, Moree, NSW, using procedures developed by CSIRO. The metabolizable energy content and crude protein of the rations were determined using FEEDTEST (Pastoral & Veterinary Institute, Hamilton, Victoria) and was approximately 11 MJ ME/kg DM and 16% CP. The lambs were introduced to the rations over a 2-week period and during this phase the protected nutrients were gradually increased. The experimental rations were offered *ad libitum* daily to the lambs for 120 days. The feed conversion data are presented on a dry matter basis. Animals were weighed weekly at the same time of day before the morning feed. Fat score assessment and ultrasound scans for eye muscle depth were carried out monthly. Individual feed intake was recorded by weighing the feed offered and the uneaten residues daily. Paddock lambs were weighed monthly and assessed for fat score and subjected to an ultrasound scan twice during the trial.

Table 1. Composition of experimental rations

Ration Composition (%)		
Component	Protected	Unprotected
Canola meal	4.50	4.50
Urea	0.50	0.75
Lupins	5.00	5.00
Wheat	30	49.75
Protected starch	10	0
Marble Plus ™	10	0
Lucerne hay	35.00	35.00
Limestone	0.75	0.75
Gypsum	0.50	0.50
Bentonite	2.4	2.4
Salt	0.60	0.60

Potassium chloride	0.50	0.50
Magnesium oxide	0.20	0.20
Vit/Min	0.05	0.05

Slaughter and dissection

Lambs were slaughtered at a commercial abattoir and the carcasses were weighed hot (HSCW) with kidneys and kidney and channel fat retained and tissue depth measured at the GR site (GR). Dressing percentages were calculated by HSCW divided by ELW. After slaughter carcasses were placed in a chiller at 5^{o}C overnight. The next afternoon carcasses were split along the spinal column. The right sides and the LL from between the second and seventh lumbar vertebrae of the left side of the carcasses were transported to Agriculture-Victoria Rutherglen's Meat Laboratory in a chiller van.

Forty-eight hours after slaughter, the right side of the carcass was weighed to obtain the cold half-carcass weight. The carcass was cut into six primal joints (Method described in Thatcher et al. 1990). Saleable meat yield was estimated as the sum of the hindleg, midloin, loin and forequarter joints as a percentage of HSCW. The soft tissue (muscle, inter- and intra-muscular fat) from the hindleg was removed from the bone and weighed.

The LL from between the second and seventh lumbar vertebrae and the *M. semimembranosus* (SM) were collected from the right side of the carcass for cooking and Warner Bratzler shear force measurement. The LL at the twelfth rib was traced onto clear plastic and its area, the eye muscle area (EMA), measured using a planimeter.

In addition to the GR tissue depth measure, measurements of the loin area included GRb (the amount of muscle at the GR site); C fat (fat over the deepest part of the eye muscle); D fat (fat over the spinous processes) and J fat (thickest layer of fat over the 12th rib).

Meat Quality Methods

The pH of the loin was measured using a Micrometer pH Vision Model 6007 inserted into the LL at dissection, 48 h post-slaughter. The LL adjacent to the first lumbar vertebra was cut into three sections of approximately 80 g each for Warner Bratzler and cooking loss measurements on day 2, 7 and 14 post slaughter. Samples were placed in a water bath at 80^{o}C for 1 h, then left under cool running water for 30 min and placed in a refrigerator at about 5^{o}C for 24 h (Bouton et al. 1971). Five subsamples with a cross-section of 1 cm x 1 cm were cut parallel to the muscle fibres and the tenderness of the LL (LLSHEAR) and the SM (SMSHEAR) measured using a Warner Bratzler shear blade fitted to an Instron Universal Testing Machine Model 4301. Samples of SM were tested at 2 days after slaughter.
On day 2-post slaughter the LL was sliced across the fibres and left exposed to the air at room temperature for 30 min. Meat colour was measured using a Minolta

Model CR-200 chromameter set on the L*, a, b system (where L* measures relative lightness, **a** relative redness and **b** relative yellowness).

