finalreport

ANIMAL HEALTH & WELFARE

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The comparison of predictive methods for determination of fatness and condition in sheep - Stage 2, 2006, NSW

Abstract

This experiment was the second stage of a comparison of manual fat scoring and condition scoring as predictive methods for the determination of fatness and condition in sheep. Both techniques are used in Australia and some concern existed as to which was most appropriate, or if they were similar in efficacy. In a previous experiment (2005) with medium wool Merino ewes it was concluded that condition scoring would offer far greater control over predicted effects on the performance of the ewes and future performance of their progeny than fat scoring.
The experiment was repeated in 2006 to re-examine the curvilinear relationship observed and to examine whether the relationship was consistent in other ewe types, *i.e.* adult first cross and fine wool merino ewes.
This experiment showed that:

- The correlation between fat scorers and condition scorers was generally very good at about 0.9.
- Despite some bias by some operators there is a strong significant relationship between both condition and fat scores and the objective carcass measurements at the C and GR sites.
- The curvilinear relationship between FS and CS found in comparison 1 was not found in the second comparison in any of the ewe types to any significant degree.
- The main conclusion from the second comparison across three ewe genotypes is that fat score and condition score have a similar ability to assess reproductive fitness in ewes and the relationship between them is linear.

Sheep producers can use either technique in assessing the reproductive fitness of ewes.

Executive Summary

This experiment was the second stage of a comparison of fat scoring and condition scoring as predictive methods for the determination of fatness and condition in sheep.

Condition scoring by manual palpation of fat and muscle over the loin (short ribs) has been used to estimate the 'energy status' or 'nutritional well-being' of adult ewes. Condition scores relate to the assessed level of fat cover and underlying muscle over the short ribs or lumbar area of the sheep and can be related to the depth of total tissue (fat + muscle) at the GR site (110 mm from the centre of the backline) over the 12th rib. The tissue depths at the GR site for the condition scores (CS) have previously been assessed as CS1 (0 to 2 mm), CS2 (3 to 7 mm), CS3 (8 to 15 mm), CS4 (16 to 22 mm) and CS5 (23+mm).

Fat scoring (FS) by manual palpation is also used to assess ewe reproductive fitness in some areas of Australia. It is commonly used to estimate the dressing percentage and carcass weight of lambs and sheep being marketed for meat. Scores 1 to 5 are related to 5 mm ranges in total tissue (fat + muscle) at the GR site.

Meat and Livestock Australia, which advocates the use of fat score for prime lamb marketing and has also endorsed fat score as a method for ewe management, was concerned that the increased use of both terminologies could be confusing to producers and others.

Stage 1 - 2005

MLA commissioned an experiment, conducted in Kojonup WA in 2005 to test;

1. That skilled industry personal can repeatably assess condition scores or fat scores
2. That the relationship between condition score and fat score is such that industry can confidently convert flock estimates between the two methods.
3. That the relationship will be similar in hogget and adult sheep.
4. That methods of subjective assessment bear a statistically significant relationship with measured ultrasonic C site fat and C site eye muscle depth and carcass GR site tissue depth (as measured on hot carcass by a GR knife).

In Stage 1 the condition score, fat score and C-site ultrasound fat and C-site ultrasound eye muscle depth were recorded for a group of 92 live Merino sheep in 6 months wool (45 young and 47 mature). All scores and measurements were done by two to four experienced assessors and repeated three times in a random order. Approximately 24 hours after the above measurements, the sheep were slaughtered at an abattoir (WAMMCO, Katanning) where the GR site tissue depth (fat + muscle) was recorded on the hot carcass for 89 of these sheep. This measurement was also done by two experienced assessors using standard GR knives and repeated three times in random order.

The major findings of Stage 1 were:

I All condition and fat score assessors showed very high repeatability (av. correlation between runs = 0.90 to 0.95).

II The condition score assessors scored similarly with only very small assessor biases.

III By contrast, there was considerable assessor bias for the fat scorers when estimating GR tissue depth in mm.

