final report

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Peter Westblade Memorial Merino Challenge 2010-2012

Meat Challenge 2010

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Abstract

The Peter Westblade Memorial Merino Challenge 2010 -2012 has been developed to assist Merino breeding operations make more informed decisions on their Merino genetics.

It has been deliberately designed to show the entrants in the Challenge and the wider sheep industry the genetic opportunities that exist for them to be more financially sustainable into the future.

PWMMC includes 50 wether teams from across Australia and has integrated key carcase and eating quality traits into the standard Merino wether trial protocol.

Results from the PWMMC demonstrate that Merino wethers have sufficient growth rates, can meet market specifications in terms of carcase weight and fat score at slaughter and analysis of various meat quality parameters indicates that meat from Merino wethers can attain acceptable levels for traits like colour and pH.

Executive summary

This project was undertaken to answer increasing questions about what potential Merinos offer in relation to meat traits under commercial management conditions. The information provided to Merino breeders on meat quality traits including growth rates, pH, colour, eye muscle area, fat depth and dressing percentage.

The project aimed to show the wider Australian sheep industry the opportunities for sheep producers to be more sustainable in the future by quantifying the variation within and between the most influential Merino bloodlines in Australia.

Positive results for the Merino industry have been demonstrated with acceptable meat quality traits across all teams entered.

The identification of superior genetics in the Merino breed will allow strategic decisions to be made for both short and long term gain. The power of genetic variation is that it allows substantial gain in net profit leading to more sustainable businesses and communities.

Demonstrate to Merino breeders the diversity and opportunities to improve meat traits, whilst maintaining high quality wool traits; allowing a full interpretation of the correlations of most of the traits effecting Merino breeding profitability.

Specific timelines and dates to allow the education of entrants and the wider sheep industry in the genetic diversity of meat quality traits in Merinos and identify the opportunities to improve profitability through enhanced genetic selection for these traits.

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1 Background

The Peter Westblade Memorial Merino Challenge was set up in memory of Peter Westblade, a true visionary in the industry.

The PWMMC 2010 -2012 has been developed to assist Merino breeding operations make more informed decisions on their Merino genetics. It has been deliberately designed to show the entrants in the trial and the wider sheep industry the genetic opportunities that exist for them to be more financially sustainable into the future.

The PWMMC 2010 -2012 is designed to encompass all of the various strains and bloodlines of Merino sheep, it is unique in that it will fully examine both the wool and meat components of the entrants teams.

2 Project objectives

1. To increase the information provided to Merino breeders on meat quality traits including growth rates, pH, colour, eye muscle area, fat depth and dressing percentage.

2. Provide a full economic analysis of production feeding Merino lambs, including a net profit per team.

3. To show the wider Australian sheep industry the opportunities for sheep producers to be more sustainable in the future by quantifying the variation within and between the most influential Merino bloodlines in Australia.

4. The identification of superior genetics in the Merino breed will allow strategic decisions to be made for both short and long term gain. The power of genetic variation is that it allows substantial gain in net profit leading to more sustainable businesses and communities.

5. Utilize the linkage that exists with several of the entrants involvement in other trials to build on the existing Merino bloodline data.

6. Demonstrate to Merino breeders the diversity and opportunities to improve meat traits, whilst maintaining high quality wool traits; allowing a full interpretation of the correlations of most of the traits effecting Merino breeding profitability.

7. Specific timelines and dates to allow the education of entrants and the wider sheep industry in the genetic diversity of meat quality traits in Merinos and identify the opportunities to improve profitability through enhanced genetic selection for these traits.

8. The collaboration of several companies in an act of good will to remember the legacy of Peter Westblade and to promote the Australian Merino Industry.

3 Methodology

1. 50 teams of 30 wethers have been entered in the PWMMC.

2. The 1500 wethers have been randomly allocated to a Meat and a Wool trial consisting of 50 teams of 15 wethers each.

3. The 50 teams of 15 wethers making up the Meat Challenge have been run together since the 12th April 2010 on pasture and more recently (14th June 2010) introduced into a feedlot at Yarragundry West Collingullie NSW.

4. Meat Challenge lambs where randomly assigned to 5 feedlot pens. Each team has a low, medium and high weight lamb per pen. The pen allocation was conducted by an I&I NSW Biometrician.

5. The Meat Challenge wethers are body weighed every two weeks in line with the INF protocols (minimum of 2 hours off feed and water and to the nearest 0.2kg). Time taken off feed and time weighed are also recorded.

6. Wether lambs will be fed in the feedlot for a maximum of 10 weeks with a final body weight taken prior to slaughter. The following measurements are scheduled to be collected prior to lambs being transported to Fletcher International Exports.
    i. Liveweights collected every two weeks
    ii. Wool length at the mid side
    iii. Wrinkle score (Sheep Visual Scores)
    iv. Pin bone fibre diameter sample

7. Predicted average liveweight is 54kg; predicted average carcase weight is 23kg (based on 4 liveweight measurements taken up to 26/7/2010) – The following table indicates the number of teams and the carcase weight range at time of slaughter (23/08/2010).

Carcase wt range	*# teams*
< 16	0
16.1 – 18.0	2
18.1 – 20.0	3
20.1 – 22.0	15
22.1 – 24.0	15
24.1 +	15

8. The wether lambs mean carcase weight is 23kg. Lambs will be slaughtered at Fletcher International Exports abattoir and the following traits measured are scheduled to be taken at Fletcher International Exports abattoir during the week of 23rd August, 2010.
    i. Fat depth measures – GR depth at the 12th rib, subcutaneous fat depth over the deepest part of the longissimus (Fat C).
    ii. Eye muscle area – by measuring the depth at the same position as Fat C and the length and multiplying by 0.8.
    iii. pH – of the longissimus at the 12th rib (an ultimate pH)
    iv. Colour - Meat colour (L*, a* and b*) will be measured after a blooming period of 30-40 min using a Minolta Model CR – 400 chromameter with a closed cone, set on the L*, a*, b* system. The chromameter will be calibrated with a white tile standard (Y = 92.8, x = 0.3160, y = 0.3323) using Illuminant D-65, with 2 degree standard observer.
    v. Carcase weight
    vi. Skin rib score (internal)
    vii. Abattoir grade and value on carcase and skin
    viii. It is not possible to collect meaningful data on cut weights under the Fletchers boning procedures as the critical weights that are being collected in

the Sheep CRC are not obtained at Fletchers. These include subcutabeous fat over the midloin, knuckle and topside weights.

9. All data being collected and analysed is supervised by I&I NSW. The analysis is being supervised by Dr David Hopkins and conducted by Remy van de Ven using a Linear Mixed Model Analysis.

4 Results and discussion

4.1 Introduction

The Peter Westblade Memorial Merino Challenge 2010 -2012 has been developed to assist Merino breeding operations make more informed decisions on their Merino genetics. It has been deliberately designed to show the entrants in the Challenge and the wider sheep industry the genetic opportunities that exist for them to be more financially sustainable into the future.

Peter Westblade was passionate about breeding profitable sheep. Being a strong supporter of a balanced approach to all things, his legacy lives strongly amongst those who had the fortune to know such a great man.

The PWMMC has received fantastic support from all of the sectors of the merino industry.

Major contributions to the success of the Peter Westblade Memorial Merino Challenge (PWMMC) 2010-2012, Meat Challenge have been made by the following

- Industry & Investment NSW, Sally Martin, Geoff Casburn, Geoff Duddy, Tracey Lamb, Dr Remy van de Ven and Dr David Hopkins.
- Moses and Son, Marty Moses and Lucy Pitkin
- Fletcher International Exports, Roger Fletcher and Terry Mitchell.
- George Wilson, Yarragundry West Collingullie

The challenge is designed to encompass all of the various strains and bloodlines of Merino sheep. It is unique in that we are fully examining both the wool and meat components of the entrant's teams.

The PWMMC has attracted teams from across Australia. The teams represent a wide cross section of the Merino bloodlines and major wool and sheep meat growers.

The focus of the Challenge extends to entrants being strictly commercial in both the size of their operation and not being a ram supplier / stud. The information contained in this report gives entrants a unique opportunity to benchmark their flocks genetics for most traits that effect meat and wool production in Merino sheep.

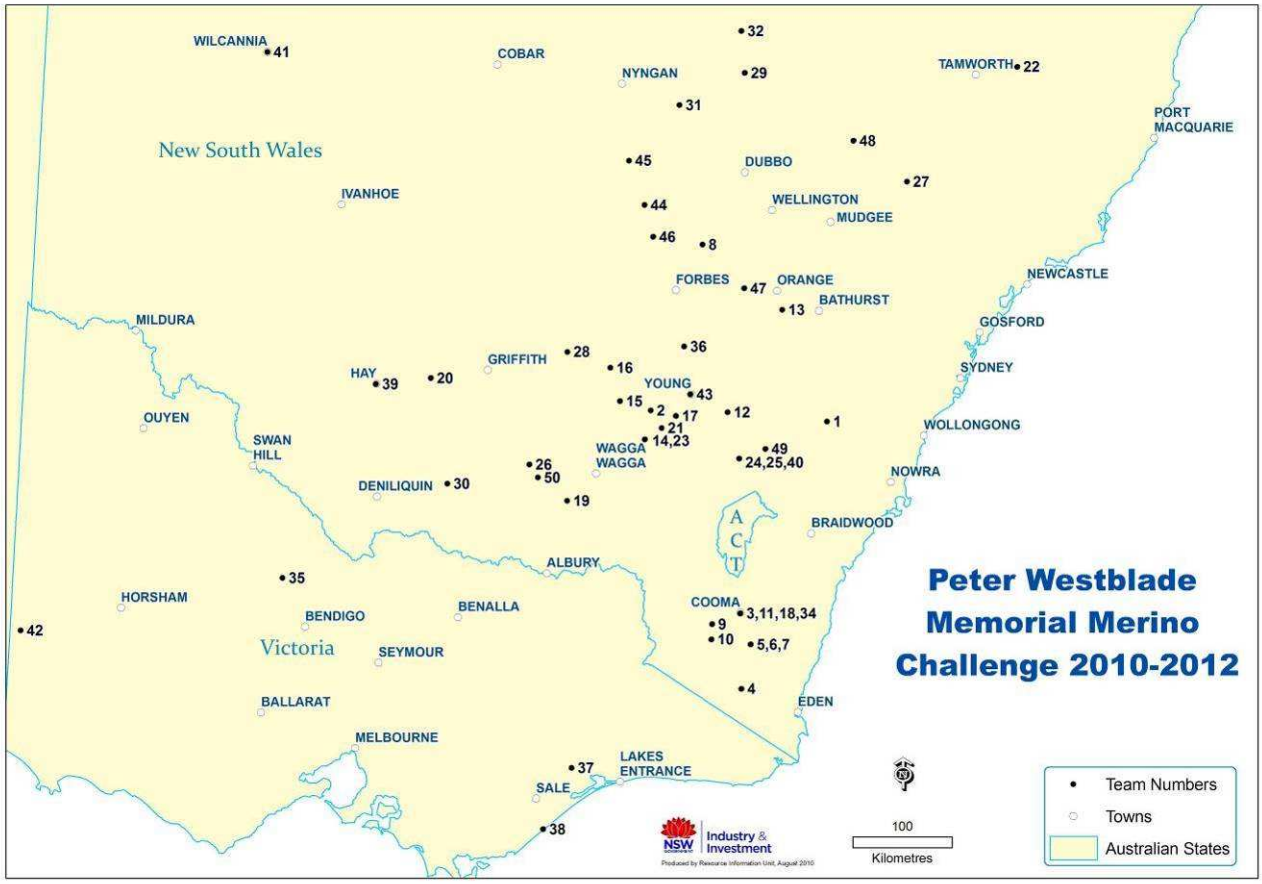
It should be remembered that the wether lambs are only a vehicle to show what is possible within the ewe flock. Recent work has demonstrated the correlations between growth, muscle, skin wrinkle and fat on reproductive performance in the ewe flock.

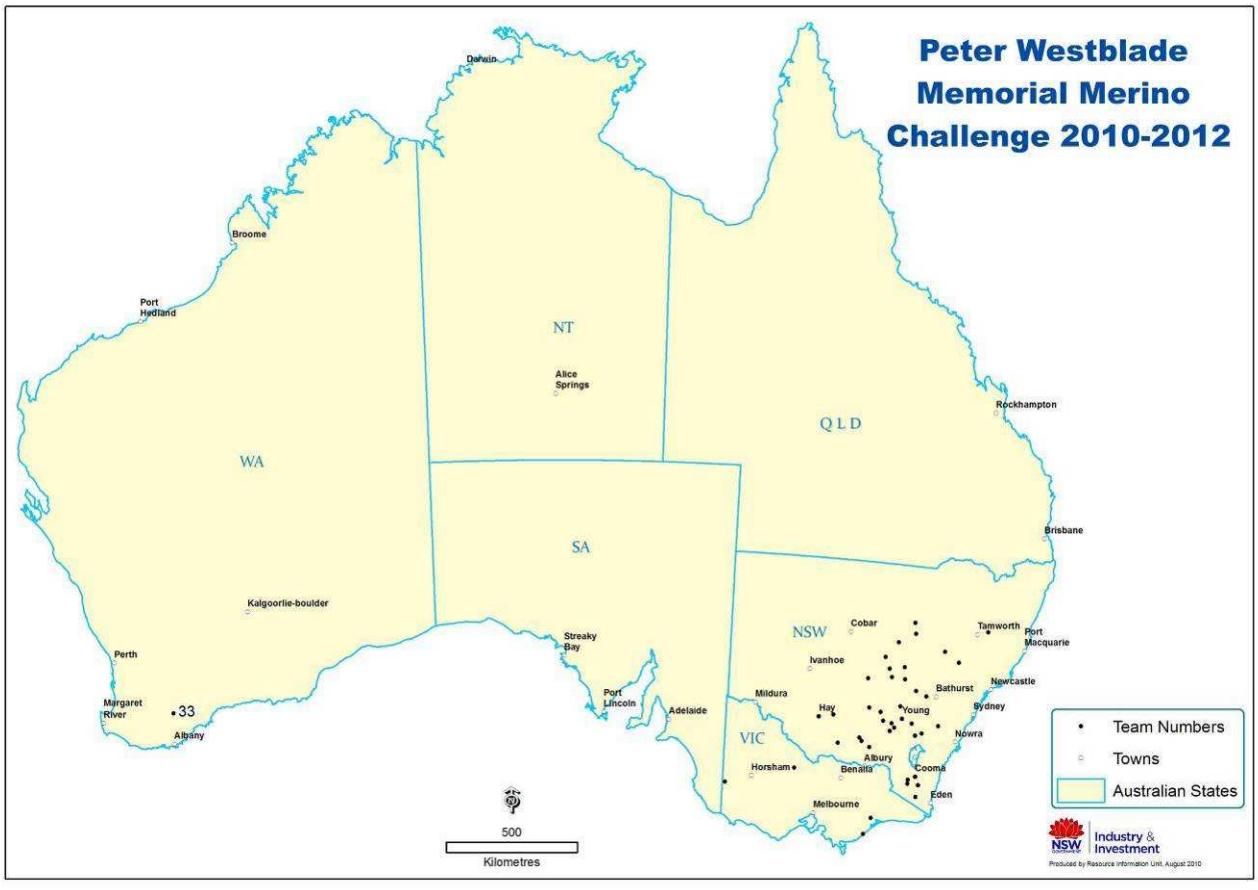
The relative performance of the wether lambs in the Challenge will be influenced by age, management and nutrition effects prior to the Challenge starting. All growth and body weight data analysed and presented in this report has been adjusted for age and all other meat traits have been adjusted for carcase weight.

The enthusiasm, goodwill and collaborative approach from all involved, makes the PWMMC a pleasure to be associated with.

4.2 Location of PWMMC 2010-2012 Entrants

PWMMC 2010-2012 Entrant number key can be found on page 6.





4.3 Trial design

4.3.1 Allocation of sheep to the Wool Challenge and the Meat Challenge

A body weight was taken pre even-up shearing and was used to allocate wethers to the Wool and Meat Challenge. The allocation was within team subsequently the wool length of individual teams did not need to be taken into consideration.

The allocation to the Wool and Meat Challenge was only based on body weight as this was the only objective measurement available at the time. Each team of 30 wethers was randomly split to enable an even distribution of body weights to either the Wool or Meat Challenge.

Example of the Meat and Wool Challenge allocation Table 1 shows how each team was sorted on body weight and then split into 5 groups of 6. Animals in each group of six where then randomly allocated to either the Meat or Wool Challenge. The example below is taken from one of the participating teams, the team averages and subsequent Wool and Meat Challenges can be seen in Table 2.

Table 1 Wool-Meat Challenge Allocation

Tag Number	Live Weight (kg)	Allocation
23	28.4	wool
27	28.8	meat
9	29.2	meat
5	30.0	meat
30	30.4	wool
12	30.6	wool
14	30.6	meat
19	30.6	meat
26	30.6	wool
18	30.8	wool
21	30.8	wool
10	31.2	meat
22	31.2	meat
3	31.4	wool
16	31.6	meat
17	31.6	wool
1	31.8	wool
6	32.0	meat
25	32.2	meat
15	32.6	meat
2	33.2	wool
11	33.2	wool
29	33.4	wool
4	33.6	meat
20	34.0	meat
24	34.8	wool
28	35.4	meat
8	36.0	wool
13	36.6	wool
7	36.8	meat

Table 2 Summary of Wool-Meat Challenge allocation

Team Count	Team Ave Body Weight	Meat Count	Meat Ave Body Weight	Wool count	Wool Ave Body Weight	Wool/Meat Bwt diff
30	32.1	15	32.0	15	32.2	0.3

4.4 Meat Challenge

4.4.1 Meat Challenge feedlot pen allocation

In the feedlot 5 pens are being used to finish the Meat Challenge lambs. A body weight was collected on the 7th June. This body weight was used to randomly allocate wethers from each team to each pen. Each pen has three wethers from each team consisting of a high, medium and low body weight lamb. The pen allocation is important to remove any potential **"pen effect"** in the final analysis.

Table 3 shows how the 5 lightest lambs where randomly assigned to Pens 1 to 5. The next 5 lightest lambs where assigned to Pens 1 to 5 and so on. This was repeated for each team.

Table 3 Feedlot pen allocation

Tag#	Bwt 7/6/10	Pen Allocation
27	31.4	1
25	32.2	4
28	35.0	5
1	35.2	2
3	35.2	3
7	35.6	3
23	35.8	5
9	36.2	2
29	37.2	4
22	38.0	1
15	38.2	4
11	39.6	3
30	39.8	1
12	41.2	5
6	41.6	2

To minimise any issues associated with social dominance or stress, pre-training to the self feeders was undertaken and adequate trough space per lamb has been accommodated. Figure 1 shows the feedlot design.

Significant rainfall events created very boggy conditions in the feedlot and the wether lambs where removed from the feedlot into a small paddock. The lambs had access to the Conqueror Mill pellets at all times, on an adlib basis and remained in the paddock situation up to processing. Figure 2 shows the rainfall events, body weighing (star) and when lambs moved in and out of the feedlot.

Figure 1 Feedlot design

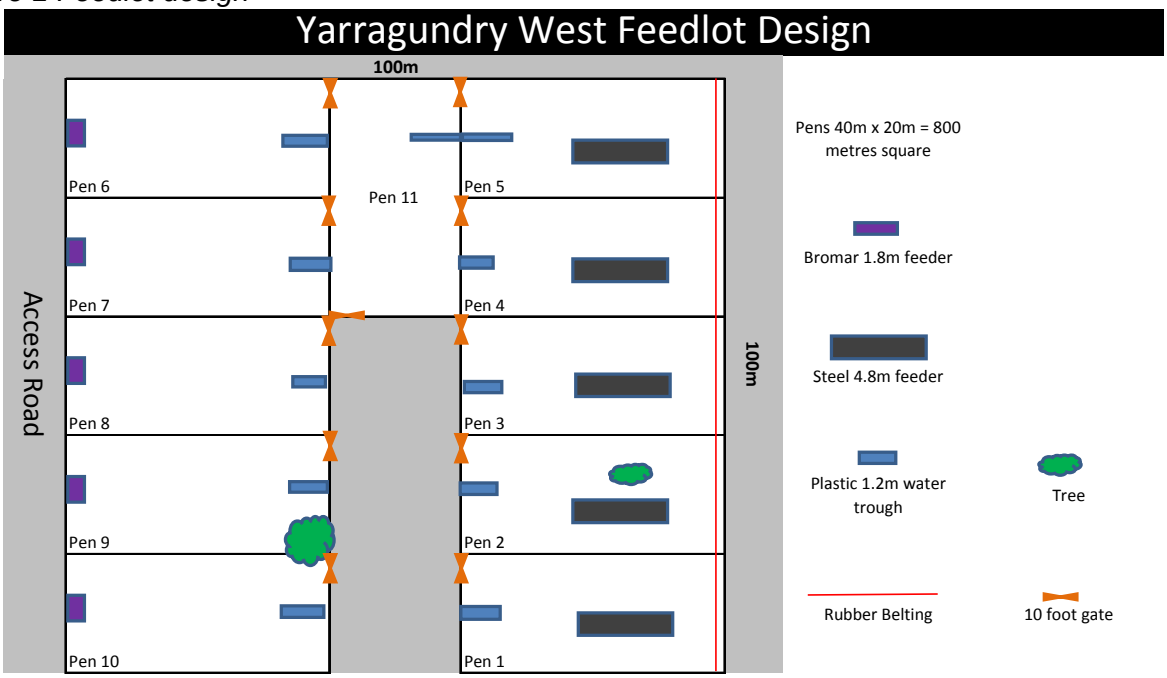
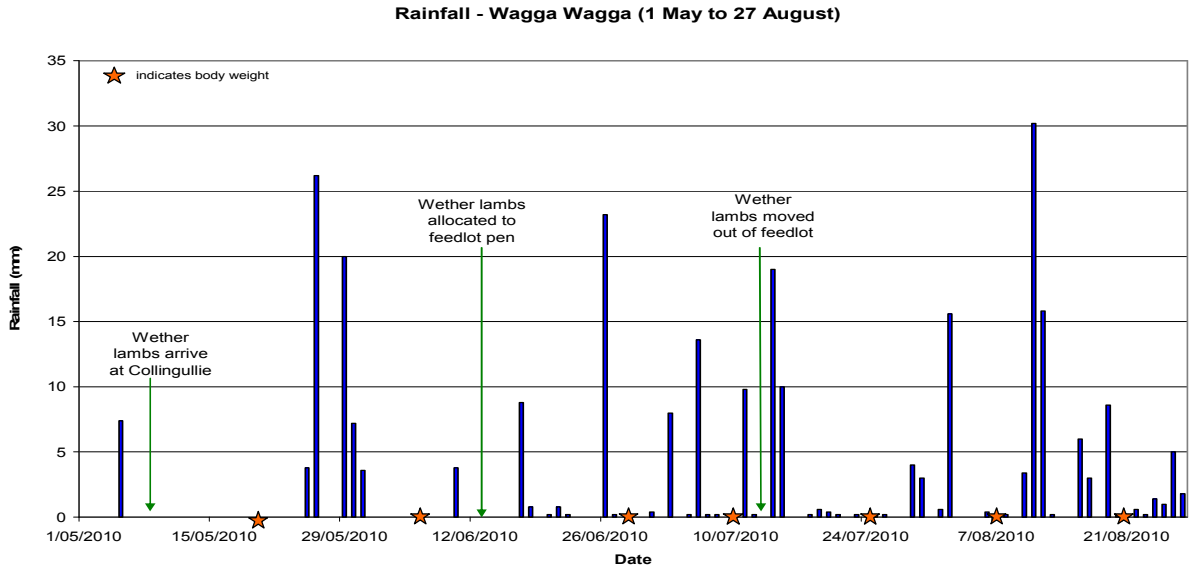


Figure 2 Wagga Wagga rainfall between 1 May and 27 August 2010



4.4.2 Traits measured

Below is a list of all the traits measured over the duration of the Meat Challenge from the 5th April to the 26th August.

Over the duration of the Meat Challenge there has been over 41,000 records collected and processed on the Merino wether lambs.

Body weight & Growth
Body weights (7 in total)
Final body weight (kg)
Dressing percentage – derived from final body and carcase weights
Age (mouthed – lamb/hogget) – prior to slaughter and at slaughter

Carcase
Carcase weight (kg)
Fat depth at GR (12th rib) (mm)

Eye muscle area – by measuring the depth at the same position as Fat C and the length

pH – of the longissimus at the 12th rib (an ultimate pH) – 24 hour

Colour - Meat colour (L*, a* and b*)

Skin
Skin length (mm)
Wool Grade (fine [1], medium [2], broad [3])
Body wrinkle (external) – 1 to 5
Skin wrinkle (internal) – 1 to 5

Body length (cm)

4.4.3 Process of collecting the meat data

Based on the body weight collected on the 9/8/2010 each team was randomly allocated to a kill date to enable an even distribution of weight range per team on the two kill days, have significant importance during the analysis phase. Table 4 reports the meat data collection schedule and the number of people required to carry out the measurements.

Table 4 Meat data collection schedule

Date	Day	Description of activity	People required
21/08/10	Saturday	Lambs drafted into slaughter date groups; final body weights collected (all lambs); Staple length, wool grade; age - first group off feed	3
22/08/10	Sunday	First slaughter group trucked to Dubbo	1
23/08/10	Monday	First slaughter group carcase measurements - dwt; skin; fat score; dressing %	9
23/08/10	Monday	Second slaughter group off feed	1
24/08/10	Tuesday	First Slaughter group chiller measurements - fat, eye muscle area (width/depth), pH, colour	13
24/08/10	Tuesday	Second slaughter group trucked to Fletchers Dubbo	1
25/08/10	Wednesday	Second slaughter group carcase measurements - dwt; skin; fat score; dressing %	12
26/08/10	Thursday	Second Slaughter group chiller measurements - fat, eye muscle area (width/depth), pH, colour	14

4.5 The results

4.5.1 Body weight and growth rate

Body weights were measured on the wether lambs 7 times over the duration of the Meat Challenge. Six of those weights have been used to generate the growth rate over that period. Team results are presented in figures 3, 4 and 5 and Tables 5, 6 and 7. Figures 3, 4 and 5 show team carcase weight relative to growth rate, age and fat depth (GR).

Data collection date	Ave Body weight	Comment
10/04/2010		Wool/Meat Allocation
7/06/2010	36.5 kg	Starting Body weight
28/06/2010		
10/07/2010		
26/07/2010		
9/08/2010		
21/08/2010	51.4 kg	Final body weight

All of the data collected on the wether lambs is applicable to your breeding ewe flock. Work in Western Australia by the Dept of Agriculture and the Sheep CRC has found positive correlations between selecting for growth and the increased proportion of twins and improved ewe milk production.