Cooking loss from each muscle was estimated as the difference between raw and cooked weight as a % of raw weight.

1.6 3.3 Results

Average daily gain

Average daily gain for the paddock lambs are based on weight gain for the first 106 days of the trial. All lambs (paddock and pen) were shorn on day 102. ADG for the penned lambs is calculated using weekly data from day 0 to day 120. From Figure 1 it can be seen that lambs did not start to put on weight until two weeks after introduction to concentrate.

Table 2. Average live weight at Days 0 and 120 and effect of sire and ration on average daily gain (ADG, g/d), feed conversion efficiency (FCE, g DMI/g ADG) and dressing percentage of individually penned lambs, and standard error of difference between means (s.e.d.)

Sire ID	Live weight, kg		ADG	FCE	Dressing %
	Day 0	Day 120			
non-Carwell – 14	26.1	52.6	243[b]	5.29	55.36
non-Carwell – 15	24.7	50.0	228[ab]	5.29	56.40
Carwell – 31	23.9	46.6	208[a]	5.63	56.99
Carwell – 32	25.4	50.2	223[ab]	5.53	55.93
s.e.d.	2.1	2.8	10	0.23	0.58
Ration					
Protected	25.2	50.1	228	5.40	56.19
Unprotected	24.9	49.6	223	5.47	56.15
s.e.d.	1.5	1.8	7	0.15	0.38

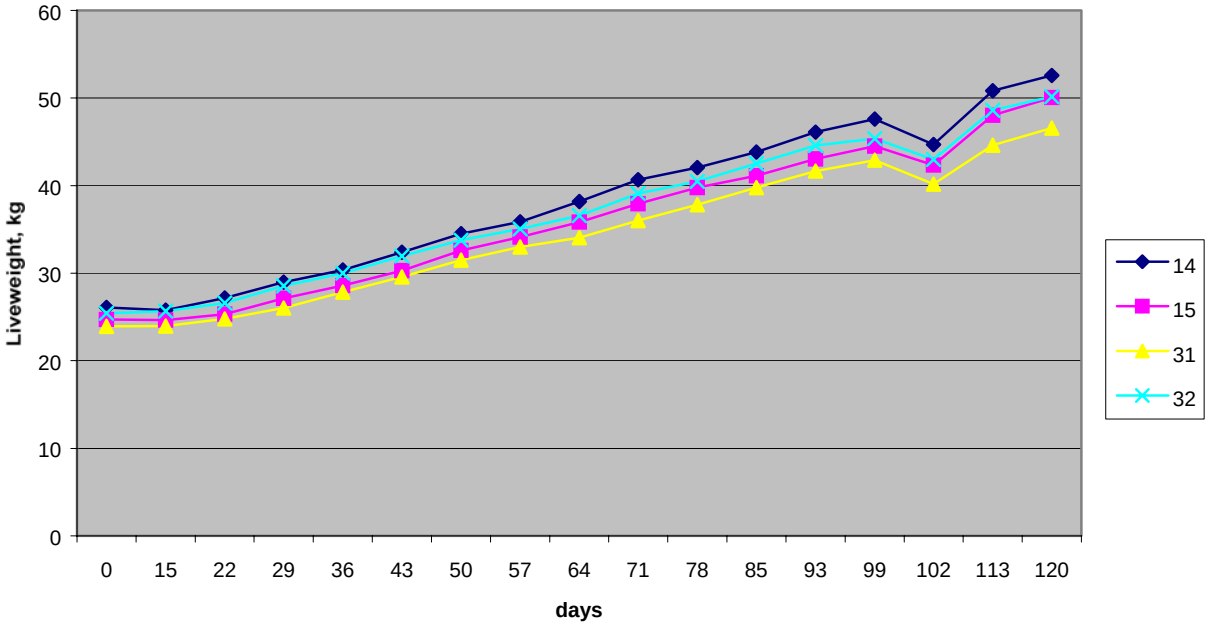

Figure 1. Liveweight change of lambs from 4 different sires and fed a feedlot ration in individual pens

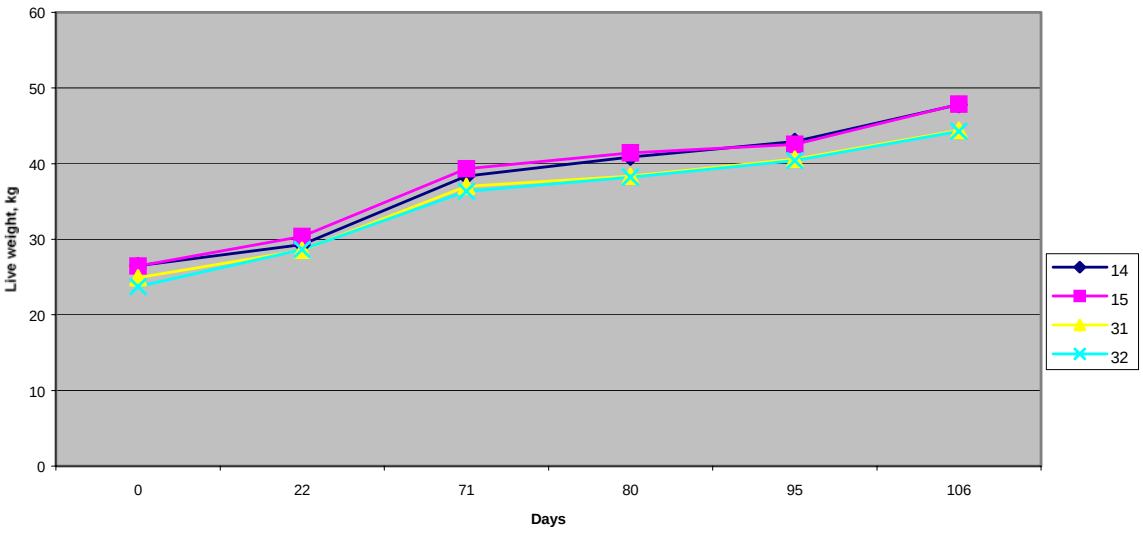

Figure 2. Live weight change of lambs from different sires and grown on improved pasture

Table 3. Live weight (at day 0 and 106) and average daily gain (ADG, g/d) of lambs kept at pasture and standard error of difference between means (s.e.d.)

Sire ID	Live weight, kg		ADG
	Day 0	Day 106	
non-Carwell – 14	26.5	47.8	193
non-Carwell – 15	26.45	47.9	192
Carwell – 31	24.9	44.4	176
Carwell – 32	23.75	44.3	181
s.e.d.	1.48	2.03	12

Carcass Data

Table 4. Effect of treatment on hot standard carcase weight (HSCW, kg), yield (%), GR (mm), hindleg weight (kg), hind leg soft tissue (ST, kg), mid loin weight (kg), loin eye weight (g) and eye muscle area (EMA, cm^2), and standard error of difference between means (s.e.d.)

Sire ID	**HSCW**	**Yield**	**GR**	**Hindleg**	**ST**	**Mid Loin**	**Loin**	**Loin eye wt**	**EMA**
non-Carwell – 14	25.27	51.43	15.56	3.48	2.18	1.67	1.58	383	15.85 a
non-Carwell – 15	24.59	51.37	18.63	3.52	2.24	1.70	1.60	394	16.26 ab
Carwell – 31	23.13	50.94	17.25	3.45	2.17	1.71	1.61	435	15.51 a
Carwell – 32	23.64	53.40	17.56	3.56	2.28	1.68	1.55	433	17.32 b

s.e.d.	1.06	1.75	0.71	0.06	0.58	0.05	0.05	22	0.57
Ration									
Grass	20.15 a	51.13	12.14 a	3.58[a]	2.30[b]	1.59[a]	1.49[a]	412	14.84 a
Protected	26.28 b	51.89	19.85 b	3.47[ab]	2.16[a]	1.74[b]	1.64[b]	410	17.07 b
Unprotected	26.03 b	52.34	19.90 b	3.46[b]	2.19[a] b	1.73[b]	1.62[b]	412	16.79 b
s.e.d.	0.91	1.49	0.70	0.06	0.57	0.05	0.05	22	0.53