Team averages for growth rate ranged from 137 to 204 grams per day. The variations between individual animals ranged from 9 to 321 grams per day. Meat Standards Australia recommends that animals should be gaining weight prior to slaughter. In particular the growth rates two weeks prior to slaughter can have an effect on eating quality. For Merino sheep and lambs should be growing at a minimum of 150g per day. Over the duration of the trial the average for the Meat Challenge lambs was 170g per day.

Figure 3 Growth rate and carcase weight (adjusted for age)

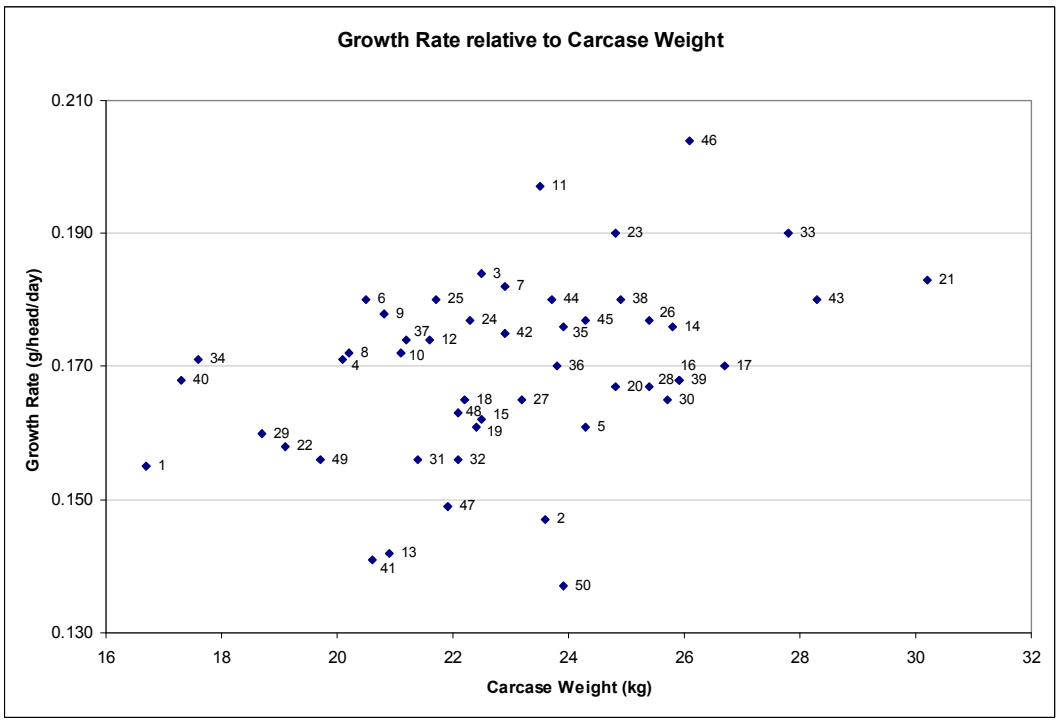


Figure 4 Carcase weight relative to age (days)

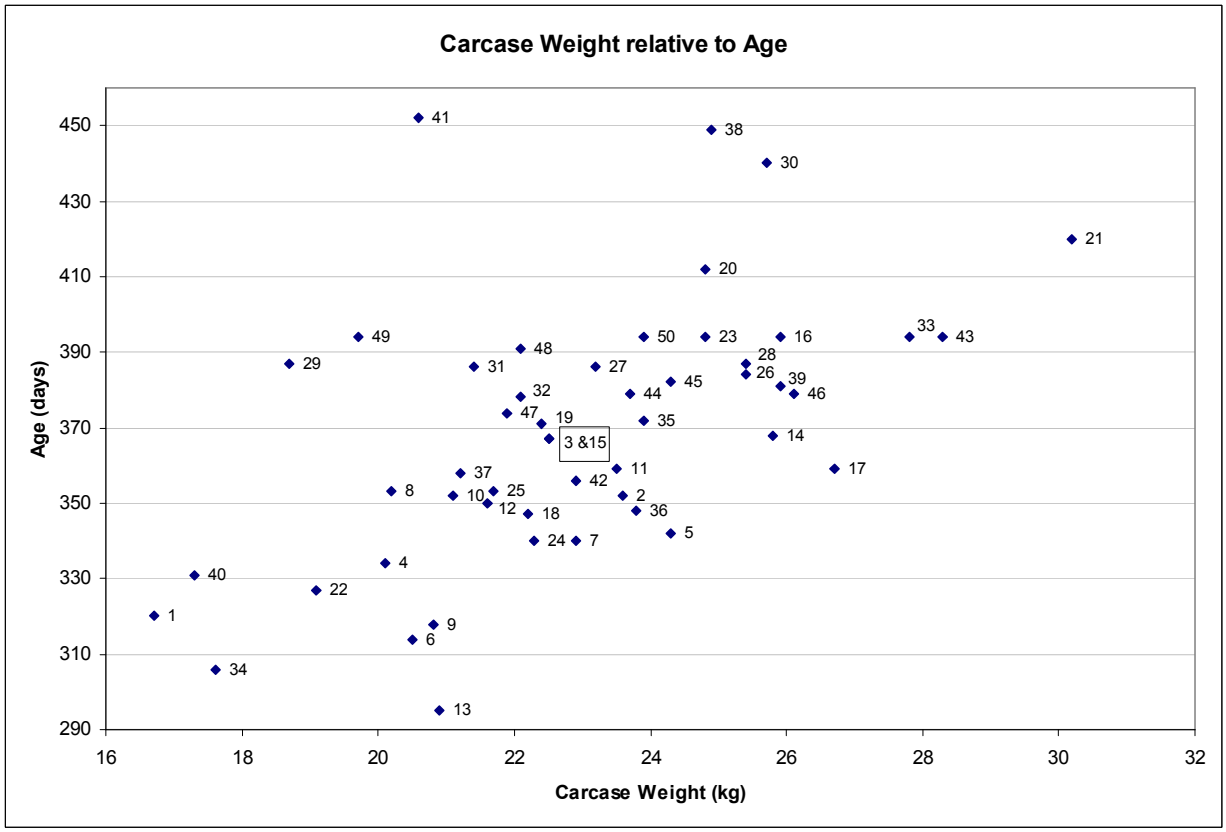


Figure 5 Carcase weight relative to fat depth (GR) adjusted for age

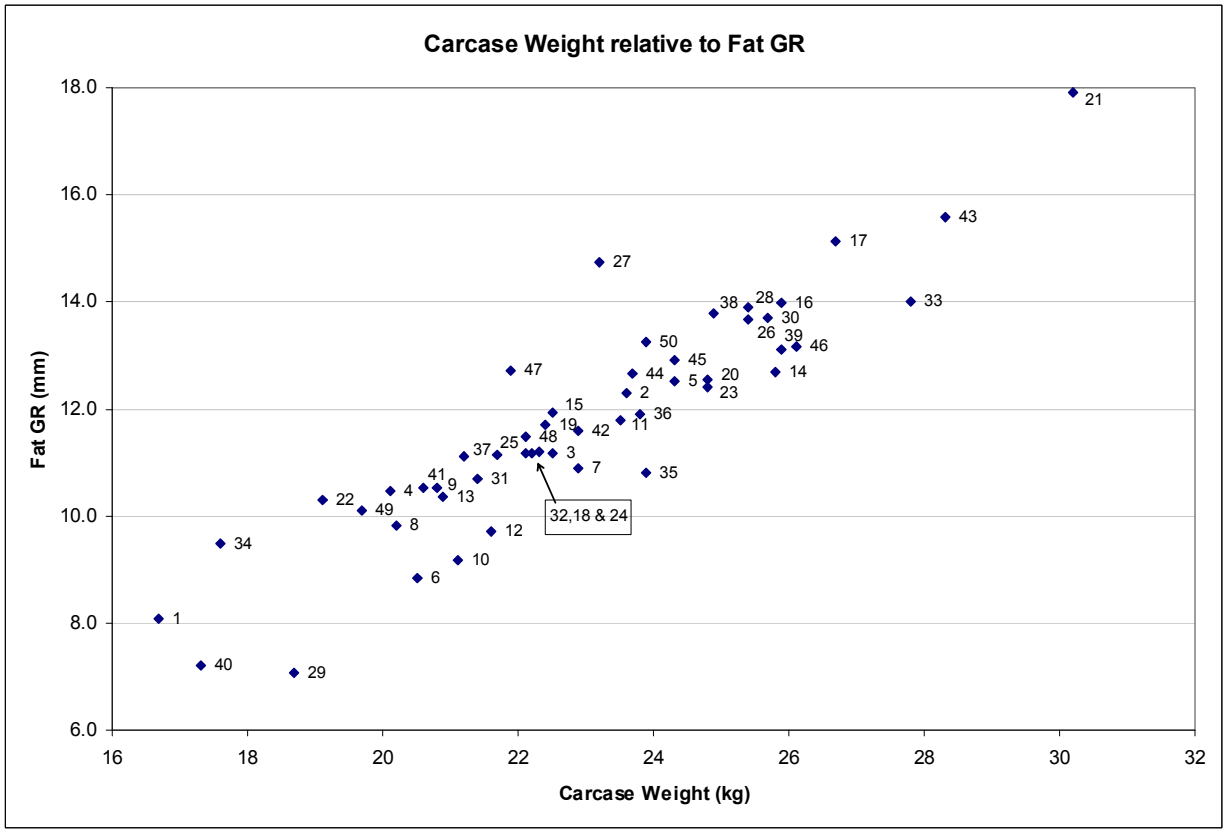
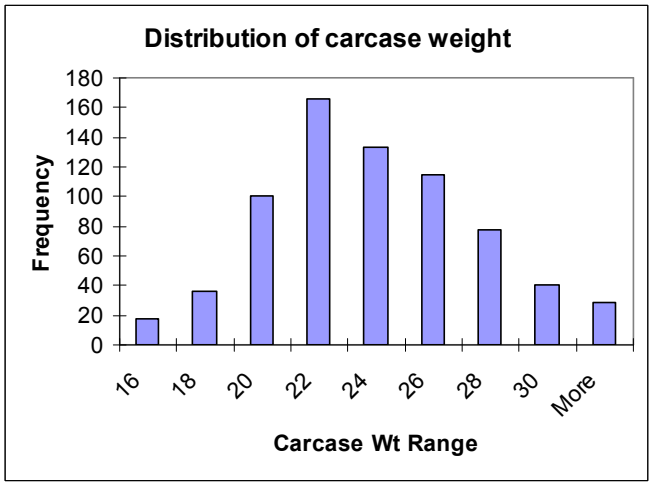


Figure 6 shows the carcase wt range for all Merino wether lambs in the Meat Challenge



The results presented in Table 5 have all been adjusted for age. The final live weight and carcase weights where used to generate the dressing percentage. The average dressing percentage for all the wether lambs was 44.4% with a range from 41.6 to 46.4 percent between teams. Individual dressing percentage ranged from 36.5 to 49.8 percent. As expected the teams that had lambs with fat scores between 2 and 3 (6-15mm) had the better dressing percentage.

Fletcher International Exports provided a grid to calculate the economic value for each carcase and team. Using the grid the market specifications where 22 to 26kg carcase 2, 3 or 4 fat score. Of the 50 teams, 27 teams met the market specifications (adjusted for age). All of the 27 teams were fat score 3 (10 to 15mm).

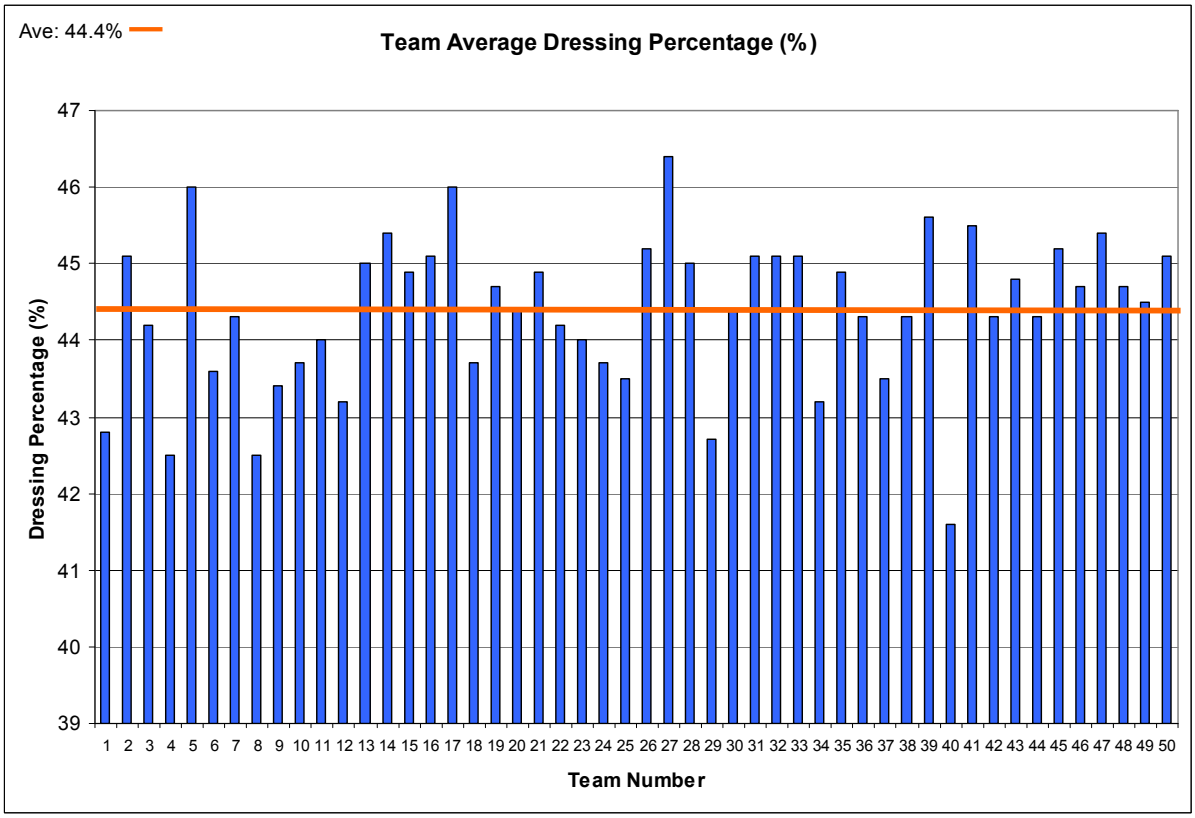


Table 5 Team production traits adjusted for age

Team#	Final Live wt kg	Growth rate grams/day	Dressing %	Carcase wt kg	Lamb %	Hogget %
1	44.5	0.155	42.8	16.7	100	0
2	52.5	0.147	45.1	23.6	93	7
3	51.1	0.184	44.2	22.5	100	0
4	51.0	0.171	42.5	20.1	100	0
5	54.6	0.161	46.0	24.3	100	0
6	51.8	0.180	43.6	20.5	100	0
7	54.0	0.182	44.3	22.9	100	0
8	49.1	0.172	42.5	20.2	100	0
9	52.5	0.178	43.4	20.8	100	0
10	50.0	0.172	43.7	21.1	100	0
11	54.2	0.197	44.0	23.5	100	0
12	51.5	0.174	43.2	21.6	100	0
13	52.8	0.142	45.0	20.9	100	0
14	56.3	0.176	45.4	25.8	100	0
15	49.8	0.162	44.9	22.5	100	0
16	54.6	0.168	45.1	25.9	86	14
17	58.0	0.170	46.0	26.7	93	7
18	52.7	0.165	43.7	22.2	100	0
19	50.0	0.161	44.7	22.4	93	7
20	51.9	0.167	44.4	24.8	47	53
21	61.4	0.183	44.9	30.2	7	93
22	47.3	0.158	44.2	19.1	100	0
23	53.9	0.190	44.0	24.8	100	0
24	53.5	0.177	43.7	22.3	100	0
25	50.1	0.180	43.5	21.7	100	0
26	54.4	0.177	45.2	25.4	93	7
27	48.3	0.165	46.4	23.2	93	7
28	54.2	0.167	45.0	25.4	64	36
29	43.3	0.160	42.7	18.7	100	0
30	51.6	0.165	44.4	25.7	53	47
31	46.3	0.156	45.1	21.4	92	8
32	48.5	0.156	45.1	22.1	100	0
33	58.6	0.190	45.1	27.8	93	7
34	46.9	0.171	43.2	17.6	100	0
35	52.9	0.176	44.9	23.9	100	0
36	55.3	0.170	44.3	23.8	100	0
37	50.1	0.174	43.5	21.2	100	0
38	49.5	0.180	44.3	24.9	47	53
39	55.0	0.168	45.6	25.9	93	7
40	45.5	0.168	41.6	17.3	100	0
41	39.7	0.141	45.5	20.6	31	69
42	52.8	0.175	44.3	22.9	100	0
43	60.2	0.180	44.8	28.3	80	20
44	52.4	0.180	44.3	23.7	100	0
45	52.5	0.177	45.2	24.3	93	7
46	56.8	0.204	44.7	26.1	93	7
47	47.8	0.149	45.4	21.9	100	0
48	47.5	0.163	44.7	22.1	92	8
49	42.6	0.156	44.5	19.7	93	7
50	50.6	0.137	45.1	23.9	86	14
Ave	**51.4 kg**	**0.170 g/head/day**	**44.4 %**	**22.9kg**	**90 %**	**10 %**

Table 6 Team deviations for growth rate, carcase and final live weight

Team	Age (days) 21/8/2010	Age (mths) 21/8/2010	Growth %	Carcase Wt %	Final Live Wt %
1	320	10.7	91	73	86
2	352	11.7	87	103	102
3	367	12.2	109	98	99
4	334	11.1	101	88	99
5	342	11.4	95	106	106
6	314	10.5	106	90	101
7	340	11.3	107	100	105
8	353	11.8	101	88	95
9	318	10.6	105	91	102
10	352	11.7	101	92	97
11	359	12.0	116	103	105
12	350	11.7	103	94	100
13	295	9.8	84	91	103
14	368	12.3	104	113	109
15	367	12.2	96	98	97
16	394	13.1	99	113	106
17	359	12.0	100	117	113
18	347	11.6	97	97	102
19	371	12.4	95	98	97
20	412	13.7	99	108	101
21	420	14.0	108	132	119
22	327	10.9	93	83	92
23	394	13.1	112	108	105
24	340	11.3	104	97	104
25	353	11.8	106	95	97
26	384	12.8	104	111	106
27	386	12.9	97	101	94
28	387	12.9	99	111	105
29	387	12.9	94	82	84
30	440	14.7	97	112	100
31	386	12.9	92	93	90
32	378	12.6	92	97	94
33	394	13.1	112	121	114
34	306	10.2	101	77	91
35	372	12.4	104	104	103
36	348	11.6	100	104	107
37	358	11.9	103	93	97
38	449	15.0	106	109	96
39	381	12.7	99	113	107
40	331	11.0	99	76	88
41	452	15.1	83	90	77
42	356	11.9	103	100	103
43	394	13.1	106	124	117
44	379	12.6	106	104	102
45	382	12.7	104	106	102
46	379	12.6	120	114	110
47	374	12.5	88	96	93
48	391	13.0	96	97	92
49	394	13.1	92	86	83
50	394	13.1	81	104	98
Ave	**369**	**12.3**	**0.170 g/day**	**22.9 kg**	**51.4 kg**

Table 7 – Percentage of team in each carcase weight range

Team Number	<16.0 %	16.1-18.0 %	18.1-20.0 %	20.1-22.0 %	22.1-24.0 %	24.1-26.0 %	26.1-28.0 %	>28.1 %
1	43	36	14	7	**0**	**0**	0	0
2	0	7	7	21	**14**	**29**	14	7
3	0	0	0	53	**27**	**13**	7	0
4	0	0	57	36	**7**	**0**	0	0
5	0	0	0	7	**43**	**29**	21	0
6	0	7	29	43	**14**	**7**	0	0
7	0	0	7	27	**47**	**20**	0	0
8	0	8	23	62	**8**	**0**	0	0
9	0	0	46	31	**8**	**15**	0	0
10	0	0	33	33	**27**	**7**	0	0
11	0	0	0	27	**33**	**27**	13	0
12	0	7	21	29	**29**	**14**	0	0
13	13	0	33	27	**7**	**13**	7	0
14	0	0	0	8	**31**	**23**	8	31
15	0	8	15	23	**15**	**31**	8	0
16	0	0	0	14	**14**	**29**	14	29
17	0	0	0	13	**13**	**13**	13	47
18	0	0	27	27	**27**	**13**	0	7
19	0	7	7	47	**7**	**20**	7	7
20	0	0	7	7	**27**	**20**	33	7
21	0	0	0	0	**0**	**0**	29	71
22	14	21	36	7	**21**	**0**	0	0
23	0	0	0	13	**33**	**33**	7	13
24	0	7	20	33	**13**	**13**	7	7
25	0	0	15	38	**31**	**15**	0	0
26	0	0	0	7	**29**	**14**	43	7
27	0	0	20	20	**20**	**20**	13	7
28	0	0	0	21	**0**	**36**	21	21
29	0	29	43	29	**0**	**0**	0	0
30	0	0	0	20	**7**	**20**	27	27
31	0	0	23	38	**31**	**0**	8	0
32	0	7	29	7	**36**	**14**	0	7
33	0	0	0	0	**0**	**20**	33	47
34	14	43	36	7	**0**	**0**	0	0
35	0	0	0	27	**40**	**13**	13	7
36	0	0	7	21	**21**	**36**	14	0
37	0	7	20	53	**0**	**13**	7	0
38	0	0	0	27	**13**	**20**	20	20
39	0	0	7	0	**21**	**29**	21	21
40	29	36	29	7	**0**	**0**	0	0
41	0	8	31	46	**15**	**0**	0	0
42	0	0	14	29	**21**	**21**	14	0
43	0	0	0	0	**0**	**20**	40	40
44	7	0	0	20	**33**	**13**	20	7
45	0	0	0	7	**27**	**53**	13	0
46	0	0	7	0	**20**	**27**	20	27
47	0	0	20	40	**20**	**20**	0	0
48	0	0	8	46	**38**	**8**	0	0
49	7	21	21	36	**14**	**0**	0	0
50	0	0	0	29	**29**	**14**	21	7

4.5.2 Lamb Growth Predictor

The Lamb Growth Predictor developed by I&I NSW and the Sheep CRC uses three to four body weights to predict the growth rates and estimated finish dates and weights for lambs.

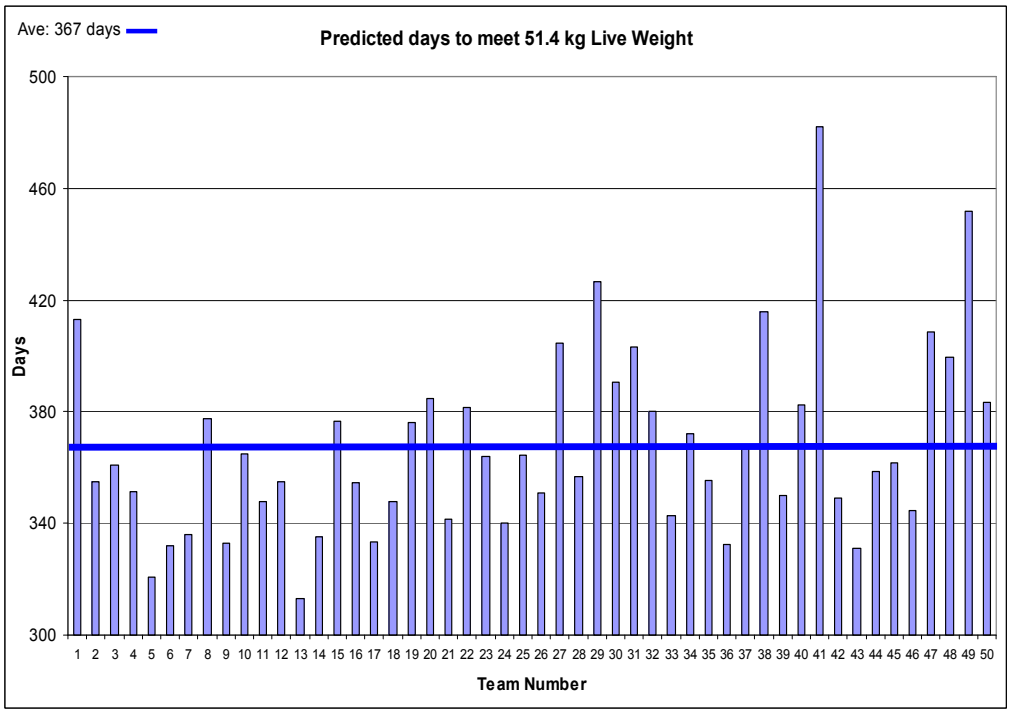
When comparing actual growth rates and final live weights the predictions where very close. The table below shows the actual and prediction values. These results should give advisors and producers confidence in using this tool to fine tune finishing operations.

Trait	Actual	Predicted
Growth (grams)	170	172
Final Live weight (kg)	51.4	51.7

Given the large variation in age of lambs entered in the PWMMC the Lamb Growth Predictor was used to estimate time (days) to meet a target weight. The actual weight at the conclusion of the Meat Challenge was used, 51.4kg.

Four body weights collected on the 28th June, 10th July, 26th July and 9th August where entered into the Lamb Growth Predictor, this then generated a date that lambs would reach or have reached the target weight (if they where over the 51.4kg target on kill day). The average length of time over the 50 teams was 367 days (12 months) of age. The range of time to reach target weight was from 10 to 15½ months of age. Figure 7 graphically reports the estimated days to reaching the target weight.

Figure 7 Predicted days to reach target weight



4.5.3 Fat GR and C

Fat was measured on three occasions during the processing of the lambs. A subjective assessment was made by one of Fletcher International Export staff on the chain, and then a fat depth was measured in the chiller 24 post slaughter at both the GR and C sites and are pictured below.

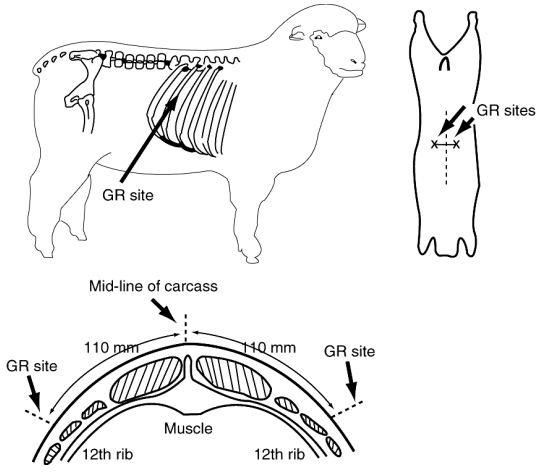
The two fat assessments give an indication of fat cover and distribution. In relationship to processing lambs, fat at the GR site affects price. Too lean (fat score 1) has an effect on

presentation of the final product and too fat (fat score 4 to 5) costs the processor due to excess trimming.
Relating this back to the ewe flock, work published in Western Australia indicates that genetically fatter ewes provide a better maternal environment for lambs resulting in higher birth weight when ewe nutrition is limiting (Ferguson). There is also a correlation between fat and increased milk production.