Meat Quality

Table 5. Effect of treatment on Warner Bratzler Shear value of LL (LLSHEAR, kg) on Day 2, 7 and 14 after slaughter and SM (SMSHEAR, kg) on Day 2, and standard error of difference between means (s.e.d.)

Sire ID	pH	LLSHEAR			SMSHEAR
		2 Day	7 Day	14 Day	
non-Carwell – 14	5.47	6.51[b]	4.80[a]	4.15	6.50
non-Carwell – 15	5.50	5.32[a]	3.96[a]	4.01	6.86
Carwell – 31	5.49	5.79[ab]	4.55[a]	4.24	6.67
Carwell – 32	5.48	6.78[b]	5.31[b]	4.49	6.77
s.e.d.	0.02	.48	0.46	0.40	0.44
Ration					
Grass	5.48	5.52[a]	4.45	4.46	6.11[a]
Protected	5.49	6.74[b]	4.88	3.86	7.21[b]
Unprotected	5.49	6.03[b]	4.64	4.36	6.78[ab]
s.e.d.	0.02	.48	.46	0.39	0.44

Table 6. Effect of treatment on pH, cooking loss in LL (CLLD %, 2, 7 and `14 day) and SM (CLSM, %) and meat colour after half hour (L^* for lightness, a for redness, b for yellowness), and standard error of difference between means (s.e.d.)

Sire ID	CLLD			CLSM	L^*	a	b
	2 Day	7 Day	14 Day				
non-Carwell – 14	32.88	34.79	38.68	36.41[b]	36.05[a]	13.65	3.69
non-Carwell – 15	30.00	33.37	37.47	34.92[ab]	37.23[b]	13.84	3.76
Carwell – 31	31.73	34.99	36.87	34.35[a]	35.84[a]	13.95	3.87
Carwell – 32	31.48	33.92	37.57	34.79[a]	35.37[a]	13.63	3.70
s.e.d.	1.09	1.131	0.85	0.78	0.48	0.23	0.15
Ration							
Grass	32.59	34.76	37.87	34.56	35.23	13.80	3.56[a]
Protected	30.71	33.81	37.83	35.26	36.27	13.91	3.97[b]
Unprotected	31.27	34.23	37.24	35.54	36.87	13.60	3.74[ab]
s.e.d.	1.09	1.11	0.83	0.78	0.48	0.24	0.16

Prediction of Fat Measurements from C, J and GR Measurements

Correlations between the C, J, and GR measurements and the fat measurements (pectoral fat (Pec_Fat), loin fat (Ln_fat) and leg fat (Leg_fat) are given below:

*** Correlation matrix ***

C	1.000				
J	0.844	1.000			
GR	0.849	0.913	1.000		
Pec_Fat	0.618	0.629	0.614	1.000	
Ln_fat	0.855	0.856	0.876	0.608	1.000

Leg_fat 0.679 0.700 0.707 0.463 0.824 1.000

C J GR Pec_Fat Ln_fatL Leg_fat

Correlations of a given fat measurement (e.g. Pec_Fat) with either C, J or GR measurements are all very similar (e.g. 0.61 to 0.63).

The pairwise scatterplots (see Appendix) indicate that the relationships between the fat measurements and the C, J or GR measurements are essentially linear, but scattered. Linear regression models were fitted to the data. The results are summarised below**:**

Table 7. Results from the linear regression of pectoral fat on C, J or GR measurements

Model		Adjusted R**2	Intercept	Coefficient for c	Coefficient for j	Coefficient for GR
C only		38.4%	51.84	10.71		
J only		39.8%	31.4		4.21	
GR only		38.2%	20.8			5.28
Best variable	2	41.9%	34.7	5.24	2.496	
All variables	3	41.5%	30.4	4.63	1.90	1.11

The best single variable model involves the “J” measurement. The adjusted R**2 values are low and indicate that good prediction of pectoral fat from either C, J or GR measurements may not be feasible.

Table 8. Results from the linear regression of loin fat on C, J or GR measurements

Model		Adjusted R**2	Intercept	Coefficient for c	Coefficient for j	Coefficient for GR
C only		74.0%	148.1	67.47		
J only		74.6%	32.8		25.89	
GR only		77.7%	-65.5			34.32
Best variable	2	81.8%	-11.7	31.39		21.07
All variables	3	82.2%	-9.3	27.26	6.09	15.48

The best single variable model involves the “GR” measurement. The adjusted R**2 values are all reasonably high which indicates that reasonably good prediction of Ln_Fat from either the C, J or GR measurements is possible.

Table 9. Results from the linear regression of leg fat on C, J or GR measurements

Model	Adjusted R**2	Intercept	Coefficient	Coefficient	Coefficient

			pt	for c	for j	for GR
C only		48.2%	401.3	59.22		
J only		51.5%	288.1		23.38	
GR only		52.7%	208.9			30.49
Best variable	2	54.3%	247.5	23.2		20.71
All variables	3	54.6%	249.4	18.1	7.70	13.71

The best single variable model involves the “GR” measurement. The adjusted R**2 values may not be high enough for useful prediction of leg fat from either the C, J or GR measurements.

1.7 3.4. Conclusions

Lambs fed protected and unprotected nutrients had significantly higher ADG's and greater carcase weights and GR than those grown at pasture. Either ration or sire type did not significantly effect feed conversion efficiency. There was data to indicate that sire type effected ADG with ADG of non-Carwell sires tending to be greater than that of Carwell sires. Carcase weights were not significantly affected by sire type. Pen fed lambs had a lag time of two weeks before starting to accrue live weight gain.

The hindleg primal tended to be heavier for Carwell sire-32 and the eye muscle area greater for Carwell sire-32 and non-Carwell sire-15, when adjusted to a standard carcase weight.

WB shear was found to be greater than 5 kg at 2 days after slaughter in all lambs. Above 5 kg is a level at which Australian consumers consider the meat tough. WB shear was found to be significantly higher in Carwell sire-32 and non-Carwell sire-14 at 2 days after slaughter and remained significantly higher in Carwell sire-32 at 7 days after slaughter. There was no significant difference between sire for tenderness (WB) at 14 days.

Lambs pen-fed protected and unprotected nutrients had significantly higher WB at 2 days than the lambs grown at pasture. There were no significant differences 7 days or 14 days.

Sire type and nutrition had no significant effects on cooking loss of the LL but non-Carwell sires had significantly greater cooking loss in SM two days after slaughter.

The correlation between C, J and GR measurements and pectoral, loin and leg fat were very similar.

The GR measurement was superior to both C and J as an indicator of loin fat. Combining GR and C or GR and J increased correlation only marginally.

The C, J and GR measurements did not give a useful prediction of leg fat.

From the above it is clear that significant sire differences exist between and within sire types for meat quality. This emphasises the need to closely monitor individual sire effects on meat quality. Nutrition played a role in meat tenderness. Though penned lambs had significantly higher growth rates before slaughter the WB shear was greater for samples from penned lambs than from lambs grown on pasture.