Table 8 presents the average team fat depth at the C and GR sites, the percentage of lambs in each fat score category (GR) and the total percent of lambs per team in the two and three score fat range. Figure 5 (page 8) shows team carcase weight relative to fat (GR).

Description	**Fat Score (GR)**
Individual ribs are easily felt and no tissue can be felt (sliding) over the ribs. Depressions are quite obvious between ribs.	1 (0-5mm)
Individual ribs are felt with some tissue able to be felt over the ribs. Depressions between ribs are obvious.	2 (6-10mm)
Individual ribs can still be felt but they are more rounded, with tissue movement being felt over the ribs. The depression between ribs is less obvious.	3 (11-15mm)
The ribs are less obvious to feel, with only some depression between ribs. Tissue movement over the ribs is apparent.	4 (16-20mm)
It is difficult to feel ribs, or any depression between ribs. Sliding over the ribs is very easy.	5 (+20mm)

Source: PROGRAZE Manual



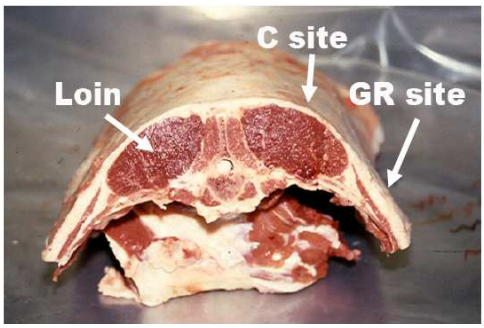


Table 8 Average team fat results

Team#	FatGR mm	FatC mm	1 Score (0-5mm) %	2 Score (6-10mm) %	3 Score (11-15mm) %	4 Score (16-20mm) %	5 Score (>21mm) %	Fat GR Acceptable%	Fat GR Not Acceptable %
1	8.1	3.7	20	**53**	**27**	**0**	0	80	20
2	12.3	5.3	14	**21**	**43**	**14**	7	79	21
3	11.2	4.8	0	**47**	**40**	**13**	0	100	0
4	10.5	4.8	0	**50**	**43**	**7**	0	100	0
5	12.5	5.6	0	**29**	**57**	**14**	0	100	0
6	8.9	4.0	20	**67**	**7**	**7**	0	80	20
7	10.9	5.0	0	**53**	**40**	**7**	0	100	0
8	9.8	4.3	7	**64**	**29**	**0**	0	93	7
9	10.5	4.6	0	**62**	**31**	**8**	0	100	0
10	9.2	4.5	7	**67**	**27**	**0**	0	93	7
11	11.8	4.7	0	**33**	**60**	**7**	0	100	0
12	9.7	5.0	7	**64**	**29**	**0**	0	93	7
13	10.4	4.3	7	**47**	**40**	**7**	0	93	7
14	12.7	5.5	14	**14**	**64**	**7**	0	86	14
15	11.9	5.1	7	**36**	**36**	**7**	14	79	21
16	14.0	4.8	0	**50**	**25**	**8**	17	83	17
17	15.1	6.9	0	**23**	**38**	**23**	15	85	15
18	11.2	4.5	7	**33**	**47**	**13**	0	93	7
19	11.7	5.4	0	**50**	**43**	**7**	0	100	0
20	12.6	5.1	7	**20**	**67**	**7**	0	93	7
21	17.9	6.5	0	**7**	**36**	**36**	21	79	21
22	10.3	4.4	0	**57**	**36**	**7**	0	100	0
23	12.4	4.7	0	**27**	**60**	**13**	0	100	0
24	11.2	5.1	0	**47**	**47**	**0**	7	93	7
25	11.1	4.8	7	**43**	**43**	**7**	0	93	7
26	13.7	5.6	0	**42**	**33**	**25**	0	100	0
27	14.8	5.7	0	**8**	**54**	**23**	15	85	15
28	13.9	5.9	0	**31**	**38**	**23**	8	92	8
29	7.1	3.7	29	**71**	**0**	**0**	0	71	29
30	13.7	5.3	0	**29**	**43**	**21**	7	93	7
31	10.7	4.7	0	**46**	**54**	**0**	0	100	0
32	11.2	5.3	0	**57**	**29**	**14**	0	100	0
33	14.0	5.1	0	**36**	**36**	**29**	0	100	0
34	9.5	4.0	0	**57**	**43**	**0**	0	100	0
35	10.8	4.5	0	**67**	**27**	**7**	0	100	0
36	11.9	4.9	0	**23**	**62**	**15**	0	100	0
37	11.1	4.7	0	**40**	**60**	**0**	0	100	0
38	13.8	5.9	7	**7**	**64**	**14**	7	86	14
39	13.1	5.5	7	**21**	**57**	**14**	0	93	7
40	7.2	3.3	33	**60**	**7**	**0**	0	67	33
41	10.5	5.0	8	**31**	**62**	**0**	0	92	8
42	11.6	4.8	0	**43**	**50**	**7**	0	100	0
43	15.6	6.1	0	**0**	**47**	**40**	13	87	13
44	12.7	5.4	7	**20**	**47**	**20**	7	87	13
45	12.9	5.8	7	**0**	**73**	**20**	0	93	7
46	13.2	5.5	7	**20**	**53**	**20**	0	93	7
47	12.7	5.4	0	**13**	**67**	**20**	0	100	0
48	11.5	4.9	0	**38**	**54**	**8**	0	100	0
49	10.1	4.6	7	**50**	**36**	**7**	0	93	7
50	13.2	5.1	0	**14**	**57**	**29**	0	100	0
Ave	**11.8**	**5.0**	**5**	**38**	**43**	**12**	**3**	**93**	**7**

4.5.4 Economic Value

An economic value for each team has been calculated using the carcase weight and fat measured at the GR site. Based on the grid below (provided by Fletcher International Exports) discounts where applied to carcases not meeting the market specifications (22 to 26 kg at 2 to 4 fat score). Further discounts where applied to hoggets. A skin value of $15.50 has been included. Table 9 and figure 8 presents the average sheep values and deviations for each team.

Grid	1 (0-5 mm)	2 (6-10 mm)	3 (11-15 mm)	4 (16-20 mm)	5 (+20 mm)
<16 kg	$2.80	$3.00	$3.00	$3.00	$2.80
16.1-18	$4.00	$4.20	$4.20	$4.20	$4.00
18.1-20	$4.20	$4.40	$4.40	$4.40	$4.20
20.1-22	$4.30	$4.50	$4.50	$4.50	$4.30
22.1-24	$4.40	**$4.60**	**$4.60**	**$4.60**	$4.40
24.1-26	$4.40	**$4.60**	**$4.60**	**$4.60**	$4.40
26.1-28	$4.20	$4.40	$4.40	$4.40	$4.20
>28 kg	$4.20	$4.40	$4.40	$4.40	$4.20
Hogget	-$0.30				
Skin	$15.50				

Figure 8 Average sheep value (carcase and skin)

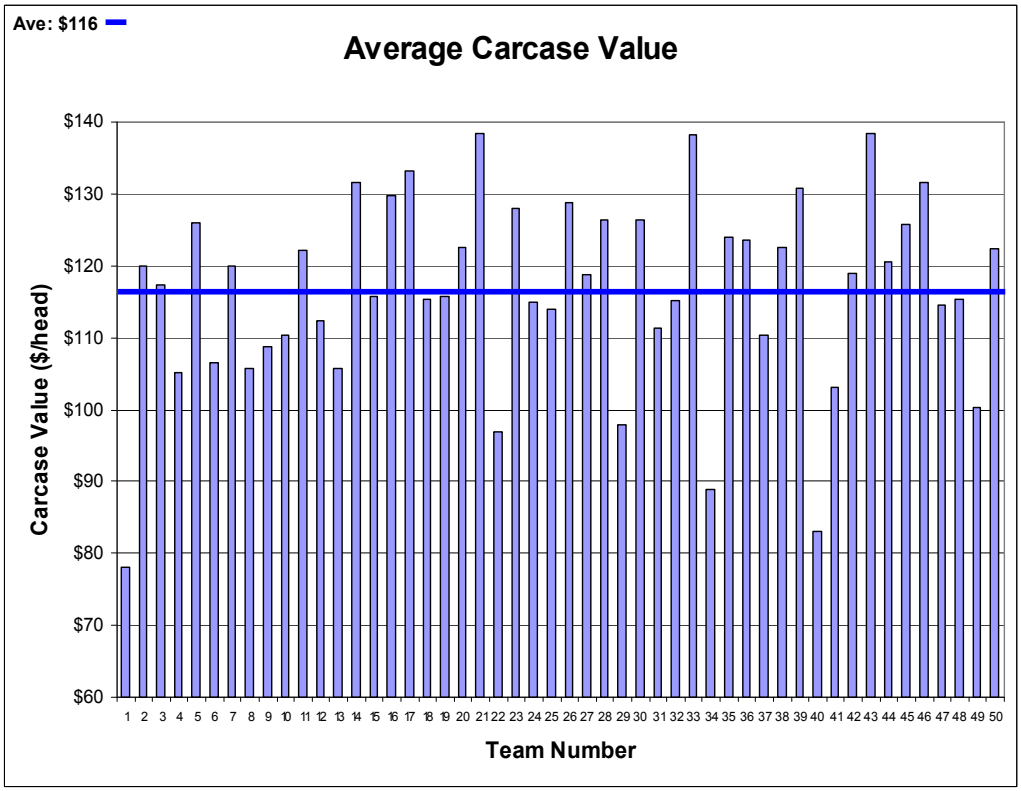


Table 9 Sheep values and deviations

Team#	Ave Value	$ Deviation
1	$78.14	-$38.49
2	$119.99	$3.37
3	$117.37	$0.74
4	$105.17	-$11.45
5	$125.96	$9.33
6	$106.59	-$10.03
7	$119.96	$3.34
8	$105.64	-$10.99
9	$108.72	-$7.90
10	$110.23	-$6.40
11	$122.23	$5.61
12	$112.42	-$4.20
13	$105.81	-$10.82
14	$131.54	$14.92
15	$115.75	-$0.87
16	$129.72	$13.10
17	$133.18	$16.55
18	$115.25	-$1.37
19	$115.81	-$0.81
20	$122.61	$5.98
21	$138.35	$21.72
22	$96.86	-$19.76
23	$127.94	$11.32
24	$114.99	-$1.64
25	$113.95	-$2.68
26	$128.81	$12.19
27	$118.78	$2.16
28	$126.27	$9.65
29	$97.80	-$18.83
30	$126.35	$9.72
31	$111.41	-$5.21
32	$115.22	-$1.40
33	$138.17	$21.54
34	$88.86	-$27.77
35	$123.93	$7.31
36	$123.54	$6.92
37	$110.36	-$6.27
38	$122.60	$5.98
39	$130.85	$14.23
40	$83.16	-$33.47
41	$103.09	-$13.53
42	$118.98	$2.35
43	$138.48	$21.85
44	$120.55	$3.93
45	$125.86	$9.24
46	$131.67	$15.04
47	$114.52	-$2.10
48	$115.26	-$1.37
49	$100.25	-$16.37
50	$122.27	$5.65
Ave	**$116.62**	

4.5.5 pH

Merinos are usually associated with high pH levels. pH has an effect on meat colour (dark cutting) and shelf life. The PWMMC had excellent results as all team averages was 5.6 or below. Above 5.8 you get less shelf life of product. There was very little difference between teams for this trait. Looking at individual animal test results a percentage of each team falling above (>) or below (<) 5.8 indicates that of the whole mob of 740 lambs there were only 7% above 5.8 pH.

Team #	pH	pH <5.8 %	pH >5.8 %
1	5.6	93	7
2	5.6	93	7
3	5.6	100	0
4	5.6	100	0
5	5.5	100	0
6	5.6	100	0
7	5.6	100	0
8	5.6	100	0
9	5.6	100	0
10	5.6	100	0
11	5.6	93	7
12	5.6	100	0
13	5.6	93	7
14	5.5	93	7
15	5.6	93	7
16	5.5	100	0
17	5.5	93	7
18	5.6	93	7
19	5.6	93	7
20	5.5	100	0
21	5.5	100	0
22	5.6	100	0
23	5.6	73	27
24	5.6	87	13
25	5.6	100	0
26	5.5	100	0
27	5.6	100	0
28	5.5	100	0
29	5.6	92	8
30	5.5	100	0
31	5.6	100	0
32	5.6	93	7
33	5.5	87	13
34	5.6	100	0
35	5.6	93	7
36	5.6	100	0
37	5.6	87	13
38	5.6	100	0
39	5.5	100	0
40	5.6	100	0
41	5.6	100	0
42	5.6	100	0
43	5.5	100	0
44	5.5	100	0
45	5.6	93	7
46	5.5	100	0
47	5.6	100	0
48	5.6	92	8
49	5.6	100	0
50	5.6	93	7
Ave	**5.6**	**93**	**7**

4.5.6 Eye muscle

Each carcase was cut at the 12th rib and the eye muscle depth (EMD) and eye muscle width (EMW) where measured. Using this information the eye muscle area (EMA) can be determined. Table 10 presents the team results.

The variation between teams for EMD, EMW and EMA ranged from 25.3 to 29.3mm, 58.3 to 65.2mm and 12 to 15.3 centimetres square respectively.

Comparing the eye muscle results to body length there is greater change in eye muscle width as body length increases, as indicated in Figure 9. Body length increases are associated with increase in age. The Sheep CRC (Practical Wisdom Information Sheets) state that there is no increase in EMD past the age of 14 months, regardless of breed. However beyond 14 months there is a continued increase in EMA indicating an increase in EMW.

Figure 10 shows eye muscle area in relation to carcase weight having a strong correlation, supporting the above statement.

There are positive correlations reported between muscle and increased number of twins in a breeding flock.

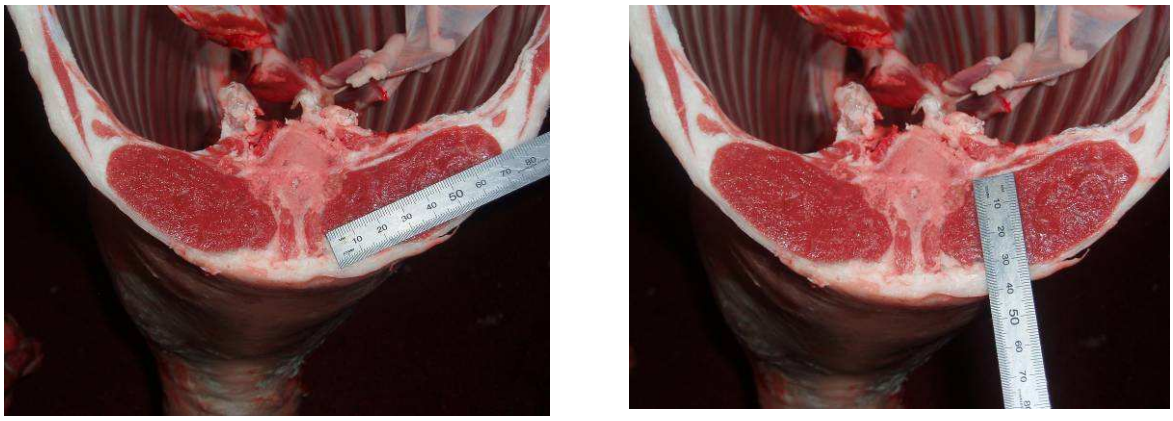


Figure 9 Eye muscle relative to body length

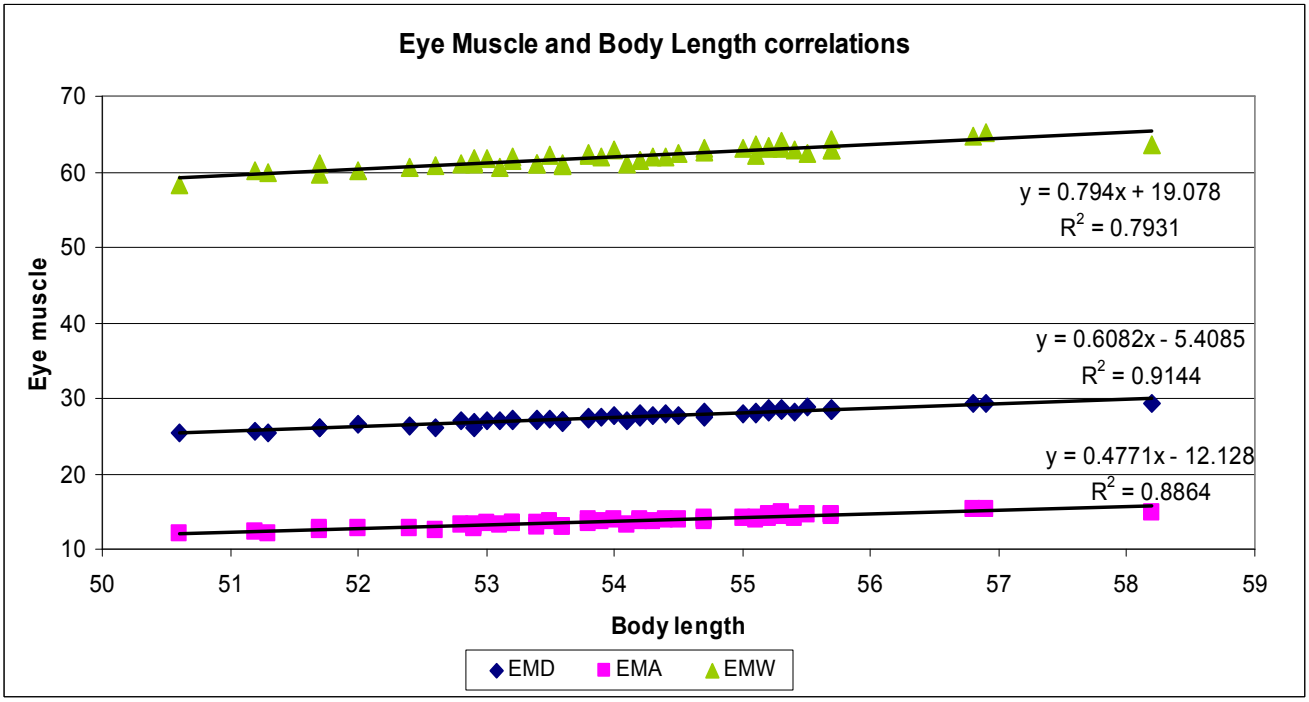
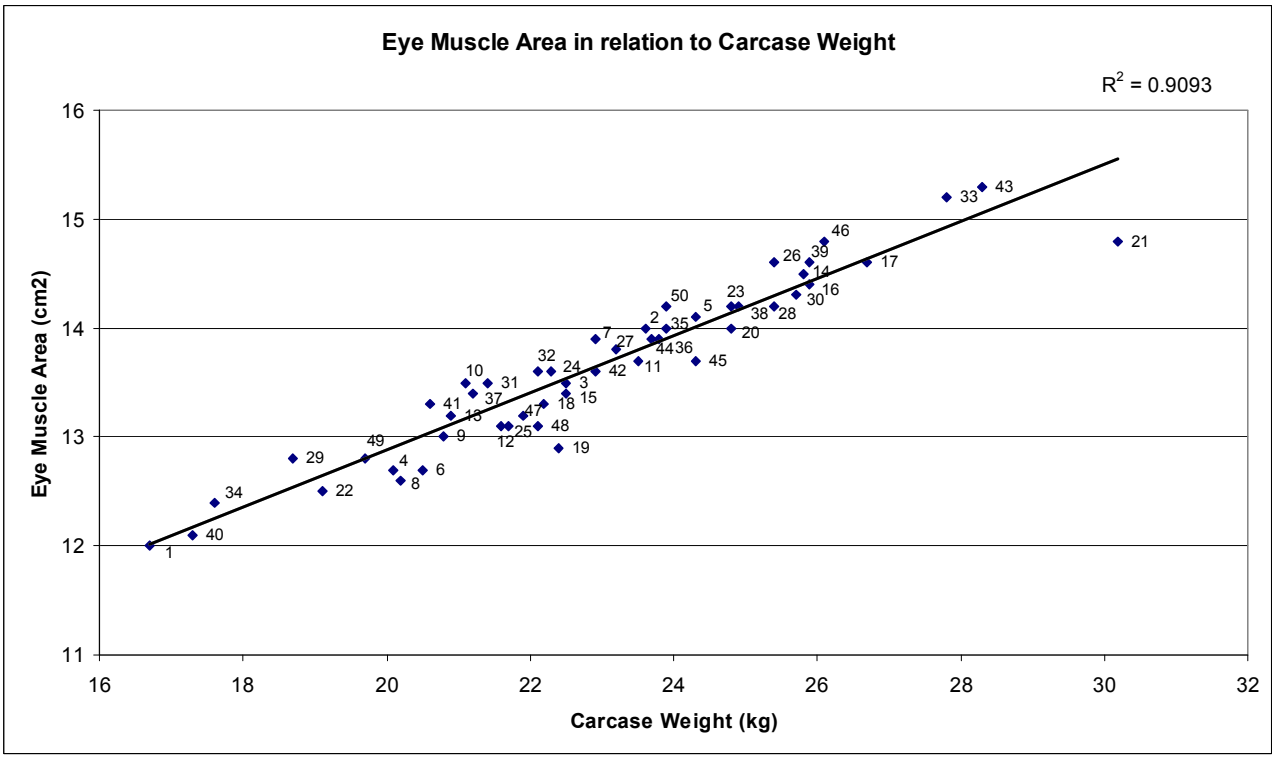


Table 10 Eye muscle depth, area and width

Team #	EMD mm	EMA cm2	EMW mm
1	25.5	12.0	58.3
2	28.0	14.0	61.9
3	27.2	13.5	62.1
4	26.3	12.7	60.5
5	27.9	14.1	63.1
6	26.2	12.7	61.1
7	27.6	13.9	62.9
8	26.0	12.6	60.8
9	26.6	13.0	61.3
10	27.1	13.5	61.8
11	27.7	13.7	61.9
12	27.0	13.1	60.7
13	26.9	13.2	61.0
14	28.8	14.5	62.4
15	27.3	13.4	61.1
16	28.4	14.4	63.2
17	28.5	14.6	64.3
18	27.1	13.3	61.1
19	26.7	12.9	60.9

Team #	EMD mm	EMA cm2	EMW mm
20	28.1	14.0	62.1
21	29.2	14.8	63.6
22	26.1	12.5	59.6
23	28.0	14.2	63.5
24	27.4	13.6	61.6
25	26.9	13.1	61.0
26	28.7	14.6	62.8
27	27.5	13.8	62.5
28	28.1	14.2	63.1
29	26.2	12.8	61.0
30	28.3	14.3	62.8
31	27.2	13.5	61.9
32	27.3	13.6	62.2
33	29.3	15.2	64.8
34	25.7	12.4	60.2
35	27.8	14.0	63.0
36	27.7	13.9	62.5
37	27.1	13.4	61.5
38	28.1	14.2	62.9
39	28.6	14.6	63.4
40	25.3	12.1	59.8
41	26.8	13.3	61.7
42	27.4	13.6	62.0
43	29.3	15.3	65.2
44	27.9	13.9	61.6
45	27.5	13.7	62.6
46	28.7	14.8	64.1
47	27.1	13.2	60.6
48	26.9	13.1	61.0
49	26.5	12.8	60.2
50	28.1	14.2	62.6
Avg	**27.4**	**13.6**	**62.0**

Figure 10 Eye muscle area relative to carcase weight



4.5.7 Colour

Colour was measured on the eye muscle area when the carcase was cut at the 12th rib. The significance of colour relates to shelf life and consumer satisfaction. The colour results from the PWMMC lambs were good. Anecdotally Merinos generally give darker cutting meat.

The "L*" value indicates whether the meat is light or dark cutting, the higher the number the better. Less than 34 you have a product that consumers don't really want. Column L* <34 gives the number of lambs per team that measured below 34. Out of the 740 lambs there were only 22 (3%) below 34 for colour. Above 44 gives a 95 percent confidence that any random consumer will accept the colour, none of the lambs reached this level.

The "a*" value indicates a red green scale. The higher the "a*" value the redder the meat. All the team values where excellent for this measurement. We need 14.5 to be 95% confident that randomly selected consumers will be satisfied. Generally, older animals have a higher "a*" value.

These findings are interesting, however not significant regarding any major profit driver on farm. Colour is more important to processors and retailers.

Team #	L* (Dark/Light)	L* <34	L* >44	a* (red/green)
1	37.1	0	0	21.2
2	36.6	1	0	21.4
3	37.0	0	0	21.4
4	37.1	0	0	21.2
5	36.6	1	0	21.7
6	37.1	0	0	21.4
7	37.0	0	0	21.5
8	37.0	0	0	21.2
9	36.8	0	0	21.4
10	36.6	1	0	21.3
11	36.8	0	0	21.3
12	36.9	0	0	21.3
13	36.9	1	0	21.4
14	36.7	0	0	21.1
15	36.4	2	0	21.5
16	36.7	1	0	21.7
17	36.9	1	0	21.3
18	36.8	0	0	21.5
19	36.8	1	0	21.2
20	36.9	0	0	21.8
21	36.7	1	0	21.9
22	36.2	0	0	21.5
23	36.9	2	0	21.1
24	36.8	0	0	20.9
25	36.6	0	0	21.6
26	36.6	0	0	21.8
27	36.5	0	0	21.5
28	36.7	1	0	21.8
29	36.7	1	0	21.1
30	36.7	1	0	21.9
31	36.7	1	0	21.4
32	36.5	1	0	21.7
33	37.2	0	0	21.2
34	36.6	0	0	21.2
35	36.8	1	0	21.1

Team #	L* (Dark/Light)	L* <34	L* >44	a* (red/green)
36	36.5	0	0	21.5
37	36.4	1	0	21.1
38	36.7	1	0	21.8
39	36.9	0	0	21.5
40	36.4	0	0	21.7
41	36.7	1	0	21.7
42	36.5	0	0	21.3
43	37.0	0	0	21.5
44	36.5	0	0	21.4
45	37.0	0	0	21.0
46	36.7	1	0	21.5
47	37.0	0	0	21.7
48	37.1	0	0	21.3
49	36.8	0	0	21.5
50	37.3	0	0	21.6
Ave	**36.8**			**21.4**

4.5.8 Skins

The average value per skin was $15.50. This was included in the average sheep value per team.

Fletcher International Exports grade all skins based on 5 traits, listed below. In addition to skin wrinkle/rib we have also assessed body wrinkle on the live animal.