1.8 3.5 Recommendations

- Further work is required to elucidate the effects of nutrition on carcase quality.
- Accurate gene marker techniques need to be developed to determine which sires have the potential to produce lambs with meat of superior quality.
- The optimum nutritional and management procedures to reduce the lag phase of lamb growth on introduction to concentrate feeds need to be developed.
- Consumer studies should be carried out to determine if consumers can discern differences in tenderness as influenced by sire type or nutrition.

1.9 3.6 Success in achieving objectives

Determine sire effects on lamb eating quality and provide a benchmark for a lamb eating quality estimated breeding value (EBV).

This objective was achieved. Individual sires were found to have significant effects of lamb meat quality as measured by pH, cooking loss and Warner Bratzler shear force. This information on meat quality provides a good basis on which further work can be done to provide a benchmark for lamb eating quality EBV's. Meat samples are currently in storage at –20°C in anticipation of future sensory studies.

Determine the effects of Carwell genotype on carcass yield and meat quality.

This objective was achieved. No significant differences were found in meat yield between genotypes. One Carwell sire was found to have significant effects on lamb meat quality as measured by pH, cooking loss and Warner Bratzler shear force. The other Carwell sire was not significantly different from the non Carwell sires for these attributes.

Test the validity of the current GR site measurement for fat on lamb carcasses of a range of weights and seek a superior measurement for heavy lamb carcasses

This objective was achieved. The GR site was found to give the best correlation with fat on the loin area, and to a lesser amount on the forequarter and hindleg however the correlation was poor between GR, J or C for predicting pectoral (forequarter) fat.

1.10 3.7 Impact on meat and livestock industry

It is evident from this work that care must be taken when introducing new sires to the sheep meat industry. Individual sires can significantly affect meat quality. It is yet to be determined if consumers can discern meat quality differences found using objective measures such as shear force.

1.11 3.8 Total funding and MLA contribution

Meat & Livestock Australia Ltd provided funding totalling $19,500. Agriculture Victoria support was estimated to be $10,500. Protected nutrients for the pen-study were provided by Rumentek Industries. This support was estimated to be $5,000. Total funding was estimated to be $35,000.

1.12 3.9 Acknowledgments

We are grateful to Rumentek Industries for the provision of the protected nutrient supplements. The feedlot staff, Mr John Cook, and Mr David Cooper, and Dookie student, Henk Vroljinks are specially thanked for feeding and managing the penned lambs. Greg Seymour, Gareth Phillips and Glenn Maurer provided additional support. We are grateful to Dr John Reynolds for the statistical analysis of the data.