The skins from the PWMMC lambs were used to make car seat covers, steering wheel covers and seatbelt straps.

Fletchers Description	Trait measured
Wool Length	Staple length
Skin size	Body length (correlated to carcase weight)
Wool quality	Wool Grade (1 fine; 2 Medium; 3 Broad)
Density	
Skin rib	Skin wrinkle

Score 5 (internal view)

Score 5 (external view)

Table 11 Skin measurements

Team #	Staple Length mm	Wool Grade (1 to 3)	Body Wrinkle (1 to 5)	Skin Wrinkle (1 to 5)	Body Length (cm)
1	35.4	1.12	1.69	2.94	50.6
2	40.1	1.87	2.56	3.24	54.4
3	42.0	2.06	1.90	3.09	53.8
4	43.7	2.00	2.80	3.68	52.4
5	41.1	2.13	1.43	2.82	55.0
6	38.8	2.06	1.78	3.19	52.9
7	40.6	2.12	1.78	3.04	54.0
8	42.4	2.00	2.44	3.47	52.6
9	39.8	2.00	2.01	3.20	52.9
10	40.0	1.94	2.64	3.54	53.0
11	44.0	2.12	2.18	3.14	54.3
12	37.1	1.69	2.36	3.24	53.6
13	38.3	1.19	1.84	2.88	52.8
14	40.3	1.87	2.44	3.04	55.5
15	38.5	1.93	2.38	3.14	53.4
16	41.1	2.00	2.32	3.10	55.3
17	41.0	2.37	1.43	2.68	55.7
18	43.0	1.87	2.53	3.29	54.1
19	40.5	1.87	2.24	3.29	53.6
20	43.5	2.25	2.41	3.14	55.1
21	44.2	2.12	2.76	3.34	58.2
22	37.5	1.21	1.60	3.14	51.7
23	40.0	2.43	2.30	3.34	55.1
24	41.3	1.94	2.07	3.14	54.2
25	41.5	1.94	1.95	3.24	53.6
26	40.1	2.13	1.52	2.72	55.7
27	40.5	2.62	1.34	2.63	53.8
28	38.5	1.93	2.19	3.21	55.2
29	37.1	2.00	2.24	3.34	51.7
30	42.0	2.12	2.51	3.44	55.7
31	39.7	2.07	2.34	3.32	53.2
32	38.8	2.19	2.24	3.39	53.5
33	43.2	2.68	1.95	3.24	56.8
34	39.5	1.86	1.95	3.14	51.2
35	41.3	2.43	2.59	3.39	54.7
36	41.8	2.33	2.50	3.14	54.5
37	38.6	1.38	2.59	3.34	53.2
38	39.3	2.19	1.95	3.14	55.4
39	38.3	2.25	1.44	2.93	55.2
40	37.8	1.63	2.64	3.34	51.3
41	36.7	2.46	1.47	2.93	52.9
42	41.0	1.81	1.95	3.29	53.9
43	42.5	2.12	2.70	3.39	56.9
44	38.3	2.12	1.67	2.83	54.2
45	40.6	2.06	1.84	2.83	54.7
46	39.3	2.06	1.73	3.19	55.3
47	37.8	1.32	1.55	3.04	53.1
48	41.1	2.33	1.47	2.82	53.4
49	39.1	1.32	1.84	3.04	52.0
50	40.3	1.80	2.34	3.14	54.7
Ave	**40.2**	**1.99**	**2.09**	**3.15**	**54.0**

5 Success in achieving objectives

#	Objective	Outcome
1	To increase the information provided to Merino breeders on meat quality traits including growth rates, pH, colour, eye muscle area, fat depth and dressing percentage.	We have provided information to Challenge entrants on their teams performance and the wider sheep industry.
2	Provide a full economic analysis of production feeding Merino lambs, including a net profit per team.	An economic analysis of team performance has been completed.
3	To show the wider Australian sheep industry the opportunities for sheep producers to be more sustainable in the future by quantifying the variation within and between the most influential Merino bloodlines in Australia.	The wider sheep industry have had access to information generated from the PWMMC Meat Challenge results.
4	The identification of superior genetics in the Merino breed will allow strategic decisions to be made for both short and long term gain. The power of genetic variation is that it allows substantial gain in net profit leading to more sustainable businesses and communities.	The PWMMC Meat Challenge findings for superior Merino genetics for meat related traits are consistent with trends identified through MERINOSELECT.
5	Utilize the linkage that exists with several of the entrants involvement in other trials to build on the existing Merino bloodline data.	Achieved.
6	Demonstrate to Merino breeders the diversity and opportunities to improve meat traits, whilst maintaining high quality wool traits; allowing a full interpretation of the correlations of most of the traits effecting Merino breeding profitability.	Achieved.
7	Specific timelines and dates to allow the education of entrants and the wider sheep industry in the genetic diversity of meat quality traits in Merinos and identify the opportunities to improve profitability through enhanced genetic selection for these traits.	Commenced and achieved given resources of the project.
8	The collaboration of several companies in an act of good will to remember the legacy of Peter Westblade and to promote the Australian Merino Industry.	Achieved.

6 Impact on meat and livestock industry

The outcomes of the Meat Challenge have been very positive. Information generated has shown the diversity of the Australian Merino and the opportunities that exist when combining both meat and wool traits. The Meat Challenge has also enabled an educational forum for entrants and other like minded producers and service providers to exchange ideas and learn from the Challenge outcomes.

The impact now relates to an increased interest in Merino sheep and the importance of selection for traits that are key profit drivers, for example growth. The impact in the future will focus on the opportunities that exist for Merinos and meat traits and taking advantage of these with improve nutrition to realise the benefits.

7 Conclusions and recommendations

Early results have provided some excellent messages for both the Meat Challenge entrants and the wider sheep industry.

The significance of this work has demonstrated that there are massive opportunities in the Merino industry. These opportunities can not only make significant improvements using selection for both carcase and wool traits but that the Merino can, provided they have adequate nutrition, produce a quality meat product.

The key for the Merino industry will be to continue to focus on the key profit drivers of fibre diameter, fleece weight, growth and reproduction being careful not to get too distracted with side issues. However given some industry bias against Merinos for meat, producers must carefully select how they market their Merino lambs.

8 Bibliography

Egan, A.F., Shay, B.J., 1988. Long-term storage of chilled fresh meats. In Proc. 34th Int. Cong. Meat Sci. Tech., pp. 476-481, Brisbane, Australia.

Fogarty, N.M., Hopkins, D.L. and van de Ven, R. (2000). Lamb production from diverse genotypes. 2. Carcass characteristics. *Anim. Sci.* **70**, 147-156.

Gilmour AR, Gogel BJ, Cullis BR, Thompson, R. (2006). *ASReml User Guide Release 2.0*. VSN International Ltd, Hemel Hempstead, HP1 1ES, UK.

Hopkins, D.L., Stanley, D.F., Martin, L.C. and Gilmour, A.R. (2007a). Genotype and age effects on sheep meat production. 1. Production and growth. *Australian Journal of Experimental Agriculture* **47,** 1119-1127.

Hopkins, D.L., Stanley, D.F., Martin, L.C., Toohey, E.S. and Gilmour, A.R. (2007b). Genotype and age effects on sheep meat production. 3. Meat quality. *Australian Journal of Experimental Agriculture* **47,** 1155-1164.

Khliji, S., van de Ven, R., Lamb, T.A., Lanza, M. and Hopkins, D.L. (2010). Relationship between consumer ranking of lamb colour and objective measures of colour. *Meat Science Meat Science* **85,** 224-229.

Ponnampalam, E.N., Hopkins, D.L., Butler, K.L., Dunshea, F.R. and Warner, R.D. (2007) Genotype and age effects on sheep meat production 2. Carcass quality traits. *Australian Journal of Experimental Agriculture* **47,** 1147-1154.

Rogan, I.M. (1988). Reference schemes, production competitions and other means of assessing genotypes. Proceedings - Sheep & Wool Conference and Refresher course, Orange, 13 - 1-15 .

9 Appendices

9.1 Appendix 1 – Journal Article

Extension Farming Systems Journal volume 2 – number 1

Variation in Merino wethers for growth and carcase traits

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Abstract. The Peter Westblade Memorial Merino Challenge (PWMMC) is a successful collaboration between private industry and Industry & Investment NSW. The PWMMC is based on the evaluation of 50 wether teams from across Australia and has successfully integrated finishing and key carcase and meat quality traits into the standard Merino wether trial protocol. Early results from the PWMMC have demonstrated that Merino wethers have sufficiently fast growth rates and their carcases meet market specifications in terms of carcase weight and fat score at slaughter when fed intensively. Furthermore, analysis of various meat quality parameters indicates that meat from Merino wethers can attain acceptable levels for traits like colour and pH.

Keywords: Merino, wether trial, meat, carcase.

Introduction

The Peter Westblade Memorial Merino Challenge (PWMMC) has been a collective wether trial set up between private industry and Industry & Investment NSW. The Challenge has attracted 50 teams of 30 wethers from across Australia. The Challenge has aimed to address the growing interest in carcase traits amongst Merino breeders whilst still maintaining a focus on wool traits. Carcase traits, in particular liveweight have previously only been valued at the conclusion of a wether trial when the animals are 3 to 5 years of age.

There is clear evidence that Merinos take longer to reach target weights (Hopkins et al. 2007a) than other types and some anecdotal claims that they produce dark cutting meat. Although this latter claim appears unfounded (Fogarty et al. 2000; Hopkins et al. 2007b) when Merinos are grown and slaughtered with other types, there is some evidence that the formation of metmyoglobin in the loin muscle from Merino lambs occurs quicker and to a greater extent than muscle from the other types (Warner et al. 2007). Merino lambs under many situations also produce meat with a higher pH (Hopkins et al. 2007b).

The PWMMC offered the opportunity to examine the benefits of intensively feeding Merino lambs representing a wide range of bloodlines and at the same time communicate to Merino breeders the relative importance of carcase and meat traits for meat production. Thus the PWMMC 2010-2012 was developed to assist Merino breeding operations make more informed decisions about their Merino genetics.

Project Background

The Challenge was named in honour of Peter Westblade, who was passionate about breeding profitable sheep, continually had a thirst for knowledge and mentored others in the industry. The Challenge is a collective effort between two commercial businesses, I&I NSW staff and 15 other supporting businesses and organisations.

The Wool Challenge is being run at the Temora Research Station as a standard wether trial and will have two assessment shearings in April 2011 and 2012.

The Meat Challenge is a new initiative within wether trials. Half the Merino wether lambs (50 teams of 15) where randomly selected and taken to Collingullie NSW where they were de-pastured for 4 weeks on irrigated lucerne and then put into a feedlot and fed a pelleted ration containing 11 MJ/kg DM Metabolisable Energy and 14.5% Crude Protein.

Materials and Methods

The design was developed by I&I NSW staff. Initial work determined the number of animals required per team given varying numbers of teams to achieve a 95 percent chance of detecting team differences. This work formed the basis for the minimum number per team (15) required for both the wool and meat sections of the Challenge and was consistent with previous work (Rogan 1988).

A liveweight was taken prior to an even-up shearing. This was then used to randomly allocate animals from each team to the Wool and Meat Challenge. As the allocation was within team, wool length did not need to be taken into consideration. Each team of 30 Merino wether lambs was randomly split to ensure an even distribution of liveweight to both the Meat and Wool Challenge. The real challenge with the meat aspect of the Challenge has been the varying age of lambs entering the feed lot, pre experimental nutrition and management and the varying Merino types entered.

In the feedlot 5 pens where used. A liveweight collected in early June 2010 was used to randomly allocate wethers from each team to each pen. In each feedlot pen there were three wethers from each team consisting of a low, medium and high liveweight animal. The pen allocation was used to remove any “pen effect” from team comparisons. To minimise any issues

associated with social dominance or stress, pre-training onto self feeders was undertaken and adequate trough space per lamb was accommodated.
The Merino wether lambs were processed at Fletcher International Exports Pty Ltd in Dubbo. The logistics of transport, processing and data collection required two kill dates. To reduce any "kill date effect" on team comparisons, individuals within teams where randomly allocated to kill dates. Again we used a liveweight collected close to the processing date when assigning individuals to kill date. Each team had a random allocation of individuals within each weight range to each kill date. This allocation to kill date, in addition to improving the power of the analyses, aimed to avoid any disadvantage to a team due to misadventure occurring between leaving the feedlot and processing.

The traits measured are listed below (Table 1) there were over 41,000 data records recorded over duration of the Meat Challenge which ran from April to August 2010.

Table 1. Trait measured in the PWMMC Meat Challenge.

Liveweight & Growth traits
Liveweights (7 in total)
Final body weight (kg)
Dressing percentage – derived from final body and carcase weights
Age (mouthed – lamb/hogget) – prior to slaughter and at slaughter
Carcase traits
Carcase weight (kg)
Fat depth at GR (12^{th} rib) (mm)
Eye muscle area – by measuring the depth at the same position as Fat C and the length
pH – of the longissimus at the 12^{th} rib (an ultimate pH) – 24 hour
Colour - Meat colour (L*, a* and b*)
Skin
Skin length (mm)
Wool Grade (fine [1], medium [2], broad [3])
Body wrinkle (external) – 1 to 5
Skin wrinkle (internal) – 1 to 5
Body length (cm)

A linear mixed model (LMM) analysis was used to analyse the results from the experiment and a number of models were applied depending on the trait. Models were fitted using ASReml (Gilmour et al. 2006). For example, the model fitted for a carcase trait was trait = baseline + Pen + KillDate + FirstCarcaseWt + ***Team + error*** where ***Team*** and ***error*** were fitted as uncorrelated random effects.

Results and Discussion
Wether lambs had an introductory feeding program for 3 weeks with barley and hay then progressed to the full pellet ration for 8 weeks.

Liveweights were measured on the wether lambs 7 times over the duration of the Meat Challenge. Six of those weights have been used to generate an average growth rate for the 50 teams involved. Team average growth rates ranged from 137 to 204 grams per day adjusted for age. The growth rate for animals ranged from 9 to 321 grams per day. There was a significant difference in growth rates between the top 10 and bottom 8 teams based on a 95 percent confidence of a difference between teams. This work highlights the opportunities within the

Merino industry when placing emphasis on growth in the breeding objective and providing appropriate nutrition.

Carcase traits

The market specifications at the time of processing were 22 to 26 kg (carcase weight) with a 2 to 4 fat score. Twenty seven of the 50 teams met the weight and fat specifications. All 27 teams had a fat score 3 (11 to 15mm). The teams that fell outside the market specifications were largely confounded by the age at entry into the Challenge.

The team means for eye muscle depth (EMD), eye muscle width (EMW) and eye muscle area (EMA) ranged from 25.3 to 29.3mm, 58.3 to 65.2mm and 12 to 15.3 centimetres square respectively, after adjusting for carcase weight.

Comparing eye muscle results with body length there was a greater change (wider) in EMW as body length increased. Body length increases can also be associated with increases in age (Ponnampalam et al. 2007). It has also been reported that there is no increase in EMD past the age of 14 months, regardless of breed (Ponnampalam et al. 2007). However beyond 14 months there is a continued increase in EMA indicating an increase in EMW and change shape of the eye muscle (Ponnampalam et al. 2007).

Ninety four percent of the teams had an average Fat GR between 6 and 15 mm. The average GR was 11.8mm and Fat C was 5mm at adjusted carcase weights within each team. There were no pens effect on GR and Fat C. The best performing team had a mean GR of 14 ± 0.65 mm at 25.9 kg which was significantly fatter than for the Merinos slaughtered by Ponnampalam et al. (2007), and probably indicates the extensive finishing regime.

Meat Traits

Merinos are often associated with high pH levels (Fogarty et al. 2000). pH has an effect on meat colour and shelf life. The results for pH showed very little to no difference between teams for pH. The average pH for animals was 5.6 with standard deviation equal 0.11. Of the individual pH results only 3.5 percent of the Merino wether lambs processed were above 5.8 pH, the value above which reduced shelf life is expected (Egan and Shay, 1988).

The average lightness (*L**) for the loins was 36.8. Values less than 34 are undesirable as consumers consider the meat too dark (Khliji et al. 2010). Out of the Merino lambs there were only 3 percent of lambs that had *L** values less than 34. Above 44 you have 95 percent confidence that any random consumer will accept the colour (Khliji et al. 2010), but none of the teams or lambs reached this level. The a* values reflect the redness of the meat. The higher the *a** value the redder the meat. It also reflects the age of the animals at slaughter with *a** values increasing as animals become older (Hopkins et al. 2007b). All team values where excellent for this measurement. The average for all teams was 21.4 with very little difference between teams. To achieve a 95 percent confidence that random consumers will be satisfied the *a** value needs to be above 14.5 (Khliji et al. 2010). Colour is important to processors and retailers, but does not have direct influence on the price producers are paid.

Conclusion

Early results have provided some excellent messages for both project entrants and the wider sheep industry.

The significance of this work has demonstrated that there are massive opportunities in the Merino industry. These opportunities can not only make significant improvements using selection for both carcase and wool traits but that the Merino can, provided they have adequate nutrition, produce a quality meat product.

The key for the Merino industry will be to continue to focus on the key profit drivers of fibre diameter, fleece weight, growth and reproduction being careful not to get too distracted with side issues. However given some industry bias against Merinos for meat, producers must carefully select how they market their Merino lambs.

Acknowledgements
This Challenge would not have been possible without the support and collaboration of a number of organisations, businesses and individuals.
Meat and Livestock Australia for their support in the data collection during meat processing.
It is estimated the Meat Challenge has cost over $200,000 to run. This figure includes in-kind contributions and actual expenses incurred.

References

Egan, A.F., Shay, B.J., 1988. Long-term storage of chilled fresh meats. In Proc. 34th Int. Cong. Meat Sci. Tech., pp. 476-481, Brisbane, Australia.

Fogarty, N.M., Hopkins, D.L. and van de Ven, R. (2000). Lamb production from diverse genotypes. 2. Carcass characteristics. *Anim. Sci.* **70**, 147-156.

Gilmour AR, Gogel BJ, Cullis BR, Thompson, R. (2006). *ASReml User Guide Release 2.0*. VSN International Ltd, Hemel Hempstead, HP1 1ES, UK.

Hopkins, D.L., Stanley, D.F., Martin, L.C. and Gilmour, A.R. (2007a). Genotype and age effects on sheep meat production. 1. Production and growth. *Australian Journal of Experimental Agriculture* **47,** 1119-1127.

Hopkins, D.L., Stanley, D.F., Martin, L.C., Toohey, E.S. and Gilmour, A.R. (2007b). Genotype and age effects on sheep meat production. 3. Meat quality. *Australian Journal of Experimental Agriculture* **47,** 1155-1164.

Khliji, S., van de Ven, R., Lamb, T.A., Lanza, M. and Hopkins, D.L. (2010). Relationship between consumer ranking of lamb colour and objective measures of colour. *Meat Science Meat Science* **85,** 224-229.

Ponnampalam, E.N., Hopkins, D.L., Butler, K.L., Dunshea, F.R. and Warner, R.D. (2007) Genotype and age effects on sheep meat production 2. Carcass quality traits. *Australian Journal of Experimental Agriculture* **47,** 1147-1154.

Rogan, I.M. (1988). Reference schemes, production competitions and other means of assessing genotypes. Proceedings - Sheep & Wool Conference and Refresher course, Orange, 13 - 1-15 .

9.2 Appendix 2 - Analysis

Biometric Consulting Series – Analysis

Title: PWMMC Complete Carcase Data Analysis

Client: Sally Martin

Author: Remy van de Ven

Date: 28 September 2010

NOTE:

Should any of the biometrical results contained in this report be used in a paper written for publication in a refereed journal, then prior to release that paper must first be subjected to an independent internal biometrical review.

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Analysis Methods:

A linear mixed model (LMM) analysis is used to analyse the results from the trail.
The model fitted in each case (where Y denotes the trait being analysed) is:

FatGR, FatC, EMD, EMA, EMW, BodyLength

Y = baseline + Pen + KillDate + FirstCarcaseWt + ***Team + error***

Team and ***error*** are fitted as uncorrelated random effects.

DP, StapleLength

Y = baseline + Pen + KillDate +***Team + error***

L, a, b

Y = baseline + Pen + KillDate + pH +***Team + error***

pH (log transformed)

Y = baseline + Pen + KillDate + TimepH + KillDate + TimepH + FirstCarcaseWt
+***Team + error***

FinalLwt210810, GrowthRate

Y = baseline + Pen + AgeDays280610 + ***Team + error***

WoolGrade, BWrk, Skin

Y = baseline + Pen + ***Team + error***

In the summary below for each trait analysed are given

- ANOVA
- Variance component table
- Summary of Fixed effects
- Table of predicted means for each Team
- Identification of a subset of Teams giving lowest value for trait
- Identification of a subset of Teams giving highest value for trait

Predicted means are calculated at the average covariate value(s) for the Team (where applicable) and at the average over Pen's and KillDate's. In the table of predicted means are also given the standard error of the predictions and an LSD ranking. For a pair of Teams (selected at random) these are not significantly different if they have a letter in common in the LSD.Rank column.

As LSD Rankings are not specifically established to compare extreme groups it has also been decided to include two other pieces of information.

First, the smallest subset of Teams considered to contain (with 95% confidence) the Team with the **largest** mean is given. Likewise, the smallest subset of Teams considered to contain (with 95% confidence) the Team with the **smallest** mean is also given.

Finally, a plot of Predicted Team means versus Rank is given. On this plot are also the Team numbers for the five most extreme Teams at either end.

Results:

FatGR:

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	47	3714.0	50.530		0.000
Pen	4	658	1.7	0.869	A	0.482
KillDate	1	659	16.1	18.680	A	0.000
FirstCarcaseWt	1	373	427.3	427.300	A	0.000

Variance Components:

	component	std.error	z.ratio
Team!Team.var	1.25	0.386	3.24
R!variance	8.74	0.483	18.12

Summary of fixed effects:

	solution	std error	z ratio
FirstCarcaseWt	0.793	0.0384	20.672
KillDate_23/08/2010	0.000	NA	NA
KillDate_25/08/2010	-0.959	0.2218	-4.322
Pen_Pen1	0.000	NA	NA
Pen_Pen2	-0.158	0.3507	-0.451
Pen_Pen3	-0.152	0.3522	-0.431
Pen_Pen4	-0.542	0.3499	-1.550
Pen_Pen5	0.039	0.3507	0.111
(Intercept)	-5.754	0.9357	-6.149

Predicted Means

FirstCarcaseWt	Team	predicted.value	standard.error	LSD.Rank
18.7	Team29	7.08	0.636	a
17.3	Team40	7.20	0.653	a
16.7	Team01	8.08	0.654	ab
20.5	Team06	8.85	0.650	abc
21.1	Team10	9.17	0.634	bcd
17.6	Team34	9.48	0.652	bcde
21.6	Team12	9.70	0.665	bcdef
20.2	Team08	9.81	0.666	bcdefg
19.7	Team49	10.09	0.635	cdefgh
19.1	Team22	10.31	0.651	cdefghi
20.9	Team13	10.35	0.634	cdefghi
20.1	Team04	10.48	0.650	cdefghij
20.8	Team09	10.52	0.666	cdefghij
20.6	Team41	10.53	0.666	cdefghij
21.4	Team31	10.68	0.665	cdefghijk
23.9	Team35	10.80	0.634	defghijkl
22.9	Team07	10.90	0.634	defghijklm
21.2	Team37	11.11	0.634	efghijklmn
21.7	Team25	11.14	0.665	efghijklmno
22.5	Team03	11.16	0.634	efghijklmno
22.1	Team32	11.16	0.649	efghijklmno
22.2	Team18	11.17	0.634	efghijklmno
22.3	Team24	11.20	0.634	efghijklmno
22.1	Team48	11.48	0.665	fghijklmnop
22.9	Team42	11.59	0.649	ghijklmnop
22.4	Team19	11.70	0.634	hijklmnop
23.5	Team11	11.78	0.634	hijklmnop
23.8	Team36	11.91	0.665	hijklmnopq
22.5	Team15	11.92	0.665	ijklmnopq
23.6	Team02	12.30	0.649	jklmnopqr
24.8	Team23	12.42	0.634	klmnopqr
24.3	Team05	12.53	0.649	lmnopqr

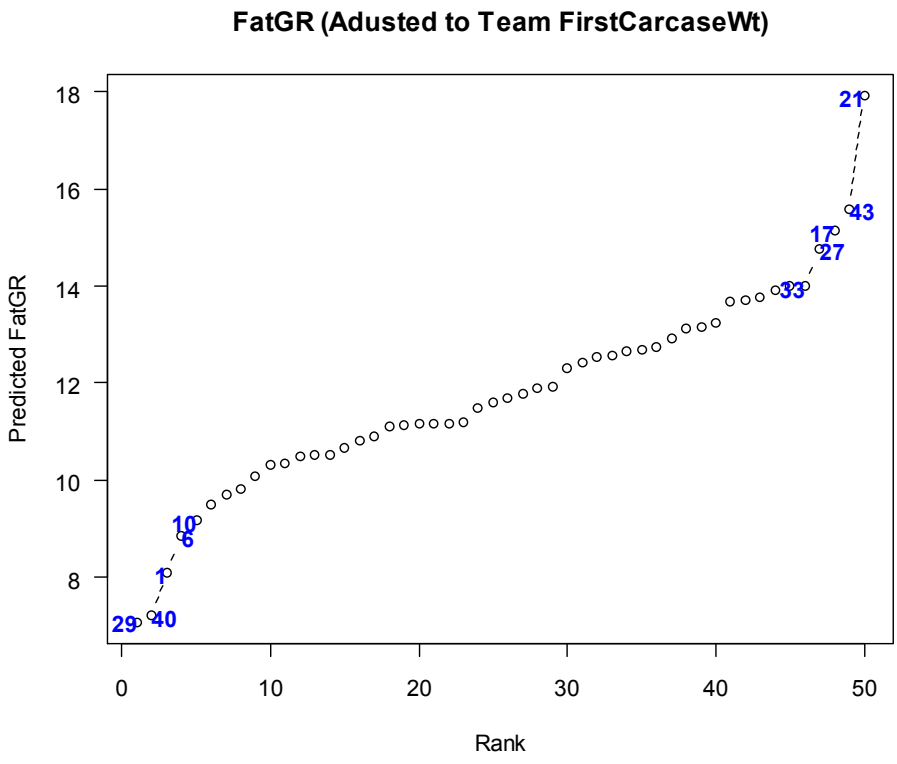
```
24.8 Team20          12.56          0.634           lmnopqr
23.7 Team44          12.66          0.634            mnopqr
25.8 Team14          12.69          0.666            mnopqr
21.9 Team47          12.73          0.634             nopqr
24.3 Team45          12.90          0.634              opqr
25.9 Team39          13.12          0.650               pqrs
26.1 Team46          13.16          0.635               pqrs
23.9 Team50          13.24          0.649               pqrs
25.4 Team26          13.67          0.650                qrst
25.7 Team30          13.71          0.635                qrst
24.9 Team38          13.78          0.634                 rst
25.4 Team28          13.91          0.650                 rstu
25.9 Team16          13.99          0.650                 rstu
27.8 Team33          14.00          0.636                 rstu
23.2 Team27          14.75          0.634                  stu
26.7 Team17          15.14          0.635                   tu
28.3 Team43          15.58          0.637                    u
30.2 Team21          17.92          0.655                     v
```

95% confident Team with largest mean FatGR is one of the following:

```
Team21
  17.9
```

95% confident Team with smallest mean FatGR is one of the following:

```
Team29 Team40 Team01
  7.08   7.20   8.08
```



FatC:

Note: a slightly improved analysis of this trait is achieved by first square-rooting the response. But as the conclusion only differ slightly between analysis on the original or square-root scale, the analysis reported below is on the original scale (for simplicity of reporting and interpretation).

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	47.1	2263.000	1.140		0.291
Pen	4	660.9	0.249	0.411	A	0.801
KillDate	1	661.4	176.200	179.800	A	0.000
FirstCarcaseWt	1	295.0	117.300	117.300	A	0.000

Variance Components:

	component	std.error	z.ratio
Team!Team.var	0.314	0.114	2.75
R!variance	3.379	0.186	18.15

Summary of fixed effects:

	solution	std error	z ratio
FirstCarcaseWt	0.247	0.0228	10.832
KillDate_23/08/2010	0.000	NA	NA
KillDate_25/08/2010	-1.845	0.1376	-13.408
Pen_Pen1	0.000	NA	NA
Pen_Pen2	0.115	0.2180	0.528
Pen_Pen3	0.237	0.2185	1.085
Pen_Pen4	0.183	0.2175	0.844
Pen_Pen5	0.232	0.2176	1.067
(Intercept)	0.112	0.5560	0.201

Predicted Means

FirstCarcaseWt	Team	predicted.value	standard.error	LSD.Rank
17.3	Team40	3.30	0.376	a
18.7	Team29	3.72	0.367	ab
16.7	Team01	3.72	0.377	ab
20.5	Team06	4.02	0.373	abc
17.6	Team34	4.03	0.376	abcd
20.9	Team13	4.25	0.365	abcde
20.2	Team08	4.28	0.381	abcdef
19.1	Team22	4.42	0.374	bcdefg
21.1	Team10	4.46	0.365	bcdefgh
22.2	Team18	4.49	0.365	bcdefgh
23.9	Team35	4.52	0.365	bcdefghi
19.7	Team49	4.55	0.366	bcdefghi
20.8	Team09	4.62	0.381	bcdefghij
21.2	Team37	4.67	0.365	bcdefghij
23.5	Team11	4.67	0.365	bcdefghijk
21.4	Team31	4.67	0.380	bcdefghijk
24.8	Team23	4.73	0.365	bcdefghijk
20.1	Team04	4.79	0.373	cdefghijkl
25.9	Team16	4.79	0.373	cdefghijkl
22.5	Team03	4.80	0.365	cdefghijkl
21.7	Team25	4.83	0.380	cdefghijklm
22.9	Team42	4.84	0.372	cdefghijklm
22.1	Team48	4.86	0.380	cdefghijklmn
23.8	Team36	4.90	0.372	cdefghijklmn
22.9	Team07	4.95	0.365	cdefghijklmn
21.6	Team12	4.97	0.372	cdefghijklmn
20.6	Team41	4.99	0.381	cdefghijklmn
22.5	Team15	5.08	0.380	defghijklmno
24.8	Team20	5.11	0.365	efghijklmno
27.8	Team33	5.12	0.368	efghijklmno
22.3	Team24	5.13	0.365	efghijklmno
23.9	Team50	5.14	0.372	efghijklmno
25.7	Team30	5.25	0.366	efghijklmno
22.1	Team32	5.27	0.372	efghijklmno
23.6	Team02	5.31	0.372	fghijklmno
22.4	Team19	5.38	0.365	ghijklmno

```
21.9 Team47          5.39         0.365       ghijklmno
23.7 Team44          5.43         0.365       ghijklmnop
25.8 Team14          5.45         0.381       ghijklmnop
25.9 Team39          5.47         0.373       ghijklmnop
26.1 Team46          5.48         0.366        hijklmnop
25.4 Team26          5.55         0.373         ijklmnop
24.3 Team05          5.60         0.372          jklmnop
23.2 Team27          5.69         0.365           klmnop
24.3 Team45          5.80         0.365            lmnop
24.9 Team38          5.87         0.365             mnop
25.4 Team28          5.91         0.373              nopq
28.3 Team43          6.06         0.368               opq
30.2 Team21          6.46         0.379                pq
26.7 Team17          6.91         0.367                 q
```

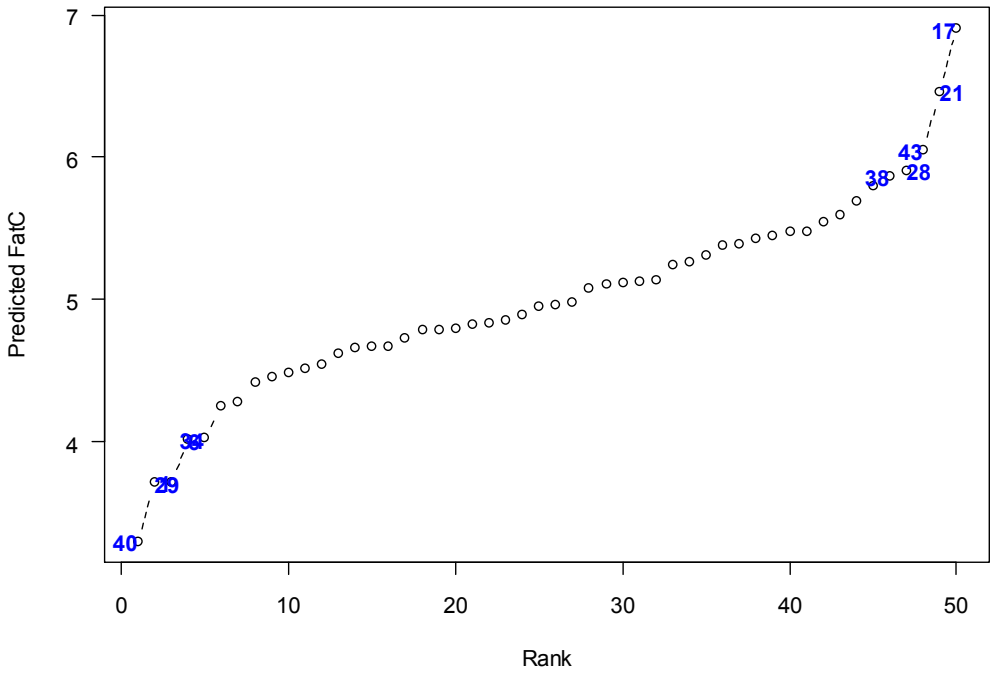
95% confident Team with largest mean FatC is one of the following:

```
Team17 Team21 Team43
  6.91   6.46   6.06
```

95% confident Team with smallest mean FatC is one of the following:

```
Team40 Team29 Team01 Team06 Team34
  3.30   3.72   3.72   4.02   4.03
```

FatC (Adusted to Team FirstCarcaseWt)



EMD:

ANOVA:

```
               Df denDF    F.inc   F.con Margin     Pr
(Intercept)     1  47.2 5.22e+04 761.600        0.0000
Pen             4 662.5 7.31e-01   0.587      A 0.6721
KillDate        1 663.3 1.47e+01  13.700      A 0.0002
FirstCarcaseWt  1 187.9 1.38e+02 137.500      A 0.0000
```

Variance Components:

	component	std.error	z.ratio
Team!Team.var	0.212	0.151	1.41
R!variance	7.277	0.401	18.16

Summary of fixed effects:

	solution	std error	z ratio
FirstCarcaseWt	0.3530	0.0301	11.7239
KillDate_23/08/2010	0.0000	NA	NA
KillDate_25/08/2010	0.7471	0.2018	3.7011
Pen_Pen1	0.0000	NA	NA
Pen_Pen2	0.0976	0.3197	0.3052
Pen_Pen3	-0.3456	0.3205	-1.0785
Pen_Pen4	-0.0196	0.3190	-0.0615
Pen_Pen5	0.0381	0.3192	0.1194
(Intercept)	19.0236	0.7388	25.7480

Predicted Means

FirstCarcaseWt	Team	predicted.value	standard.error	LSD.Rank
17.3	Team40	25.3	0.415	a
16.7	Team01	25.5	0.419	ab
17.6	Team34	25.7	0.414	abc
20.2	Team08	26.0	0.406	abcd
19.1	Team22	26.1	0.406	abcde
18.7	Team29	26.2	0.403	abcde
20.5	Team06	26.2	0.401	abcde
20.1	Team04	26.3	0.402	abcdef
19.7	Team49	26.5	0.399	bcdefg
20.8	Team09	26.6	0.405	bcdefgh
22.4	Team19	26.7	0.393	cdefghi
20.6	Team41	26.8	0.405	defghij
20.9	Team13	26.9	0.396	defghij
21.7	Team25	26.9	0.403	defghijk
22.1	Team48	26.9	0.402	defghijk
21.6	Team12	27.0	0.399	defghijkl
21.1	Team10	27.1	0.395	defghijklm
21.9	Team47	27.1	0.394	defghijklm
22.2	Team18	27.1	0.394	defghijklm
21.2	Team37	27.1	0.395	efghijklm
22.5	Team03	27.2	0.393	efghijklm
21.4	Team31	27.2	0.403	efghijklm
22.1	Team32	27.3	0.398	fghijklmn
22.5	Team15	27.3	0.402	fghijklmn
22.9	Team42	27.4	0.398	fghijklmn
22.3	Team24	27.4	0.394	fghijklmno
24.3	Team45	27.5	0.394	ghijklmno
23.2	Team27	27.5	0.393	ghijklmno
22.9	Team07	27.6	0.393	hijklmnop
23.5	Team11	27.7	0.394	ijklmnopq
23.8	Team36	27.7	0.398	ijklmnopq
23.9	Team35	27.8	0.394	jklmnopq
24.3	Team05	27.9	0.399	jklmnopq
23.7	Team44	27.9	0.394	jklmnopq
23.6	Team02	28.0	0.398	klmnopq
24.8	Team23	28.0	0.395	lmnopq
24.8	Team20	28.1	0.395	mnopq
25.4	Team28	28.1	0.401	mnopqr
24.9	Team38	28.1	0.396	mnopqr
23.9	Team50	28.1	0.398	mnopqr
25.7	Team30	28.3	0.398	nopqrs
25.9	Team16	28.4	0.403	nopqrs
26.7	Team17	28.5	0.401	opqrs
25.9	Team39	28.6	0.403	pqrs
25.4	Team26	28.7	0.401	qrs
26.1	Team46	28.7	0.399	qrs
25.8	Team14	28.8	0.407	qrs

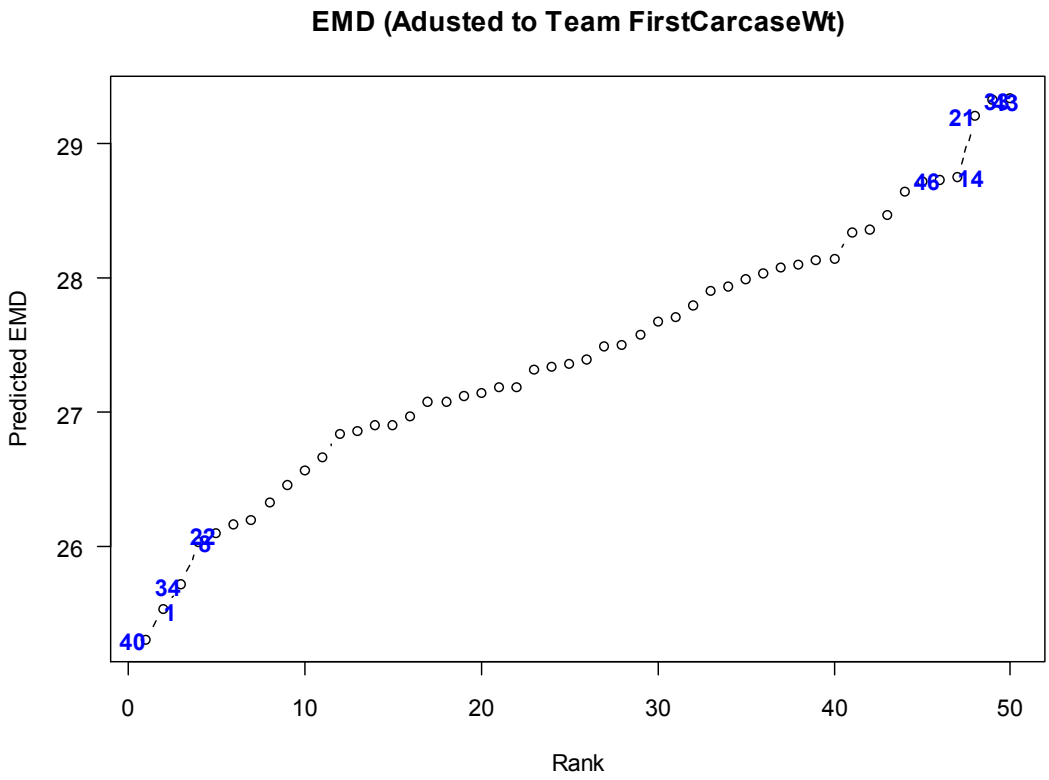
```
          30.2 Team21           29.2          0.427                  rs
          28.3 Team43           29.3          0.409                   s
          27.8 Team33           29.3          0.406                   s
```

95% confident Team with largest mean EMD is one of the following:

```
Team33 Team43 Team21 Team14 Team46 Team26
  29.3   29.3   29.2   28.8   28.7   28.7
```

95% confident Team with smallest mean EMD is one of the following:

```
Team40 Team01 Team34 Team08 Team22
  25.3   25.5   25.7   26.0   26.1
```



EMA:

ANOVA:

```
               Df denDF    F.inc  F.con Margin     Pr
(Intercept)     1  47.6 28470.00 261.10        0.0000
Pen             4 662.2     1.48   1.28      A 0.2772
KillDate        1 662.9    13.30  12.10      A 0.0005
FirstCarcaseWt  1 223.2   207.60 207.60      A 0.0000
```

Variance Components:

```
              component std.error z.ratio
Team!Team.var     0.135    0.0678    2.00
```

```
R!variance        2.737    0.1507   18.16
```

Summary of fixed effects:

```
                    solution std error z ratio
FirstCarcaseWt        0.2777    0.0193  14.408
KillDate_23/08/2010   0.0000        NA      NA
KillDate_25/08/2010   0.4307    0.1238   3.479
Pen_Pen1              0.0000        NA      NA
Pen_Pen2              0.1717    0.1961   0.875
Pen_Pen3             -0.2413    0.1966  -1.227
Pen_Pen4              0.0782    0.1957   0.400
Pen_Pen5             -0.0722    0.1958  -0.369
(Intercept)           7.0680    0.4715  14.989
```

Predicted Means

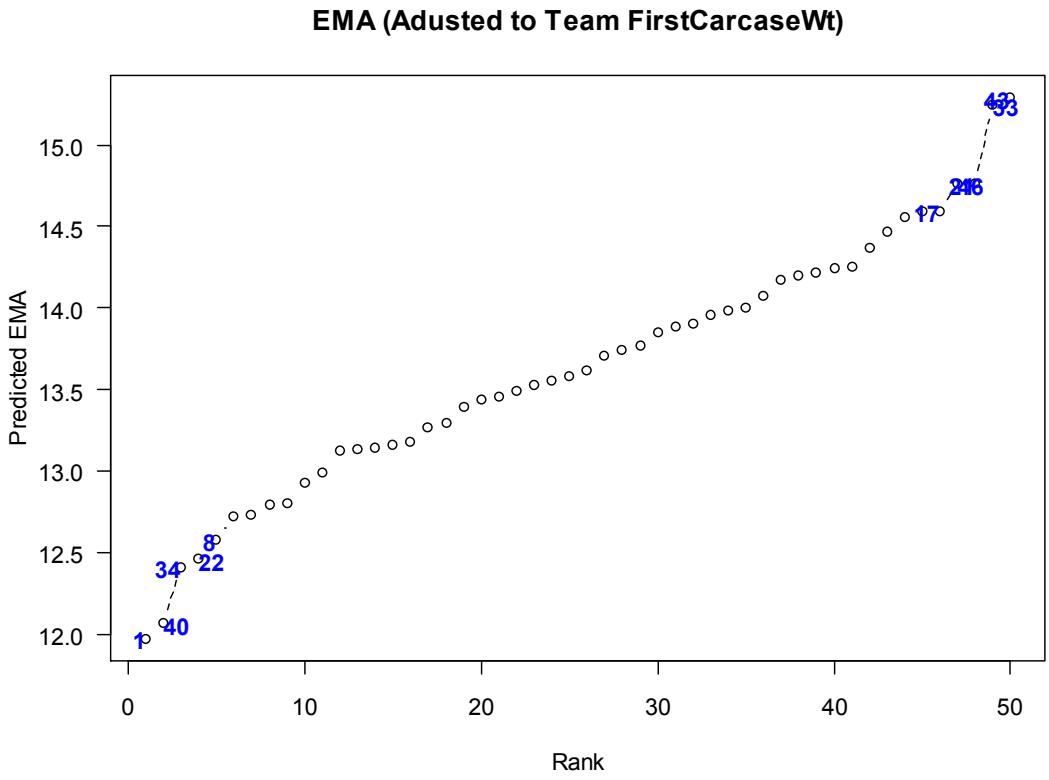
FirstCarcaseWt	Team	predicted.value	standard.error	LSD.Rank
16.7	Team01	12.0	0.295	a
17.3	Team40	12.1	0.294	ab
17.6	Team34	12.4	0.293	abc
19.1	Team22	12.5	0.290	abc
20.2	Team08	12.6	0.293	abcd
20.1	Team04	12.7	0.288	abcde
20.5	Team06	12.7	0.288	abcde
19.7	Team49	12.8	0.285	bcdef
18.7	Team29	12.8	0.286	bcdef
22.4	Team19	12.9	0.283	cdefg
20.8	Team09	13.0	0.292	cdefgh
22.1	Team48	13.1	0.291	cdefghi
21.7	Team25	13.1	0.292	cdefghi
21.6	Team12	13.1	0.287	cdefghi
20.9	Team13	13.2	0.283	cdefghi
21.9	Team47	13.2	0.283	cdefghij
22.2	Team18	13.3	0.283	defghijk
20.6	Team41	13.3	0.292	defghijkl
22.5	Team15	13.4	0.291	efghijklm
21.2	Team37	13.4	0.283	efghijklmn
21.1	Team10	13.5	0.283	efghijklmno
22.5	Team03	13.5	0.283	efghijklmnop
21.4	Team31	13.5	0.292	efghijklmnop
22.3	Team24	13.6	0.283	fghijklmnop
22.9	Team42	13.6	0.287	fghijklmnopq
22.1	Team32	13.6	0.287	ghijklmnopq
24.3	Team45	13.7	0.283	ghijklmnopqr
23.5	Team11	13.7	0.283	hijklmnopqr
23.2	Team27	13.8	0.283	hijklmnopqrs
23.7	Team44	13.9	0.283	ijklmnopqrst
23.8	Team36	13.9	0.287	ijklmnopqrst
22.9	Team07	13.9	0.283	ijklmnopqrst
23.6	Team02	14.0	0.287	jklmnopqrst v
24.8	Team20	14.0	0.283	klmnopqrstu
23.9	Team35	14.0	0.283	klmnopqrstu
24.3	Team05	14.1	0.287	lmnopqrstu
25.4	Team28	14.2	0.288	mnopqrstu
23.9	Team50	14.2	0.287	mnopqrstu
24.9	Team38	14.2	0.283	nopqrstu
24.8	Team23	14.2	0.283	opqrstu
25.7	Team30	14.3	0.284	pqrstu
25.9	Team16	14.4	0.289	qrstu
25.8	Team14	14.5	0.293	rstu w
25.4	Team26	14.6	0.288	stu wx
25.9	Team39	14.6	0.289	tu wx
26.7	Team17	14.6	0.286	tu wx
26.1	Team46	14.8	0.285	u wx
30.2	Team21	14.8	0.298	uvwx
27.8	Team33	15.2	0.288	wx
28.3	Team43	15.3	0.289	x

95% confident Team with largest mean EMA is one of the following:

```
Team43 Team33 Team21 Team46
  15.3   15.2   14.8   14.8
```

95% confident Team with smallest mean EMA is one of the following:

```
Team01 Team40 Team34 Team22
  12.0   12.1   12.4   12.5
```



EMW:

ANOVA:

```
               Df denDF    F.inc    F.con Margin     Pr
(Intercept)     1  48.5 1.19e+05 2802.000        0.0000
Pen             4 662.8 2.01e+00    1.982      A 0.0955
KillDate        1 663.4 1.06e+00    0.812      A 0.3679
FirstCarcaseWt  1 244.0 1.17e+02  116.700      A 0.0000
```

Variance Components:

```
              component std.error z.ratio
Team!Team.var     0.745     0.331    2.25
R!variance       12.461     0.686   18.17
```

Summary of fixed effects:

```
                    solution std error z ratio
FirstCarcaseWt         0.452    0.0419  10.802
KillDate_23/08/2010    0.000        NA      NA
```

```
KillDate_25/08/2010    0.238    0.2642   0.901
Pen_Pen1               0.000        NA      NA
Pen_Pen2               0.632    0.4185   1.511
Pen_Pen3              -0.150    0.4195  -0.357
Pen_Pen4               0.462    0.4175   1.106
Pen_Pen5              -0.352    0.4177  -0.844
(Intercept)           51.372    1.0232  50.209
```

Predicted Means

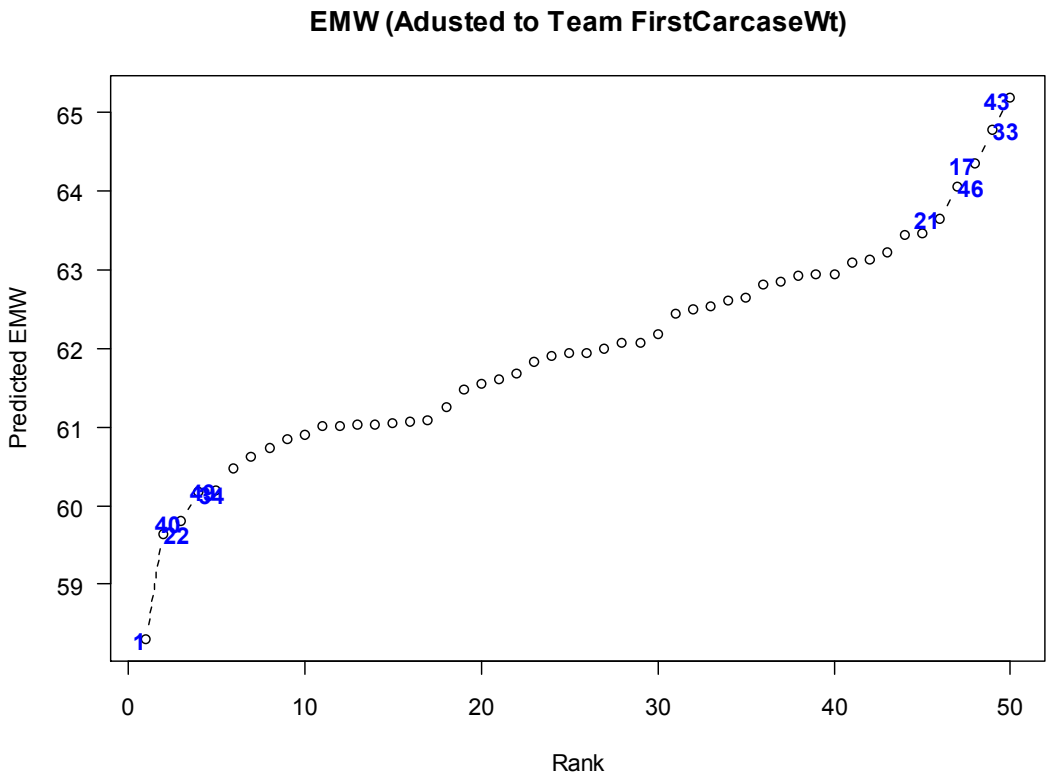
FirstCarcaseWt	Team	predicted.value	standard.error	LSD.Rank
16.7	Team01	58.3	0.660	a
19.1	Team22	59.6	0.650	ab
17.3	Team40	59.8	0.657	abc
17.6	Team34	60.2	0.656	bcd
19.7	Team49	60.2	0.638	bcd
20.1	Team04	60.5	0.647	bcde
21.9	Team47	60.6	0.634	bcde
21.6	Team12	60.7	0.645	bcdef
20.2	Team08	60.8	0.658	bcdefg
22.4	Team19	60.9	0.634	bcdefg
21.7	Team25	61.0	0.656	bcdefgh
18.7	Team29	61.0	0.641	bcdefgh
20.9	Team13	61.0	0.635	bcdefgh
22.1	Team48	61.0	0.656	bcdefghi
20.5	Team06	61.1	0.647	bcdefghi
22.5	Team15	61.1	0.656	bcdefghi
22.2	Team18	61.1	0.634	bcdefghi
20.8	Team09	61.3	0.657	bcdefghij
21.2	Team37	61.5	0.635	cdefghijk
23.7	Team44	61.6	0.634	cdefghijk
22.3	Team24	61.6	0.634	defghijk
20.6	Team41	61.7	0.658	defghijkl
21.1	Team10	61.8	0.635	defghijklm
23.5	Team11	61.9	0.634	defghijklm
23.6	Team02	61.9	0.644	defghijklm
21.4	Team31	61.9	0.656	defghijklm
22.9	Team42	62.0	0.644	efghijklm
22.5	Team03	62.1	0.634	efghijklm
24.8	Team20	62.1	0.635	efghijklm
22.1	Team32	62.2	0.645	efghijklm
25.8	Team14	62.4	0.659	fghijklmn
23.2	Team27	62.5	0.634	fghijklmn
23.8	Team36	62.5	0.645	ghijklmn
24.3	Team45	62.6	0.635	ghijklmno
23.9	Team50	62.6	0.645	ghijklmno
25.4	Team26	62.8	0.647	hijklmno
25.7	Team30	62.8	0.637	ijklmno
22.9	Team07	62.9	0.634	jklmno
24.9	Team38	62.9	0.635	jklmno
23.9	Team35	63.0	0.634	jklmno
24.3	Team05	63.1	0.645	klmnop
25.4	Team28	63.1	0.647	klmnop
25.9	Team16	63.2	0.648	klmnop
25.9	Team39	63.4	0.648	lmnopq
24.8	Team23	63.5	0.635	lmnopq
30.2	Team21	63.6	0.665	mnopq
26.1	Team46	64.1	0.638	nopq
26.7	Team17	64.3	0.639	opq
27.8	Team33	64.8	0.643	pq
28.3	Team43	65.2	0.645	q