1.13 3.10 References

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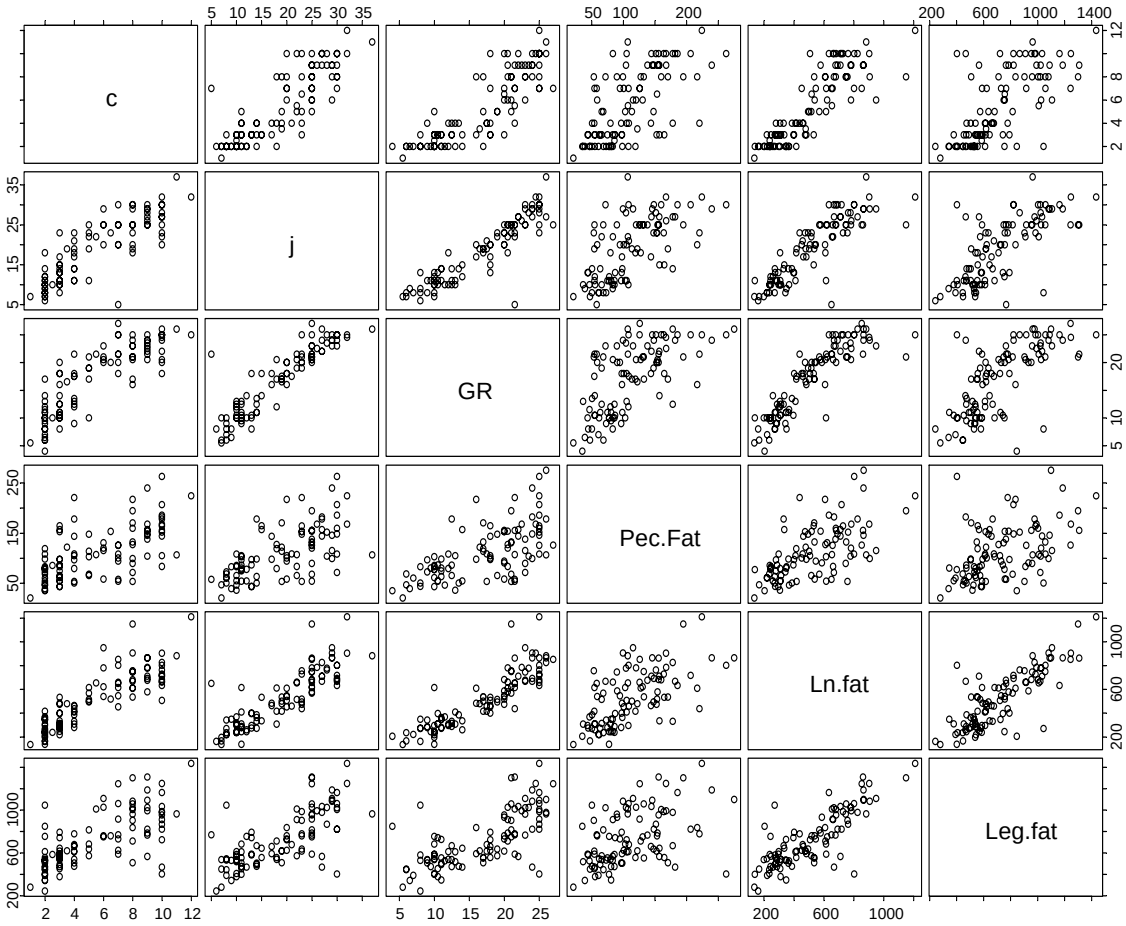
APPENDIX

1.14 Pairwise Scatterplots



1.15 LAMB.326 (Stage 1) Milestones and cashflow budget

MILESTONES	ACHIEVEMENT CRITERIA	ACHIEVEMENTS
1. Production of data from feedlot and paddock study Collection of meat and carcass data as per methodology.	Letter to MLA and Program Coordinator. December 1998	• Animals produced in pens and at pasture. Transported for slaughter at Vodusek's Abattoirs, Cobram. • Loin samples and half-carcases relocated to Rutherglen research Institute Meat Laboratory. • Cut up to primals and loins stored at –20°C. • Progress report supplied.
2. Meat quality testing and analysis	Progress report to MLA and Program Coordinator December 1998	• Meat samples tested for pH and colour. • Meat samples cooked for tenderness assessment, cooking loss. • Meat samples tested for WB shear force at 2, 7 and 14 days., • Progress report supplied.
3. Fat sites measured and analysis	Progress report to MLA and Program Coordinator February 1999	• GR, C and J fat sites measured and included in analysis. • Progress report supplied; extension of project to 31/5/99 requested..
4. Final report and recommendations	Final report to MLA and Program Coordinator July 1999	• Final report and recommendations prepared and submitted to MLA and Program Coordinator

CASH FLOW BUDGET

DATE Deliverable		CONTRACTED COSTS ($)	OUTSTANDING ($)	Comments
November 1998	Milestone 1	5,000	5,000	No invoice raised for contracted amount
February	Milestone	6,000	6 000	No invoice raised for contracted amount

1999	2			
February 199	Milestone 3	4,000	4,000	No invoice raised for contracted amount
June 1999	Milestone 4	4,500	4,500	No invoice raised for contracted amount
TOTAL		19,500	19,500	Invoice to MLA to be raised for total project costs

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