95% confident Team with largest mean EMW is one of the following:

```
Team43 Team33 Team17 Team46
  65.2   64.8   64.3   64.1
```

95% confident Team with smallest mean EMW is one of the following:

```
Team01 Team22 Team40
  58.3   59.6   59.8
```



BodyLength: ***(Here FirstCarcaseWt included as a co-variate)***

ANOVA:

```
                Df denDF    F.inc   F.con Margin    Pr
(Intercept)      1  48.1 2.20e+05 3908.00        0.000
Pen              4 661.5 1.16e+00    1.01      A 0.403
KillDate         1 662.8 5.48e+01   58.18      A 0.000
FirstCarcaseWt   1 189.6 3.27e+02  327.30      A 0.000
```

Variance Components:

```
               component std.error z.ratio
Team!Team.var      0.190     0.137    1.39
R!variance         6.721     0.370   18.14
```

Summary of fixed effects:

```
                    solution std error z ratio
FirstCarcaseWt        0.5240    0.0290 18.0925
KillDate_23/08/2010   0.0000        NA      NA
KillDate_25/08/2010  -1.4819    0.1943 -7.6276
Pen_Pen1              0.0000        NA      NA
```

```
Pen_Pen2             -0.5073    0.3084 -1.6449
Pen_Pen3             -0.1947    0.3080 -0.6321
Pen_Pen4             -0.0634    0.3065 -0.2069
Pen_Pen5              0.0281    0.3067  0.0917
(Intercept)          42.8920    0.7104 60.3814
```

Predicted Means

FirstCarcaseWt	Team	predicted.value	standard.error	LSD.Rank
16.7	Team01	50.6	0.400	a
17.6	Team34	51.2	0.394	ab
17.3	Team40	51.3	0.396	ab
18.7	Team29	51.7	0.384	bc
19.1	Team22	51.7	0.386	bc
19.7	Team49	52.0	0.380	bcd
20.1	Team04	52.4	0.387	cde
20.2	Team08	52.6	0.386	cdef
20.9	Team13	52.8	0.377	defg
20.8	Team09	52.9	0.385	defgh
20.5	Team06	52.9	0.382	defgh
20.6	Team41	52.9	0.385	defgh
21.1	Team10	53.0	0.376	efghi
21.9	Team47	53.1	0.375	efghi
21.4	Team31	53.2	0.384	efghij
21.2	Team37	53.2	0.376	efghij
22.1	Team48	53.4	0.383	efghijk
22.5	Team15	53.4	0.383	efghijk
22.1	Team32	53.5	0.379	efghijk
21.6	Team12	53.6	0.379	fghijkl
21.7	Team25	53.6	0.383	fghijkl
22.4	Team19	53.6	0.374	fghijkl
22.5	Team03	53.8	0.374	ghijklm
23.2	Team27	53.8	0.374	ghijklm
22.9	Team42	53.9	0.378	hijklm
22.9	Team07	54.0	0.374	ijklmn
22.2	Team18	54.1	0.375	jklmno
23.7	Team44	54.2	0.375	jklmnop
22.3	Team24	54.2	0.374	jklmnop
23.5	Team11	54.3	0.374	klmnopq
23.6	Team02	54.4	0.378	klmnopqr
23.8	Team36	54.5	0.379	lmnopqrs
23.9	Team35	54.7	0.375	mnopqrst
23.9	Team50	54.7	0.379	mnopqrst
24.3	Team45	54.7	0.375	mnopqrst
24.3	Team05	55.0	0.379	nopqrst
24.8	Team20	55.1	0.376	opqrst
24.8	Team23	55.1	0.376	opqrst
25.4	Team28	55.2	0.382	opqrst
25.9	Team39	55.2	0.388	pqrst
26.1	Team46	55.3	0.380	qrst
25.9	Team16	55.3	0.383	qrst
24.9	Team38	55.4	0.376	rst
25.8	Team14	55.5	0.387	st
26.7	Team17	55.7	0.382	t
25.4	Team26	55.7	0.382	t
25.7	Team30	55.7	0.379	t
27.8	Team33	56.8	0.387	u
28.3	Team43	56.9	0.390	u
30.2	Team21	58.2	0.407	v

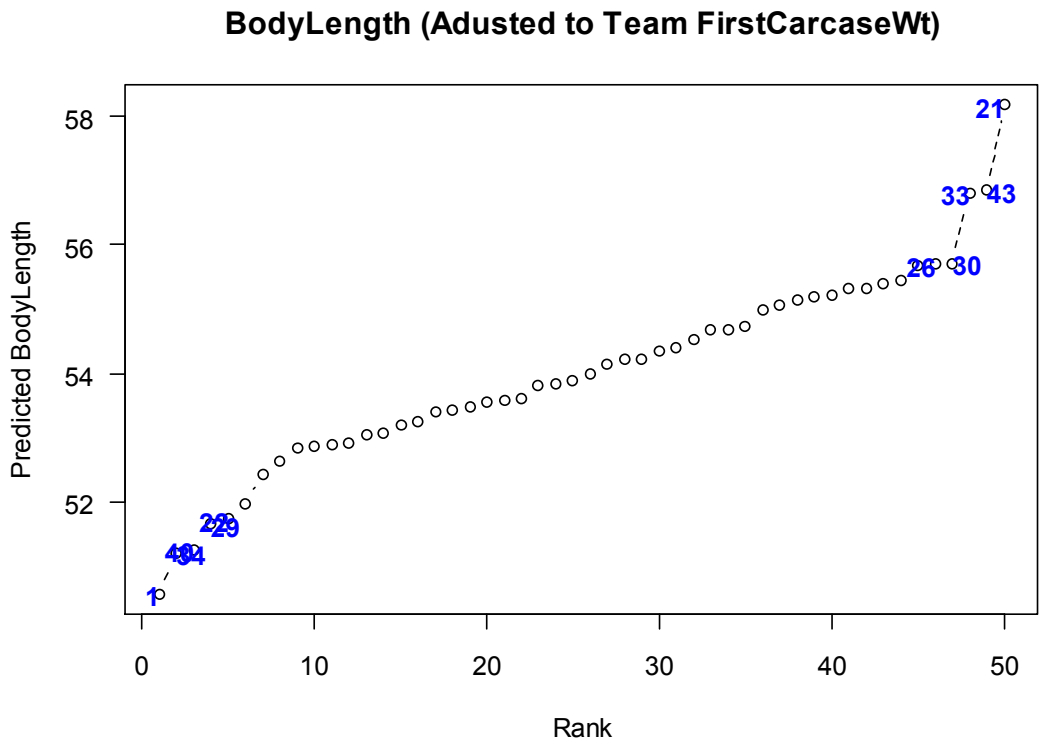
95% confident Team with largest mean BodyLength is one of the following:

```
Team21
  58.2
```

95% confident Team with smallest mean BodyLength is one of the following:

```
Team01 Team34 Team40
```

```
  50.6   51.2   51.3
```



DP (Dressing Percent):

Note: Traits with DP = 0 set to missing/

ANOVA:

```
            Df denDF    F.inc    F.con Margin    Pr
(Intercept)  1  48.9 6.73e+04 6.73e+04        0.000
Pen          4 661.8 7.87e-01 7.90e-01      A 0.532
KillDate     1 661.9 2.03e-01 2.03e-01      A 0.652
```

Variance Components:

```
              component std.error z.ratio
Team!Team.var      1.21     0.297    4.08
R!variance         3.64     0.200   18.18
```

Summary of fixed effects:

```
                    solution std error z ratio
KillDate_23/08/2010   0.0000        NA      NA
KillDate_25/08/2010   0.0644     0.143   0.451
Pen_Pen1              0.0000        NA      NA
Pen_Pen2              0.1366     0.226   0.604
Pen_Pen3             -0.1756     0.227  -0.774
Pen_Pen4              0.0649     0.226   0.288
Pen_Pen5              0.1913     0.226   0.847
(Intercept)          44.3162     0.234 189.430
```

Predicted Means

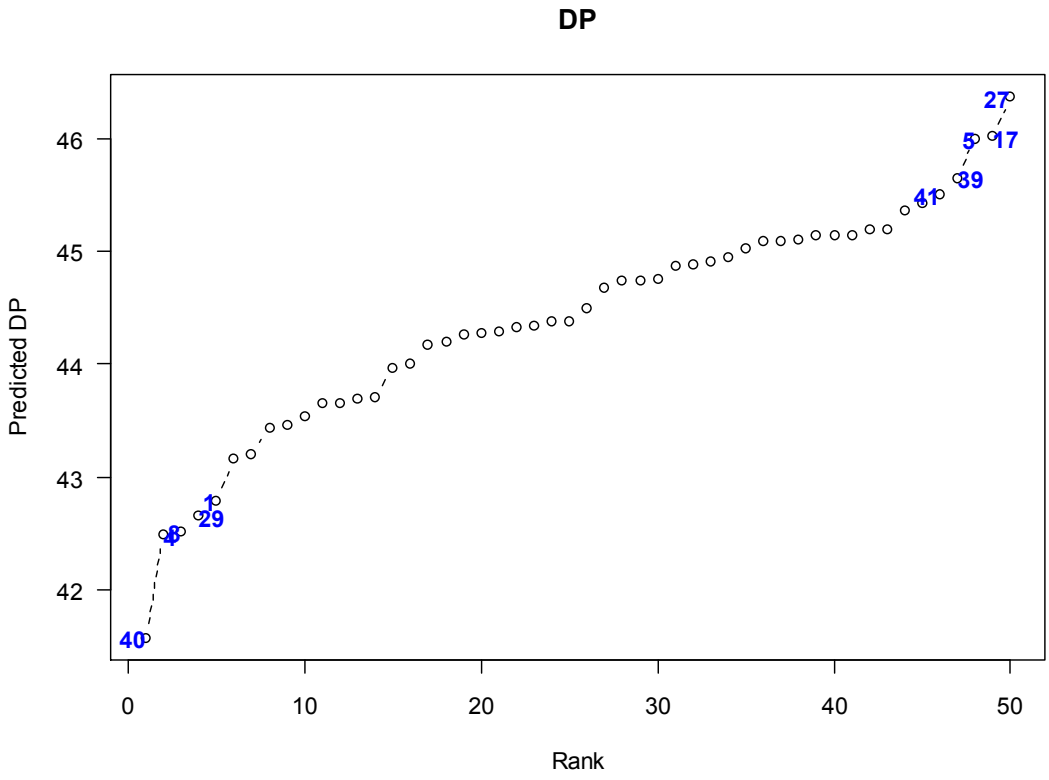
Team	predicted.value	standard.error	LSD.Rank
Team40	41.6	0.464	a
Team04	42.5	0.464	ab
Team08	42.5	0.478	ab
Team29	42.7	0.450	ab
Team01	42.8	0.464	abc
Team34	43.2	0.464	bcd
Team12	43.2	0.464	bcd
Team09	43.4	0.478	bcde
Team37	43.5	0.450	bcde
Team25	43.5	0.478	bcdef
Team06	43.6	0.464	bcdefg
Team18	43.7	0.450	bcdefg
Team10	43.7	0.450	bcdefgh
Team24	43.7	0.450	bcdefgh
Team11	44.0	0.450	cdefghi
Team23	44.0	0.450	cdefghi
Team22	44.2	0.464	defghij
Team03	44.2	0.450	defghijk
Team38	44.3	0.450	defghijk
Team44	44.3	0.450	defghijk
Team36	44.3	0.464	defghijk
Team07	44.3	0.450	defghijk
Team42	44.3	0.464	defghijkl
Team30	44.4	0.450	defghijkl
Team20	44.4	0.450	defghijkl
Team49	44.5	0.450	efghijkl
Team19	44.7	0.450	efghijkl
Team48	44.7	0.478	efghijklm
Team46	44.7	0.450	fghijklm
Team43	44.8	0.450	fghijklm
Team15	44.9	0.478	fghijklm
Team21	44.9	0.464	ghijklm
Team35	44.9	0.450	ghijklm
Team13	45.0	0.450	hijklm
Team28	45.0	0.464	ijklm
Team32	45.1	0.464	ijklmn
Team31	45.1	0.478	ijklmn
Team16	45.1	0.464	ijklmn
Team02	45.1	0.464	ijklmn
Team50	45.1	0.464	ijklmn
Team33	45.1	0.450	ijklmn
Team45	45.2	0.450	ijklmn
Team26	45.2	0.464	ijklmn
Team47	45.4	0.450	jklmn
Team14	45.4	0.478	jklmn
Team41	45.5	0.478	klmn
Team39	45.6	0.464	lmn
Team05	46.0	0.464	mn
Team17	46.0	0.450	mn
Team27	46.4	0.450	n

95% confident Team with largest mean DP is one of the following:

Team27	Team17	Team05	Team39	Team41	Team14	Team47
46.4	46.0	46.0	45.6	45.5	45.4	45.4

95% confident Team with smallest mean DP is one of the following:

Team40	Team04	Team08	Team29
41.6	42.5	42.5	42.7



StapleLength:

Note: Here the response takes only values 25, 30, 35, …, 55. Given this, it is felt that a normal LMM analysis should be adequate.

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	49.1	10740.00	10740.00		0.0000
Pen	4	679.8	2.02	1.99	A	0.0945
KillDate	1	680.3	1.25	1.25	A	0.2644

Variance Components:

	component	std.error	z.ratio
Team!Team.var	5.54	1.52	3.64
R!variance	29.03	1.58	18.43

Summary of fixed effects:

	solution	std error	z ratio
KillDate_23/08/2010	0.0000	NA	NA
KillDate_25/08/2010	-0.4450	0.398	-1.117
Pen_Pen1	0.0000	NA	NA
Pen_Pen2	0.6872	0.630	1.091
Pen_Pen3	0.0745	0.632	0.118
Pen_Pen4	-0.9241	0.629	-1.469

```
Pen_Pen5             -0.5930     0.629  -0.943
(Intercept)          40.5546     0.588  68.914
```

Predicted Means

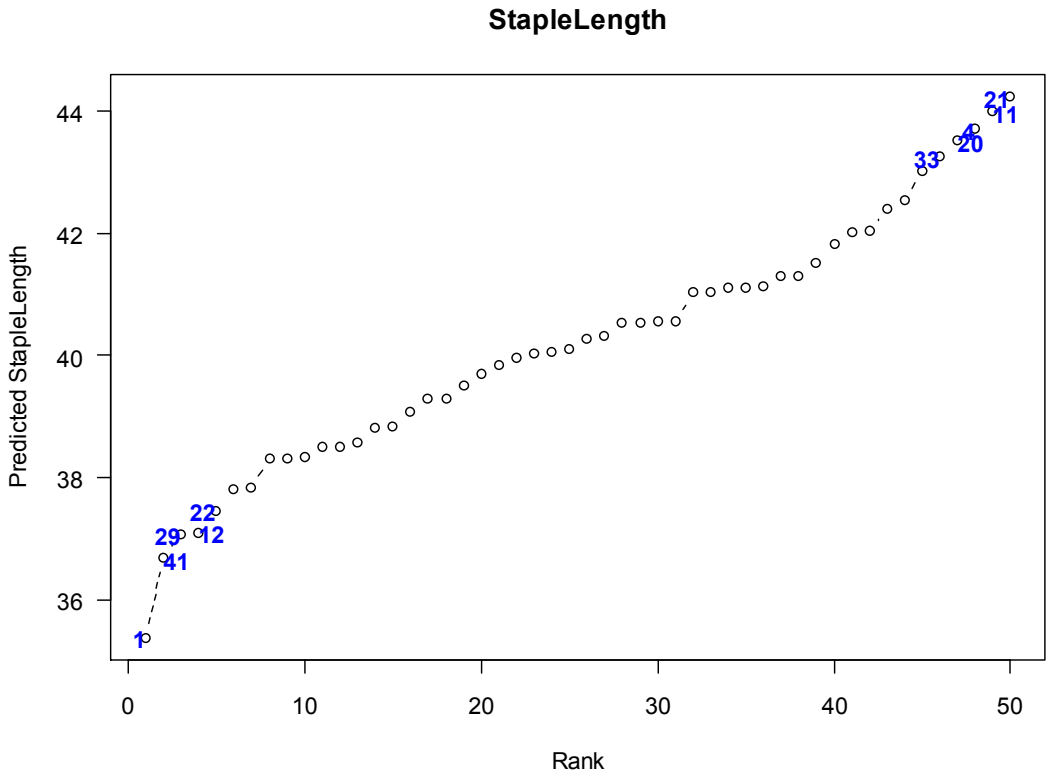
Team	predicted.value	standard.error	LSD.Rank
Team01	35.4	1.17	a
Team41	36.7	1.23	ab
Team29	37.1	1.20	abc
Team12	37.1	1.20	abc
Team22	37.5	1.23	abcd
Team40	37.8	1.20	abcde
Team47	37.8	1.20	abcde
Team13	38.3	1.20	abcdef
Team44	38.3	1.20	abcdef
Team39	38.3	1.20	abcdef
Team15	38.5	1.23	abcdefg
Team28	38.5	1.23	abcdefg
Team37	38.6	1.20	abcdefg
Team06	38.8	1.20	bcdefgh
Team32	38.8	1.20	bcdefgh
Team49	39.1	1.20	bcdefghi
Team38	39.3	1.20	bcdefghij
Team46	39.3	1.20	bcdefghij
Team34	39.5	1.23	bcdefghij
Team31	39.7	1.27	bcdefghijk
Team09	39.8	1.23	bcdefghijkl
Team10	40.0	1.20	bcdefghijkl
Team23	40.0	1.20	bcdefghijkl
Team02	40.1	1.20	bcdefghijkl
Team26	40.1	1.23	bcdefghijklm
Team14	40.3	1.23	cdefghijklmn
Team50	40.3	1.23	cdefghijklmn
Team19	40.5	1.20	defghijklmn
Team27	40.5	1.20	defghijklmn
Team07	40.6	1.20	defghijklmn
Team45	40.6	1.20	defghijklmn
Team17	41.0	1.20	efghijklmno
Team42	41.0	1.20	efghijklmno
Team48	41.1	1.23	efghijklmno
Team05	41.1	1.23	efghijklmno
Team16	41.1	1.23	efghijklmno
Team24	41.3	1.20	fghijklmno
Team35	41.3	1.20	fghijklmno
Team25	41.5	1.20	fghijklmno
Team36	41.8	1.23	ghijklmno
Team03	42.0	1.20	hijklmno
Team30	42.0	1.20	hijklmno
Team08	42.4	1.23	ijklmno
Team43	42.5	1.20	jklmno
Team18	43.0	1.20	klmno
Team33	43.2	1.20	lmno
Team20	43.5	1.20	mno
Team04	43.7	1.23	no
Team11	44.0	1.20	o
Team21	44.2	1.20	o

95% confident Team with largest mean StapleLength is one of the following:

Team21	Team11	Team04	Team20	Team33	Team18	Team43	Team08
44.2	44.0	43.7	43.5	43.2	43.0	42.5	42.4

95% confident Team with smallest mean StapleLength is one of the following:

Team01	Team41	Team29	Team12	Team22	Team40	Team47	Team13	Team44
35.4	36.7	37.1	37.1	37.5	37.8	37.8	38.3	38.3



For traits L, a, b

Model: Y = baseline + Pen + KillDate + pH + ***Team + error***

L:

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	48.5	2.64e+05	340.60		0.0000
Pen	4	670.1	1.87e+00	1.67	A	0.1556
KillDate	1	672.9	1.11e+01	5.48	A	0.0195
pH	1	716.8	2.85e+01	28.49	A	0.0000

Variance Components:

	component	std.error	z.ratio
Team!Team.var	0.101	0.0528	1.92
R!variance	2.248	0.1230	18.27

Summary of fixed effects:

	solution	std error	z ratio
pH	-2.8611	0.536	-5.34
KillDate_23/08/2010	0.0000	NA	NA
KillDate_25/08/2010	0.2653	0.113	2.34
Pen_Pen1	0.0000	NA	NA
Pen_Pen2	0.1908	0.176	1.08
Pen_Pen3	-0.1807	0.177	-1.02
Pen_Pen4	-0.2073	0.176	-1.18
Pen_Pen5	-0.0885	0.177	-0.50
(Intercept)	52.6411	2.996	17.57

Predicted Means

pH	Team	predicted.value	standard.error	LSD.Rank
5.70	Team23	36.2	0.253	a
5.57	Team16	36.4	0.253	ab
5.53	Team41	36.4	0.257	abc
5.57	Team38	36.4	0.249	abc
5.58	Team43	36.5	0.249	abcd
5.55	Team28	36.5	0.253	abcd
5.63	Team33	36.5	0.250	abcd
5.60	Team45	36.5	0.250	abcd
5.63	Team37	36.5	0.250	abcd
5.54	Team05	36.6	0.253	abcd
5.59	Team27	36.6	0.249	abcd
5.54	Team26	36.6	0.253	abcd
5.60	Team02	36.6	0.253	abcde
5.57	Team10	36.6	0.249	abcde
5.59	Team35	36.6	0.249	abcde
5.55	Team31	36.7	0.257	abcde
5.56	Team47	36.7	0.249	abcde
5.59	Team15	36.7	0.253	abcde
5.57	Team30	36.7	0.249	abcde
5.61	Team17	36.7	0.250	abcde
5.63	Team29	36.7	0.250	abcde
5.58	Team32	36.7	0.253	abcde
5.56	Team39	36.7	0.253	abcde
5.55	Team22	36.7	0.253	abcde
5.58	Team42	36.7	0.253	abcde
5.60	Team36	36.8	0.253	abcde
5.55	Team20	36.8	0.250	abcde
5.59	Team50	36.8	0.253	abcde
5.59	Team19	36.8	0.249	abcde
5.56	Team25	36.8	0.253	abcde
5.55	Team09	36.8	0.257	abcde
5.59	Team11	36.8	0.250	abcde
5.60	Team18	36.9	0.250	abcde
5.49	Team21	36.9	0.251	abcde
5.59	Team14	36.9	0.257	bcde
5.59	Team24	36.9	0.249	bcde
5.58	Team13	36.9	0.249	bcde
5.53	Team40	36.9	0.250	bcde
5.56	Team03	37.0	0.249	bcde
5.56	Team07	37.0	0.249	bcde
5.54	Team46	37.0	0.250	bcde
5.57	Team08	37.0	0.253	bcde
5.55	Team44	37.0	0.249	bcde
5.56	Team48	37.0	0.257	bcde
5.52	Team06	37.1	0.250	bcde
5.54	Team04	37.1	0.253	bcde
5.54	Team49	37.1	0.250	bcde
5.55	Team01	37.1	0.250	cde
5.57	Team34	37.2	0.253	de
5.53	Team12	37.3	0.250	e

95% confident Team with largest mean L is one of the following:

Team12	Team34	Team01	Team49	Team04	Team06	Team48	Team44	Team08	Team46
37.3	37.2	37.1	37.1	37.1	37.1	37.0	37.0	37.0	37.0

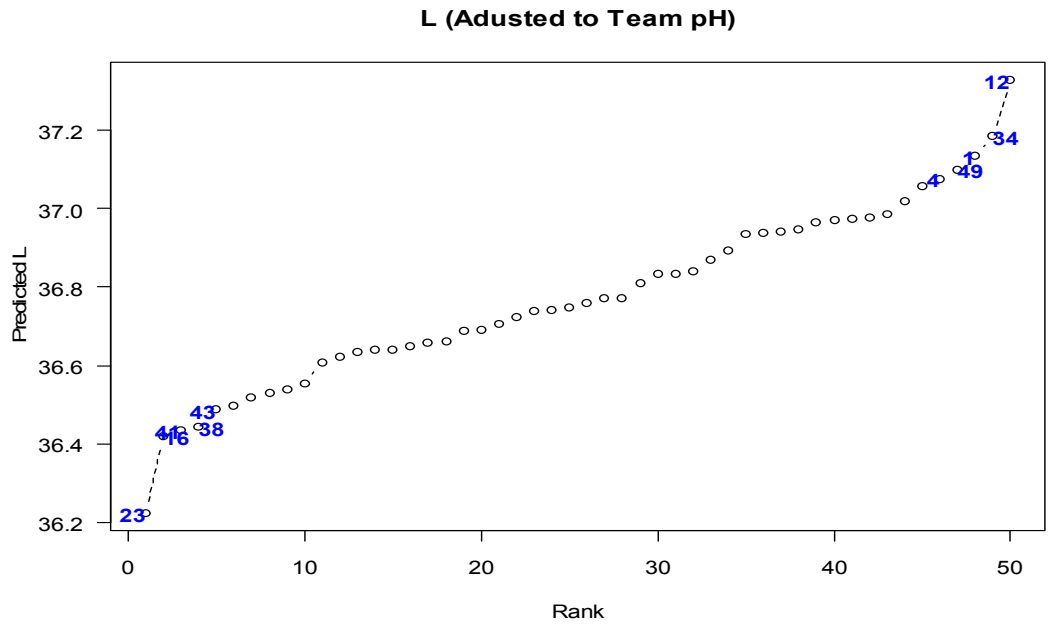
Team07	Team03	Team40	Team13	Team24	Team14	Team21	Team18	Team11
37.0	37.0	36.9	36.9	36.9	36.9	36.9	36.9	36.8

95% confident Team with smallest mean L is one of the following:

Team23	Team16	Team41	Team38	Team43	Team28	Team33	Team45	Team37	Team05
36.2	36.4	36.4	36.4	36.5	36.5	36.5	36.5	36.5	36.6

Team27	Team26	Team02	Team10	Team35	Team31	Team47	Team15	Team30	Team17

```
  36.6   36.6   36.6   36.6   36.6   36.7   36.7   36.7   36.7   36.7

Team29
  36.7
```



a:

ANOVA:

```
            Df denDF    F.inc  F.con Margin    Pr
(Intercept)  1    49 1.51e+05 357.70        0.000
Pen          4   670 8.69e-01   0.96      A 0.429
KillDate     1   672 7.92e+01 110.60      A 0.000
pH           1   714 9.98e+01  99.76      A 0.000
```

Variance Components:

```
              component std.error z.ratio
Team!Team.var      0.08     0.031    2.59
R!variance         1.04     0.057   18.28
```

Summary of fixed effects:

```
                    solution std error z ratio
pH                   -3.6696    0.3674  -9.988
KillDate_23/08/2010   0.0000        NA      NA
KillDate_25/08/2010  -0.8115    0.0771 -10.518
Pen_Pen1              0.0000        NA      NA
Pen_Pen2              0.0149    0.1201   0.124
Pen_Pen3              0.1103    0.1205   0.915
Pen_Pen4             -0.1094    0.1198  -0.913
Pen_Pen5             -0.0608    0.1205  -0.504
(Intercept)          42.2963    2.0538  20.594
```

Predicted Means

```
   pH   Team predicted.value standard.error      LSD.Rank
 5.59 Team24            20.9          0.195 a
 5.60 Team45            21.0          0.195 ab
```

```
 5.63 Team29            21.1          0.195 ab
 5.59 Team35            21.1          0.195 abc
 5.63 Team37            21.1          0.195 abc
 5.70 Team23            21.1          0.196 abcd
 5.59 Team14            21.1          0.202 abcde
 5.57 Team34            21.2          0.198 abcdef
 5.57 Team08            21.2          0.198 abcdefg
 5.63 Team33            21.2          0.195 abcdefgh
 5.54 Team04            21.2          0.198 abcdefghi
 5.59 Team19            21.2          0.195 abcdefghij
 5.55 Team01            21.2          0.195 abcdefghij
 5.59 Team11            21.3          0.195 abcdefghijk
 5.57 Team10            21.3          0.195 abcdefghijk
 5.53 Team12            21.3          0.195 abcdefghijk
 5.56 Team48            21.3          0.202 abcdefghijkl
 5.58 Team42            21.3          0.198 abcdefghijkl
 5.61 Team17            21.3          0.195 abcdefghijkl
 5.55 Team31            21.4          0.202 abcdefghijklm
 5.55 Team44            21.4          0.195 abcdefghijklm
 5.58 Team13            21.4          0.195 abcdefghijklm
 5.56 Team03            21.4          0.195 abcdefghijklm
 5.52 Team06            21.4          0.195 abcdefghijklm
 5.60 Team02            21.4          0.198 abcdefghijklm
 5.55 Team09            21.4          0.202 abcdefghijklm
 5.60 Team18            21.5          0.195  bcdefghijklm
 5.54 Team46            21.5          0.195  bcdefghijklm
 5.58 Team43            21.5          0.195  bcdefghijklm
 5.56 Team39            21.5          0.198  bcdefghijklm
 5.54 Team49            21.5          0.195  bcdefghijklm
 5.59 Team15            21.5          0.198  bcdefghijklm
 5.60 Team36            21.5          0.198  bcdefghijklm
 5.56 Team07            21.5          0.195  bcdefghijklm
 5.55 Team22            21.5          0.198  bcdefghijklm
 5.59 Team27            21.5          0.195  bcdefghijklm
 5.59 Team50            21.6          0.198  bcdefghijklm
 5.56 Team25            21.6          0.198   cdefghijklm
 5.53 Team40            21.7          0.195    defghijklm
 5.56 Team47            21.7          0.195     efghijklm
 5.57 Team16            21.7          0.198      fghijklm
 5.58 Team32            21.7          0.198       ghijklm
 5.54 Team05            21.7          0.198       ghijklm
 5.53 Team41            21.7          0.202        hijklm
 5.55 Team28            21.8          0.198         ijklm
 5.57 Team38            21.8          0.195          jklm
 5.54 Team26            21.8          0.198          jklm
 5.55 Team20            21.8          0.195           klm
 5.57 Team30            21.9          0.195            lm
 5.49 Team21            21.9          0.195             m
```

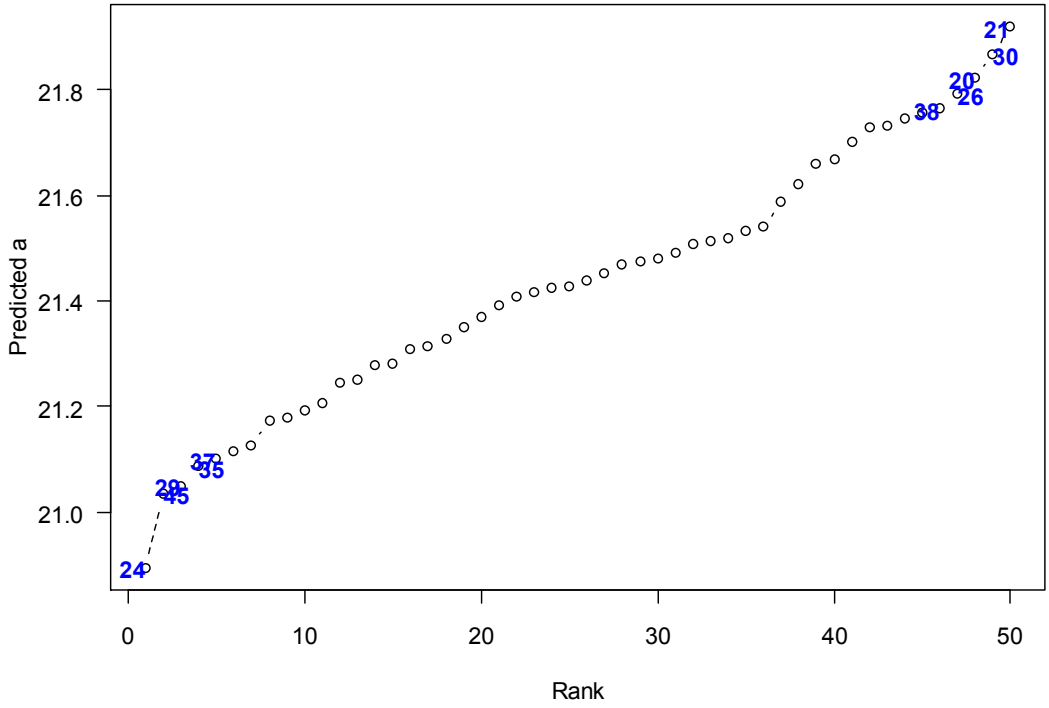
95% confident Team with largest mean a is one of the following:

```
Team21 Team30 Team20 Team26 Team38 Team28 Team41 Team05 Team32 Team16
  21.9   21.9   21.8   21.8   21.8   21.8   21.7   21.7   21.7   21.7

Team47 Team40 Team25
  21.7   21.7   21.6
```

95% confident Team with smallest mean a is one of the following:

```
Team24 Team45 Team29 Team35 Team37 Team23 Team14 Team34 Team08 Team33
  20.9   21.0   21.1   21.1   21.1   21.1   21.1   21.2   21.2   21.2

Team04 Team19 Team01 Team11
  21.2   21.2   21.2   21.3
```

a (Adusted to Team pH)



b:

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	49.1	106.60	90.49		0.0000
Pen	4	671.5	4.35	3.73	A	0.0052
KillDate	1	675.3	61.67	92.00	A	0.0000
pH	1	713.3	115.50	115.50	A	0.0000

Variance Components:

	component	std.error	z.ratio
Team!Team.var	0.0102	0.0123	0.829
R!variance	0.7128	0.0390	18.281

Summary of fixed effects:

	solution	std error	z ratio
pH	-3.2054	0.2983	-10.745
KillDate_23/08/2010	0.0000	NA	NA
KillDate_25/08/2010	-0.6115	0.0638	-9.592
Pen_Pen1	0.0000	NA	NA
Pen_Pen2	0.1312	0.0993	1.320
Pen_Pen3	-0.0533	0.0997	-0.535
Pen_Pen4	-0.2393	0.0990	-2.416
Pen_Pen5	-0.0911	0.0996	-0.914
(Intercept)	18.5743	1.6675	11.139

Predicted Means

pH	Team	predicted.value	standard.error	LSD.Rank
5.70	Team23	-0.0488	0.1006	a
5.63	Team37	0.0939	0.0969	ab
5.63	Team29	0.1199	0.0970	abc
5.63	Team33	0.1357	0.0970	abcd

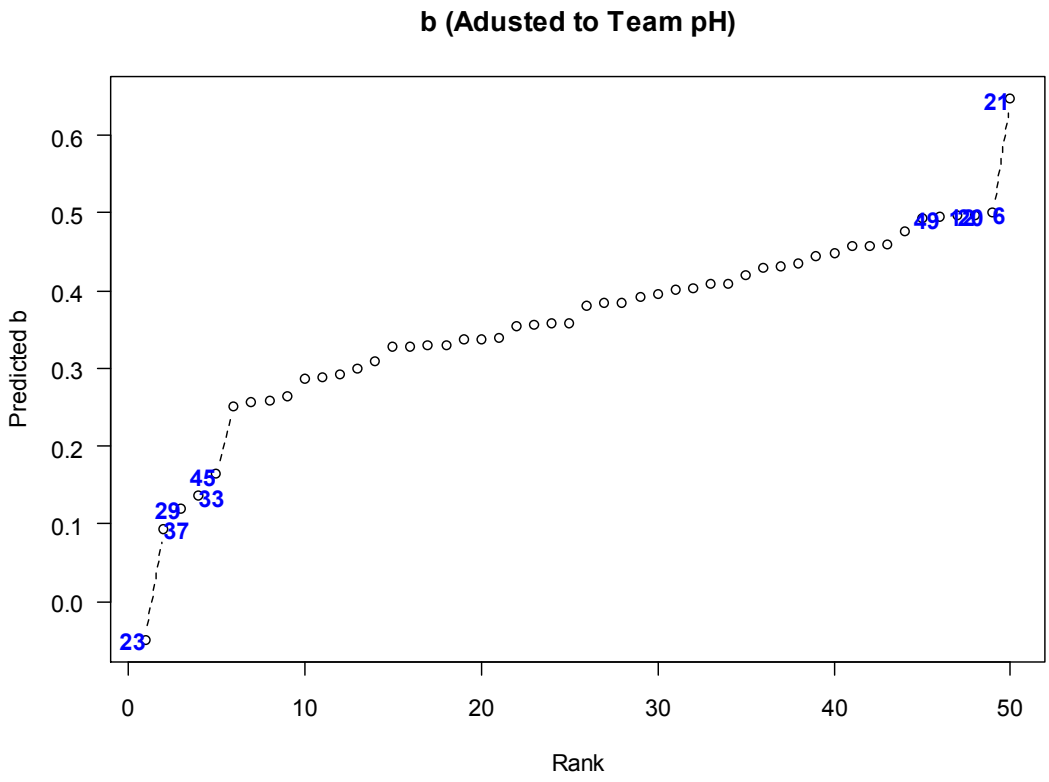
```
 5.60 Team45          0.1644         0.0962  abcde
 5.59 Team24          0.2511         0.0959   bcdef
 5.60 Team02          0.2557         0.0966   bcdef
 5.57 Team10          0.2593         0.0958   bcdef
 5.59 Team35          0.2638         0.0959   bcdef
 5.61 Team17          0.2863         0.0962   bcdef
 5.58 Team43          0.2889         0.0958   bcdef
 5.59 Team14          0.2930         0.0972   bcdef
 5.59 Team11          0.3001         0.0960   bcdef
 5.59 Team27          0.3094         0.0959   bcdef
 5.57 Team16          0.3278         0.0965   bcdef
 5.60 Team36          0.3283         0.0968   bcdef
 5.60 Team18          0.3290         0.0961   bcdef
 5.58 Team42          0.3299         0.0965   bcdef
 5.57 Team38          0.3368         0.0958   bcdef
 5.59 Team15          0.3377         0.0965   bcdef
 5.59 Team19          0.3392         0.0959   bcdef
 5.58 Team13          0.3548         0.0959    cdef
 5.59 Team50          0.3569         0.0966    cdef
 5.55 Team31          0.3574         0.0972    cdef
 5.57 Team34          0.3578         0.0965    cdef
 5.57 Team08          0.3807         0.0965    cdef
 5.58 Team32          0.3838         0.0965     def
 5.55 Team22          0.3843         0.0966     def
 5.55 Team09          0.3925         0.0972     defg
 5.55 Team28          0.3959         0.0966     defg
 5.56 Team03          0.4008         0.0959      efg
 5.56 Team47          0.4039         0.0959      efg
 5.56 Team39          0.4078         0.0965      efg
 5.56 Team48          0.4087         0.0971      efg
 5.55 Team01          0.4195         0.0960      efg
 5.56 Team25          0.4301         0.0965       fg
 5.53 Team41          0.4303         0.0976       fg
 5.55 Team44          0.4352         0.0960       fg
 5.54 Team04          0.4449         0.0969       fg
 5.54 Team05          0.4474         0.0967       fg
 5.57 Team30          0.4574         0.0959       fg
 5.54 Team26          0.4579         0.0968       fg
 5.56 Team07          0.4595         0.0959       fg
 5.53 Team40          0.4767         0.0963       fg
 5.54 Team46          0.4926         0.0962       fg
 5.54 Team49          0.4947         0.0961       fg
 5.55 Team20          0.4974         0.0960       fg
 5.53 Team12          0.4976         0.0963       fg
 5.52 Team06          0.4997         0.0967       fg
 5.49 Team21          0.6469         0.0979        g
```

95% confident Team with largest mean b is one of the following:

```
Team21 Team06 Team12 Team20 Team49 Team46 Team40 Team07 Team26 Team30
 0.647  0.500  0.498  0.497  0.495  0.493  0.477  0.459  0.458  0.457

Team05 Team04 Team44 Team41 Team25 Team01
 0.447  0.445  0.435  0.430  0.430  0.420
```

95% confident Team with smallest mean b is one of the following:

```
 Team23  Team37  Team29  Team33
-0.0488  0.0939  0.1199  0.1357
```



pH:

This trait was log(e) transformed prior to analysis (i.e. Y = $\log_e$(pH)) This transformation seems to be common for analysis of this trait and is aimed at removing (right) skewness in the residuals. Unfortunately here the transformation helped very little but was performed non the less for consistency.

Model:

$\log_e$(pH) = baseline + Pen + KillDate + TimepH + KillDate:TimepH
+ FatGR + FirstCarcaseWt + ***Team + error***

Here TimepH is Time when pH was measured and has been included in attempt to see if some of the skewness in the data can be explained by a linear trend in time of pH measurement.

FatGR is not a significant (p = 0.13) and is removed from the model

The summary of the fitted model is given below. The predicted means are for Teams, averaged over Pen's and KillDate's at TimepH = 12 (midday) and at the average FirstCarcaseWt for that Team.

NOTE: Predicted means and associated standard errors have been re-transformed back to the original scale.

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	47.6	4.582e+06	6.589e+04		0.0000
Pen	4	659.1	8.830e-01	4.671e-01	B	0.7599
KillDate	1	698.9	2.647e+01	1.270e+01	A	0.0004

```
TimepH           1 673.6 2.924e+01 4.978e+01      A 0.0000
FatGR            1 673.2 2.583e+00 2.305e+00      B 0.1294
FirstCarcaseWt   1 318.7 2.026e+01 1.966e+01      B 0.0000
KillDate:TimepH  1 703.4 3.026e+01 3.026e+01      B 0.0000
```

Variance Components:

```
              component std.error z.ratio
Team!Team.var 1.104e-05 6.696e-06   1.649
R!variance    3.018e-04 1.667e-05  18.101
```

Summary of fixed effects:

```
                             solution std error  z ratio
KillDate_23/08/2010:TimepH  0.0000000        NA       NA
KillDate_25/08/2010:TimepH -0.0060036 0.0010915  -5.5005
FirstCarcaseWt             -0.0012623 0.0002847  -4.4341
FatGR                       0.0003252 0.0002142   1.5183
TimepH                      0.0074436 0.0008321   8.9455
KillDate_23/08/2010         0.0000000        NA       NA
KillDate_25/08/2010         0.0774955 0.0126822   6.1106
Pen_Pen1                    0.0000000        NA       NA
Pen_Pen2                    0.0004457 0.0020596   0.2164
Pen_Pen3                    0.0024591 0.0020686   1.1888
Pen_Pen4                    0.0016129 0.0020642   0.7814
Pen_Pen5                    0.0016848 0.0020634   0.8165
(Intercept)                 1.6467926 0.0102931 159.9901
```

Predicted Means

TimepH	FirstCarcaseWt	Team	predicted.value	standard.error	LSD.Rank
12	30.16	Team21	5.506	0.01783	a
12	26.06	Team46	5.522	0.01624	ab
12	28.29	Team43	5.524	0.01706	ab
12	25.39	Team26	5.525	0.01637	ab
12	25.36	Team28	5.532	0.01652	abc
12	25.89	Team39	5.533	0.01630	abcd
12	24.30	Team05	5.537	0.01628	abcd
12	26.72	Team17	5.539	0.01670	abcd f
12	23.72	Team44	5.540	0.01606	abcd
12	25.86	Team16	5.540	0.01630	abcd
12	24.77	Team20	5.541	0.01591	abcd
12	25.82	Team14	5.541	0.01648	abcde
12	27.78	Team33	5.543	0.01677	abcde hi
12	25.73	Team30	5.545	0.01598	abcde h
12	24.92	Team38	5.551	0.01607	bcde g
12	22.89	Team07	5.551	0.01622	abcde g
12	24.35	Team45	5.552	0.01620	bcde g
12	23.19	Team27	5.552	0.01604	bcde g
12	22.47	Team03	5.552	0.01626	bcde g
12	20.46	Team06	5.555	0.01693	abcde g
12	21.55	Team12	5.556	0.01655	bcde g
12	23.81	Team36	5.556	0.01647	bcde g
12	23.94	Team35	5.556	0.01614	bcde g
12	22.91	Team42	5.557	0.01630	bcde g
12	23.89	Team50	5.557	0.01619	bcde g
12	23.48	Team11	5.558	0.01609	bcde g
12	21.85	Team47	5.560	0.01632	bcde g
12	22.07	Team48	5.560	0.01673	bcde g
12	21.70	Team25	5.561	0.01667	bcde g
12	22.15	Team32	5.561	0.01631	bcde g
12	21.44	Team31	5.562	0.01687	bcde g
12	23.56	Team02	5.562	0.01606	bcde g
12	22.43	Team19	5.563	0.01620	bcde g
12	22.47	Team15	5.563	0.01653	bcde g
12	20.14	Team04	5.564	0.01690	bcde g
12	20.79	Team09	5.565	0.01699	bcde g

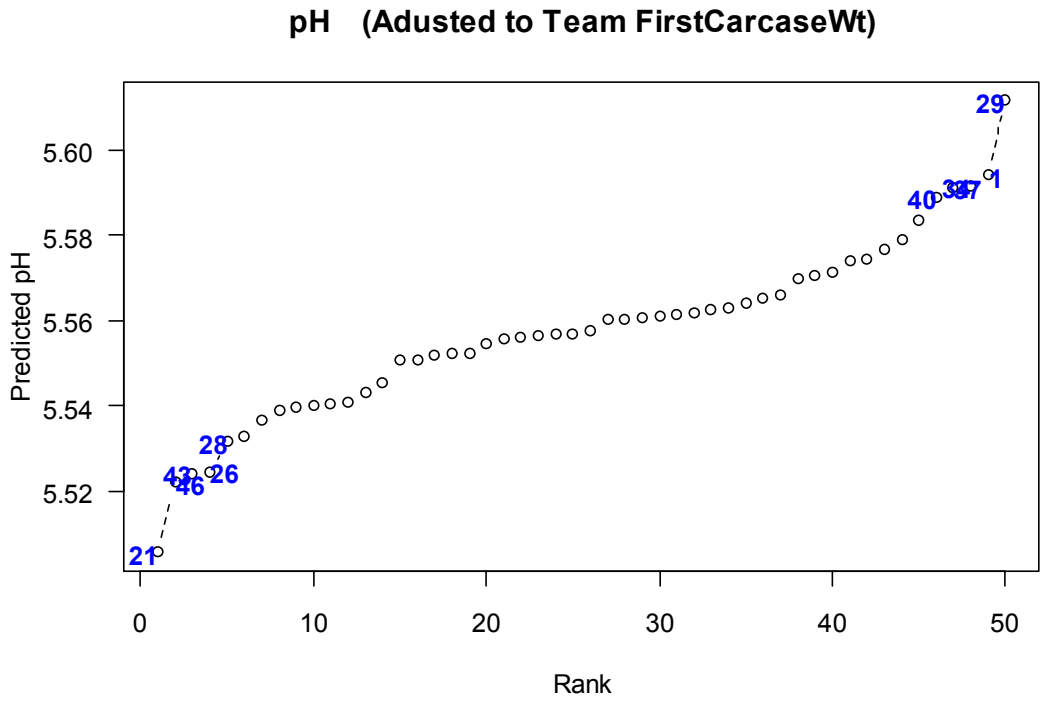
```
12          20.65 Team41          5.566        0.01681  bcde g
12          22.17 Team18          5.570        0.01629   cde g  j
12          20.89 Team13          5.570        0.01637   cde g  j
12          21.08 Team10          5.571        0.01648   cde g  j
12          22.29 Team24          5.574        0.01632   cde g  j
12          19.67 Team49          5.574        0.01708   cde g  j
12          20.25 Team08          5.577        0.01732   cde g  j
12          19.11 Team22          5.579        0.01731    de g  j
12          24.75 Team23          5.584        0.01620     e g  j
12          17.29 Team40          5.589        0.01844     efg  j
12          21.21 Team37          5.591        0.01655       g  j
12          17.60 Team34          5.591        0.01797       gh j
12          16.70 Team01          5.594        0.01851       g ij
12          18.72 Team29          5.611        0.01778          j
```

95% confident Team with largest mean pH is one of the following:

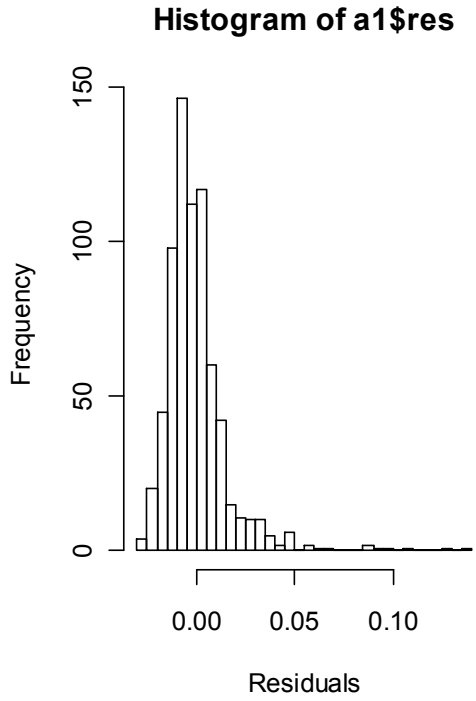
```
Team29 Team01 Team34 Team37 Team40 Team23 Team22 Team08
 5.611  5.594  5.591  5.591  5.589  5.584  5.579  5.577
```

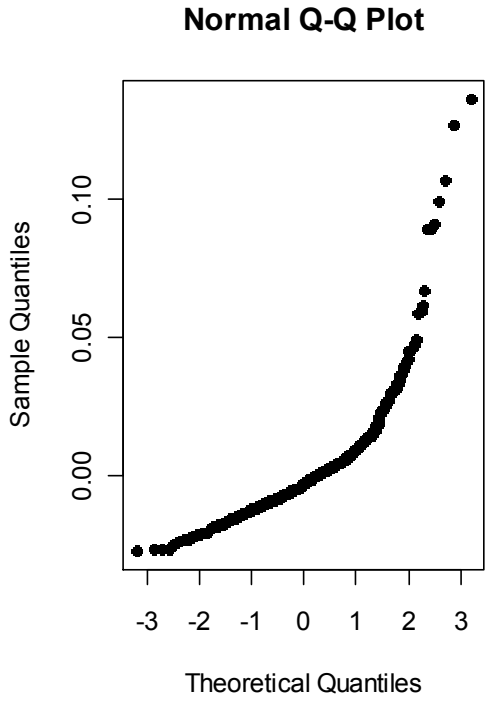
95% confident Team with smallest mean pH is one of the following:

```
Team21 Team46 Team43 Team26 Team28 Team39 Team05 Team17 Team44 Team16 Team20
 5.506  5.522  5.524  5.525  5.532  5.533  5.537  5.539  5.540  5.540  5.541
```



Aside: The histogram and qqplot for the residuals for the fitted model are given below. These show significant skewness even after the log transformation.





Here we analyse ***FinalLwt210810*** and ***GrowthRate***, where GrowthRate is the average daily weight gain over the 54 days between 28/06/2010 and 21.08/2010.

In each case the model fitted is (where Y denotes the trait)

Y = baseline + Pen + AgeDays280610 + ***Team + error***

AgeDays280610 is the average age for animals in the Team on 28/06/2010.

FinalLwt210810:

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	48	5924.000	13.93		0.0005
Pen	4	679	0.446	0.45	A	0.7721
AgeDays280610	1	48	19.850	19.85	A	0.0001

Variance Components:

	component	std.error	z.ratio
Team!Team.var	20.7	4.55	4.55
R!variance	23.5	1.28	18.43

Summary of fixed effects:

	solution	std error	z ratio
AgeDays280610	0.0887	0.0199	4.455
Pen_Pen1	0.0000	NA	NA
Pen_Pen2	-0.1263	0.5669	-0.223
Pen_Pen3	-0.3407	0.5690	-0.599

```
Pen_Pen4       -0.6573    0.5660  -1.161
Pen_Pen5       -0.5060    0.5669  -0.893
(Intercept)    23.8255    6.3083   3.777
```

Predicted Means

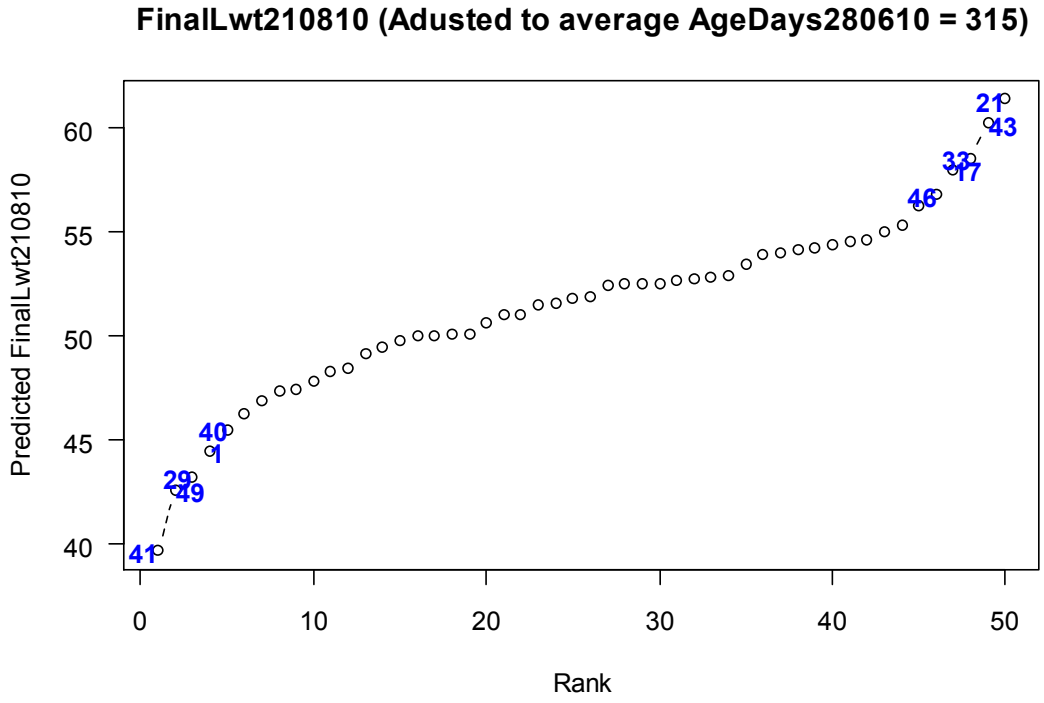
Age	Team	predicted.value	standard.error	LSD.Rank
315	Team41	39.7	1.97	a
315	Team49	42.6	1.29	ab
315	Team29	43.3	1.25	abc
315	Team01	44.5	1.51	abcd
315	Team40	45.5	1.40	bcd
315	Team31	46.3	1.33	cde
315	Team34	46.9	1.70	bcdef k
315	Team22	47.3	1.47	cdef h l
315	Team48	47.5	1.31	defg
315	Team47	47.8	1.21	defgh
315	Team27	48.3	1.25	defgh j
315	Team32	48.5	1.22	defgh j l
315	Team08	49.1	1.28	efgh j lm
315	Team38	49.5	1.91	defgh j lmno q
315	Team15	49.8	1.25	efgh j lmn
315	Team10	50.0	1.25	efgh j lmn
315	Team19	50.0	1.21	fgh j lmno
315	Team25	50.1	1.24	fgh j lmno
315	Team37	50.1	1.22	fgh j lmno
315	Team50	50.6	1.33	fgh j lmnop
315	Team04	51.0	1.40	g i
315	Team03	51.1	1.21	hi r
315	Team12	51.5	1.26	ij rs
315	Team30	51.6	1.78	hijk rst
315	Team06	51.8	1.58	g ij rst
315	Team20	51.9	1.45	i kl rst
315	Team44	52.4	1.22	i m rst
315	Team09	52.5	1.56	ij m rstu
315	Team45	52.5	1.23	i m rst
315	Team02	52.5	1.25	i m rst
315	Team18	52.7	1.27	i n rst
315	Team13	52.8	1.83	ij mn rstuv
315	Team42	52.8	1.23	i n rstu
315	Team35	52.9	1.21	i n rstu
315	Team24	53.5	1.32	i o rstuv
315	Team23	53.9	1.29	i p stuv
315	Team07	54.0	1.32	i pq stuv
315	Team28	54.2	1.29	i rstuv
315	Team11	54.2	1.22	i pq stuv
315	Team26	54.4	1.28	i rstuv
315	Team05	54.6	1.34	pqrstuvw
315	Team16	54.6	1.33	i rstuvw
315	Team39	55.0	1.23	stuvw
315	Team36	55.3	1.31	tuvwx
315	Team14	56.3	1.25	uvwx
315	Team46	56.8	1.22	vwx
315	Team17	58.0	1.22	wxy
315	Team33	58.6	1.29	xy
315	Team43	60.2	1.29	y
315	Team21	61.4	1.53	y

95% confident Team with largest mean FinalLwt210810 is one of the following:

```
Team21 Team43
  61.4   60.2
```

95% confident Team with smallest mean FinalLwt210810 is one of the following:

```
Team41 Team49 Team29
  39.7   42.6   43.3
```



GrowthRate:

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	48	3461.000	56.210		0.000
Pen	4	678	0.396	0.396	A	0.812
AgeDays280610	1	48	1.602	1.602	A	0.212

Variance Components:

	component	std.error	z.ratio
Team!Team.var	0.000282	0.000085	3.31
R!variance	0.001950	0.000106	18.40

Summary of fixed effects:

	solution	std error	z ratio
AgeDays280610	-0.000109	8.59e-05	-1.266
Pen_Pen1	0.000000	NA	NA
Pen_Pen2	-0.004462	5.16e-03	-0.864
Pen_Pen3	0.001099	5.20e-03	0.211
Pen_Pen4	-0.003366	5.15e-03	-0.653
Pen_Pen5	-0.002081	5.16e-03	-0.403
(Intercept)	0.205515	2.74e-02	7.513

Predicted Means

Age	Team	predicted.value	standard.error	LSD.Rank
315	Team50	0.137	0.00981	a
315	Team41	0.141	0.01081	abc
315	Team13	0.142	0.01043	ab
315	Team02	0.147	0.00953	abcd
315	Team47	0.149	0.00948	abcde

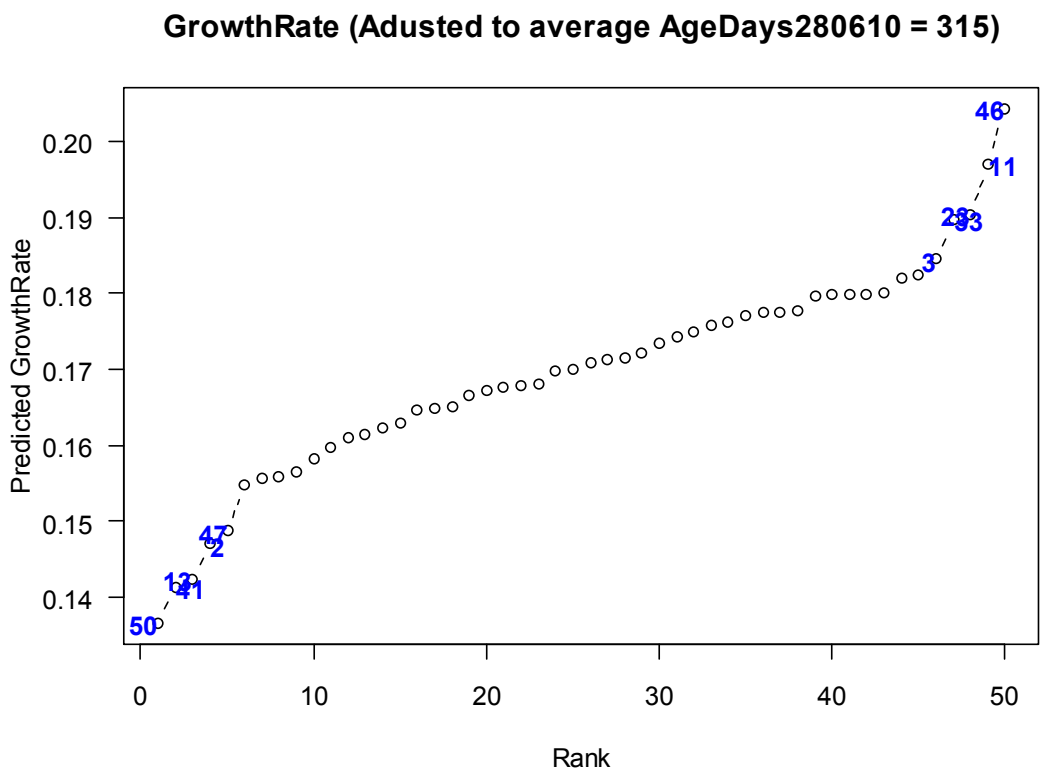
```
 315 Team01           0.155        0.00991 abcdef
 315 Team32           0.156        0.00949 abcdefg
 315 Team49           0.156        0.00981 abcdefg
 315 Team31           0.156        0.00999 abcdefg
 315 Team22           0.158        0.01000 abcdefgh
 315 Team29           0.160        0.00953 abcdefgh
 315 Team19           0.161        0.00948 abcdefgh
 315 Team05           0.161        0.00983 abcdefgh
 315 Team15           0.162        0.00970 abcdefgh
 315 Team48           0.163        0.00978 abcdefghi
 315 Team30           0.165        0.01035  bcdefghij
 315 Team27           0.165        0.00953  bcdefghij
 315 Team18           0.165        0.00956  bcdefghij
 315 Team20           0.167        0.00980  bcdefghij
 315 Team28           0.167        0.00976  bcdefghij
 315 Team40           0.168        0.00974  bcdefghij
 315 Team16           0.168        0.00981  bcdefghij
 315 Team39           0.168        0.00950  bcdefghij
 315 Team17           0.170        0.00949  bcdefghij
 315 Team36           0.170        0.00978  bcdefghij
 315 Team04           0.171        0.00991   cdefghijk
 315 Team34           0.171        0.01036   cdefghijk
 315 Team08           0.172        0.00975    defghijk
 315 Team10           0.172        0.00953    defghijk
 315 Team37           0.174        0.00950    defghijk
 315 Team12           0.174        0.00954     efghijk
 315 Team42           0.175        0.00951     efghijk
 315 Team35           0.176        0.00948      fghijk
 315 Team14           0.176        0.00970      fghijk
 315 Team45           0.177        0.00951      fghijk
 315 Team24           0.177        0.00963      fghijkl
 315 Team26           0.177        0.00974      fghijkl
 315 Team09           0.178        0.01014      fghijkl
 315 Team44           0.180        0.00949      fghijkl
 315 Team38           0.180        0.01057      fghijkl
 315 Team25           0.180        0.00975      fghijkl
 315 Team06           0.180        0.01001      fghijkl
 315 Team43           0.180        0.00959      fghijkl
 315 Team07           0.182        0.00963       ghijkl
 315 Team21           0.183        0.00993      fghijkl
 315 Team03           0.184        0.00948        hijkl
 315 Team33           0.190        0.00959         ijkl
 315 Team23           0.190        0.00959          jkl
 315 Team11           0.197        0.00949           kl
 315 Team46           0.204        0.00949            l
```

95% confident Team with largest mean GrowthRate is one of the following:

```
Team46 Team11 Team23 Team33 Team03 Team21 Team07 Team43 Team06 Team25
 0.204  0.197  0.190  0.190  0.184  0.183  0.182  0.180  0.180  0.180
```

95% confident Team with smallest mean GrowthRate is one of the following:

```
Team50 Team41 Team13 Team02 Team47 Team01 Team32 Team49
 0.137  0.141  0.142  0.147  0.149  0.155  0.156  0.156
```



Traits *WoolGrade, BWrk* and *Skin*.

These traits have limited numbers of discrete scores. In particular, the numbers of animals obtaining each score for these three traits are:

Score	WoolGrade	BWrk	Skin
1	106	186	
2	533	316	81
3	95	190	468
4		31	172
5			10

Given this, it is still considered that a linear mixed model treating the response as quantitative and with a random Team effect is adequate given the number of Teams and the number of animals within each Team. The model fitted for each trait (denoting the trait by Y) is

Y = baseline + Pen + **Team + Error**

The summaries for the fitted models are as for the earlier analyses.

WoolGrade:

ANOVA:

```
            Df denDF   F.inc   F.con Margin    Pr
(Intercept)  1  49.1 1412.00 1412.00        0.000
Pen          4 680.2    1.81    1.81      A 0.125
```

Variance Components:

	component	std.error	z.ratio
Team!Team.var	0.130	0.02822	4.6
R!variance	0.144	0.00781	18.4

Summary of fixed effects:

	solution	std error	z ratio
Pen_Pen1	0.00000	NA	NA
Pen_Pen2	0.00207	0.0444	0.0467
Pen_Pen3	-0.03992	0.0445	-0.8963
Pen_Pen4	0.00196	0.0443	0.0443
Pen_Pen5	-0.09410	0.0443	-2.1246
(Intercept)	2.01272	0.0599	33.6089

Predicted Means

Team	predicted.value	standard.error	LSD.Rank
Team01	1.12	0.0918	a
Team13	1.19	0.0946	a
Team22	1.21	0.0977	a
Team47	1.32	0.0946	a
Team49	1.32	0.0946	a
Team37	1.38	0.0946	ab
Team40	1.63	0.0946	bc
Team12	1.69	0.0946	cd
Team50	1.80	0.0977	cde
Team42	1.81	0.0946	cde
Team34	1.86	0.0977	cdef
Team14	1.87	0.0977	cdef
Team02	1.87	0.0946	cdef
Team18	1.87	0.0946	cdef
Team19	1.87	0.0946	cdef
Team15	1.93	0.0977	defg
Team28	1.93	0.0977	defg
Team10	1.94	0.0946	defg
Team24	1.94	0.0946	defg
Team25	1.94	0.0946	defg
Team04	2.00	0.0977	efgh
Team08	2.00	0.0977	efgh
Team29	2.00	0.0946	efgh
Team09	2.00	0.0977	efgh
Team16	2.00	0.0977	efgh
Team03	2.06	0.0946	efghi
Team06	2.06	0.0946	efghi
Team45	2.06	0.0946	efghi
Team46	2.06	0.0946	efghi
Team31	2.07	0.1011	efghi
Team07	2.12	0.0946	fghij
Team11	2.12	0.0946	fghij
Team21	2.12	0.0946	fghij
Team30	2.12	0.0946	fghij
Team43	2.12	0.0946	fghij
Team44	2.12	0.0946	fghij
Team05	2.13	0.0977	fghij
Team26	2.13	0.0977	fghij
Team32	2.19	0.0946	ghijk
Team38	2.19	0.0946	ghijk
Team20	2.25	0.0946	hijkl
Team39	2.25	0.0946	hijkl
Team48	2.33	0.0977	ijkl
Team36	2.33	0.0977	ijkl
Team17	2.37	0.0946	jklm
Team23	2.43	0.0946	klmn
Team35	2.43	0.0946	klmn

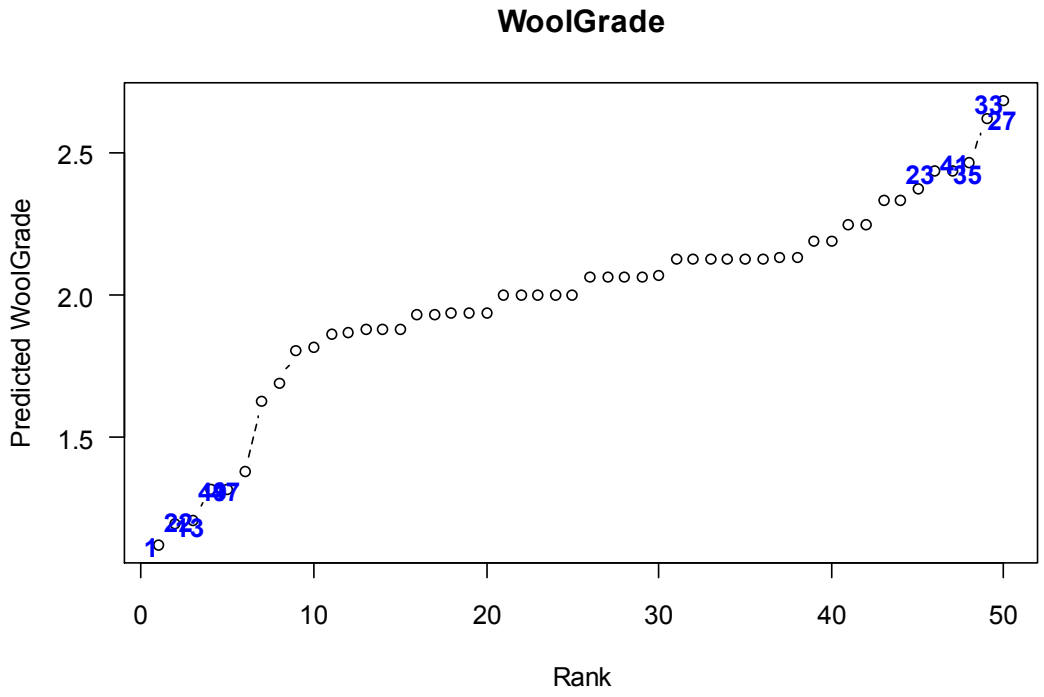
```
 Team41            2.46         0.0977            lmn
 Team27            2.62         0.0946             mn
 Team33            2.68         0.0946              n
```

95% confident Team with largest mean WoolGrade is one of the following:

```
Team33 Team27
  2.68   2.62
```

95% confident Team with smallest mean WoolGrade is one of the following:

```
Team01 Team13 Team22 Team47
  1.12   1.19   1.21   1.32
```



BWrk:

ANOVA:

```
            Df denDF   F.inc   F.con Margin    Pr
(Intercept)  1  48.9 925.900 925.900        0.000
Pen          4 669.4   0.758   0.758      A 0.553
```

Variance Components:

```
              component std.error z.ratio
Team!Team.var     0.202    0.0476    4.23
R!variance        0.488    0.0267   18.29
```

Summary of fixed effects:

```
            solution std error z ratio
Pen_Pen1      0.0000        NA      NA
Pen_Pen2     -0.1156    0.0823  -1.404
```

```
Pen_Pen3     -0.1253    0.0825  -1.520
Pen_Pen4     -0.1048    0.0823  -1.273
Pen_Pen5     -0.0738    0.0823  -0.897
(Intercept)   2.1720    0.0862  25.196
```

Predicted Means

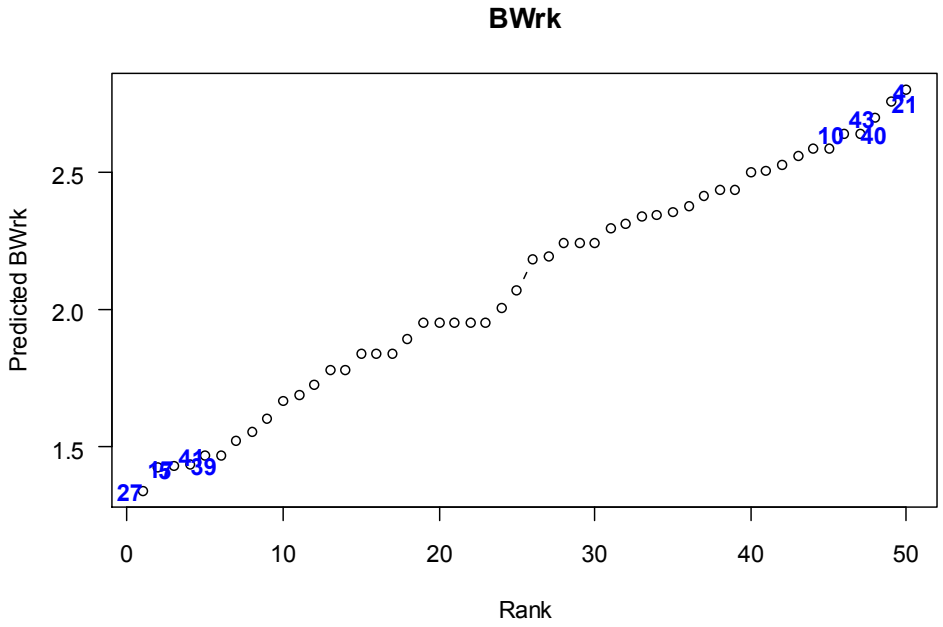
Team	predicted.value	standard.error	LSD.Rank
Team27	1.34	0.173	a
Team05	1.43	0.178	ab
Team17	1.43	0.178	ab
Team39	1.44	0.168	ab
Team41	1.47	0.173	abc
Team48	1.47	0.173	abc
Team26	1.52	0.173	abcd
Team47	1.55	0.168	abcd
Team22	1.60	0.184	abcde
Team44	1.67	0.168	abcde
Team01	1.69	0.163	abcde
Team46	1.73	0.168	abcdef
Team06	1.78	0.168	abcdefg
Team07	1.78	0.168	abcdefg
Team13	1.84	0.168	bcdefgh
Team45	1.84	0.168	bcdefgh
Team49	1.84	0.168	bcdefgh
Team03	1.90	0.173	bcdefghi
Team34	1.95	0.173	cdefghijk
Team25	1.95	0.168	defghij
Team33	1.95	0.168	defghij
Team38	1.95	0.168	defghij
Team42	1.95	0.168	defghij
Team09	2.01	0.178	defghijkl
Team24	2.07	0.168	efghijklm
Team11	2.18	0.168	fghijklmn
Team28	2.19	0.173	fghijklmn
Team19	2.24	0.168	ghijklmno
Team29	2.24	0.168	ghijklmno
Team32	2.24	0.168	ghijklmno
Team23	2.30	0.168	hijklmnop
Team16	2.32	0.173	hijklmnopq
Team31	2.34	0.178	ijklmnopq
Team50	2.34	0.178	ijklmnopq
Team12	2.36	0.168	ijklmnopq
Team15	2.38	0.173	ijklmnopq
Team20	2.41	0.168	jklmnopq
Team08	2.44	0.173	klmnopq
Team14	2.44	0.173	klmnopq
Team36	2.50	0.173	lmnopq
Team30	2.51	0.173	mnopq
Team18	2.53	0.168	mnopq
Team02	2.56	0.173	nopq
Team35	2.59	0.168	nopq
Team37	2.59	0.168	nopq
Team10	2.64	0.168	nopq
Team40	2.64	0.168	nopq
Team43	2.70	0.168	opq
Team21	2.76	0.168	pq
Team04	2.80	0.173	q

95% confident Team with largest mean BWrk is one of the following:

Team04	Team21	Team43	Team40	Team10	Team37	Team35	Team02	Team18	Team30
2.80	2.76	2.70	2.64	2.64	2.59	2.59	2.56	2.53	2.51

95% confident Team with smallest mean BWrk is one of the following:

Team27	Team05	Team17	Team39	Team41	Team48	Team26	Team47
1.34	1.43	1.43	1.44	1.47	1.47	1.52	1.55



Skin:

ANOVA:

	Df	denDF	F.inc	F.con	Margin	Pr
(Intercept)	1	49	5651.000	5651.000		0.000
Pen	4	678	0.787	0.787	A	0.534

Variance Components:

	component	std.error	z.ratio
Team!Team.var	0.0664	0.0178	3.73
R!variance	0.3134	0.0170	18.40

Summary of fixed effects:

	solution	std error	z ratio
Pen_Pen1	0.00000	NA	NA
Pen_Pen2	0.10216	0.0654	1.5609
Pen_Pen3	0.02931	0.0657	0.4463
Pen_Pen4	0.00526	0.0656	0.0802
Pen_Pen5	0.02421	0.0654	0.3699
(Intercept)	3.11940	0.0590	52.8965

Predicted Means

Team	predicted.value	standard.error	LSD.Rank
Team27	2.63	0.126	a
Team17	2.68	0.126	ab
Team26	2.72	0.130	ab
Team48	2.82	0.130	abc
Team05	2.82	0.130	abc
Team44	2.83	0.126	abcd
Team45	2.83	0.126	abcd
Team13	2.88	0.126	abcde
Team41	2.93	0.130	abcdef
Team39	2.93	0.126	abcdef

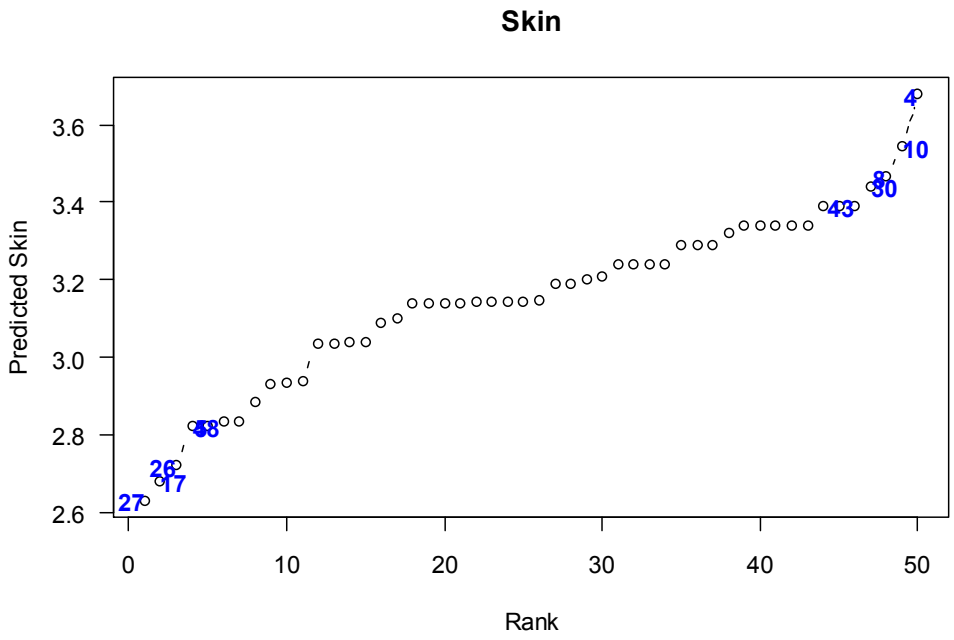
Team01	2.94	0.123	abcdef
Team07	3.04	0.126	bcdefg
Team47	3.04	0.126	bcdefg
Team14	3.04	0.130	bcdefg
Team49	3.04	0.130	bcdefg
Team03	3.09	0.126	cdefgh
Team16	3.10	0.133	cdefghi
Team11	3.14	0.126	cdefghi
Team20	3.14	0.126	cdefghi
Team24	3.14	0.126	cdefghi
Team38	3.14	0.126	cdefghi
Team22	3.14	0.130	cdefghi
Team50	3.14	0.130	cdefghi
Team36	3.14	0.130	cdefghi
Team34	3.14	0.130	cdefghi
Team15	3.14	0.130	cdefghi
Team06	3.19	0.126	defghij
Team46	3.19	0.126	defghij
Team09	3.20	0.130	efghij
Team28	3.21	0.133	efghij
Team02	3.24	0.126	efghij
Team12	3.24	0.126	efghij
Team25	3.24	0.126	efghij
Team33	3.24	0.126	efghij
Team18	3.29	0.126	fghij
Team19	3.29	0.126	fghij
Team42	3.29	0.126	fghij
Team31	3.32	0.133	ghijk
Team21	3.34	0.126	ghijk
Team23	3.34	0.126	ghijk
Team29	3.34	0.126	ghijk
Team37	3.34	0.126	ghijk
Team40	3.34	0.126	ghijk
Team32	3.39	0.126	ghijk
Team35	3.39	0.126	ghijk
Team43	3.39	0.126	ghijk
Team30	3.44	0.126	hijk
Team08	3.47	0.130	ijk
Team10	3.54	0.126	jk
Team04	3.68	0.130	k

95% confident Team with largest mean Skin is one of the following:

Team04	Team10	Team08	Team30	Team43	Team35	Team32	Team40
3.68	3.54	3.47	3.44	3.39	3.39	3.39	3.34

95% confident Team with smallest mean Skin is one of the following:

Team27	Team17	Team26	Team48	Team05	Team44	Team45
2.63	2.68	2.72	2.82	2.82	2.83	2.83



Concluding Remark:

When fitting the model for WoolGrade I initially inadvertently left AgeDays280610 in the model. I noticed it was highly significant (P < 0.001). This significant effect can be seen from the plot below of the average WoolGrade vs Average Age for each Team. I am not sure what should be made of this observation.