IV There was a strong significant relationship between both condition and fat scores and the ultrascan measurements at the C site and objective measurement at the GR sites.

V There was a strong significant relationship between condition score and fat score:
   i Prediction of the average condition score from a single fat score could be done with average error of about 0.25 CS units and 95% confidence to within three quarters of a condition score unit.
   ii However, because the relationship was not linear, in the range of CS 2 to 3 there was very little variation in estimated or actual GR tissue depth (1 to 4 mm and 1 to 3 mm, respectively).

VI There was a significant effect of age on some of the above relationships, including the relationship between fat and condition score.

It was concluded from Stage 1 that targets framed in terms of condition score would offer far greater control over predicted effects on the performance of the ewes and future performance of their progeny than targets framed in terms of fat score or estimated GR tissue depth in mm.

It was hypothesised that the curvilinear relationship between condition score and estimated GR tissue depth evident in Stage 1 may be explained by the fact that estimation of condition score includes changes in eye muscle as well as tissue cover (fat & muscle) over the spine and short ribs. In Stage 1 eye muscle depth increased linearly with increasing condition whereas there was a lag of at least 5 mm in eye muscle depth before any increase GR tissue depth was evident.

There were a number of small differences in the various relationships between mature and young ewes. For example the estimated condition score of adult ewes was about 0.25 of a score greater than young ewes at the same estimated GR tissue depth (mm) over the critical range of 3 to 12 mm. However, none of these small differences would have any great impact on how the industry currently used or contemplated using condition score or estimated GR tissue depth in the future.

Discussion of the results by MLA, AWI and Agricultural departmental representatives from states that encouraged producers to use either condition scoring or fat scoring resulted in a decision to repeat the experiment to re-examine the curvilinear relationship observed and to examine whether the relationship was consistent in other ewe genotypes (i.e. adult first cross and fine wool Merino ewes).

Stage 2 - 2006

The same objectives as used in Stage I were repeated in the second experiment conducted at Glen Innes in October 2006 with the additional objective of:

5. Demonstrating that methods of subjective assessment bear a statistically significant relationship with carcass measures of C site fat depth and eye muscle depth and 3rd lumbar site fat depth and eye muscle depth (as measured on the carcass by either a GR knife or Toland style probe).

The Stage 2 experimental design was also varied to include 2 groups of 45 adult mature Merino ewes (fine wool and medium wool) and 1 group of 45 adult 1st X ewes to cover the range of FS and CS from 1 to 5 as much as possible. The same subjective palpation techniques for estimating fatness (CS and FS) were used with each technique represented by four skilled assessors. Objective measurements of fatness and eye muscle depth were taken by two practised ultrascanners on the live

sheep, as occurred in Stage 1. C fat and C eye muscle depth (mm) were estimated by ultrasound scanning at the C site and the ultrascanners were also asked to assess fat depth and eye muscle depth at the 3 rd lumbar rib site (over the rib about 40 mm from the centre of the backline). To establish the relationship between assessments of FS or CS and objective measures at corresponding sites on the carcass 5 carcass measures were taken. These were

i) Total tissue depth at the GR site (GR in mm) on the hot carcass (as measured in Stage 1 -2005), plus an additional four measurements aimed at assessing the components of fat and muscle assessed at the C and 3rd lumbar sites)

ii) Measured C site fat depth and C site eye muscle depth on the hot carcass.

iii) Measured 3rd lumbar site fat depth and 3rd lumbar site eye muscle depth on the hot carcass.

The major findings of Stage 2 were:

- All fat and condition score assessors showed high repeatability in assessments on medium wool Merino ewes and 1st X ewes (for fat scorers 0. 89 to 0.94 and for condition scorers 0.78 to 0.91).
- Both fat scorers and condition scorers had less repeatability in assessments of the fine wool ewes (for fat scorers 0. 69 to 0.92 and for condition scorers 0.56 to 0.87).
- Across all ewe types the repeatability between assessments for fat scorers was 0.92 to 0.94 and for condition scorers was 0.83 to 0.93.
- The correlation between CSers and FSers was generally very good at about 0.9.
- There was some bias in both fat scorers and condition scorers (against average scores for either assessment) in their assessments within and between ewe groups. For CSers the bias for one operator was up to 0.4 of a condition score above the average of CS and for FS one operator showed a bias of 3 mm above the average and another 3 mm below - in both cases for sheep in mid range GR mm live. Care needs to be taken with this comparison as FS was assessed in mm GR while CS was assessed in scores which contain a range of mm GR equivalent.
- Compared to measured carcass GR, the bias by individual fat scorers of assessed mm GR on the live sheep was up to 5mm higher in the fine wool and medium wool merino ewes and up to 4mm under in the 1st X ewes and was more pronounced in the mid fat score range (5 to 15 mm GR assessed).
- Compared to measured carcass GR the bias by individual condition scorers was up to 0.4 of a CS (approximately 3.75mm GR equivalent).
- Despite some bias by some operators there is a strong significant relationship between both condition and fat scores and the objective carcass measurements at the C and GR sites. When ignoring bias the average prediction errors for each of the fat and condition scorers were similar for all the objective measures.
- The curvilinear relationship between FS and CS found in Stage 1 was not evident in Stage 2 for any of the ewe types to any significant degree. This could indicate something peculiar to the group of WA medium wool used in comparison 1. For example, the feeding regime that these ewes were given to increase condition or fat score range in some of the group may have resulted in repletion of muscle, but not fat – hence creating different palpation scenarios.

The main conclusion from Stage 2 across the three ewe genotypes is that fat score and condition score have a similar ability to assess reproductive fitness in ewes and the relationship between them is linear in all but very lean sheep (less than 2mm GR).

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1 Background

Condition score (CS) relates to the tissue cover (fat + muscle) as manually palpated over the loin (short rib) area of sheep whereas fat score (FS) relates to the tissue cover (fat + muscle) as manually palpated over the 12th rib (2nd long rib from the short loin) at the GR site, approximately 110 mm from the centre of the backline.

CS has been used to estimate the 'energy status' or 'nutritional well-being' of adult ewes (Russell *et al*. 1969, J. Agric Sci. Camb.72, 451-454; Feeding standards for Australian Livestock, Ruminants p 58-68). FS has also been used to estimate the 'energy status' or 'nutritional well-being' of adult ewes but has also been used to estimate the yield of saleable meat (%) of young sheep being marketed for meat. Fat scores are related to 5 mm ranges in total tissue depth (fat and muscle) at the GR site over the 12th rib (White and Holst 2006 Primefact 302 NSWDPI Nov 2006)).

The Lifetime Wool project (LTW; AWI-EC298) is a National project writing new nutritional guidelines for ewe flocks that will be framed in terms of 'fatness' and/or liveweight (LW) targets. LTW staff have variously been using CS (Vic, WA & SA) or FS (NSW) to manage flocks. Within LTW there was rigorous internal debate between the condition scorers and the fat scorers. Similarly during the MLA Prime Time Roadshow forums in 2004 it became very clear that both academics and producers were confused with respect to the pros and cons of the 2 approaches to estimating fatness in live sheep.

Hence MLA convened a meeting in Sydney in November 2004 to discuss the issues. As a result of the discussions Chris Oldham (DAFWA) was asked to design an experiment that would resolve the issues and for the first time calibrate both CS & FS against a continuous scale of tissue depth measured at the GR site in both mature and young Merino ewes.

In this experiment (Stage 1 - WA 2005) the repeatability of all skilled operators (both subjective and objective) was very high and commercially acceptable. However, while the relationship between condition score and estimated GR tissue depth explained 88% of the variance, the relationship was not linear. In fact, in the condition score range of 2 to 3, considered to be critical for the management of ewes in the Lifetime Wool project, there was very little variation in estimated or actual GR tissue depth (about 1 to 4 mm in both cases). It was concluded from Stage 1 that targets framed in terms of condition score would offer far greater control over predicted effects on the performance of the ewes and future performance of their progeny than targets framed in terms of estimated GR tissue depth.

Furthermore, it was hypothesised that the curvilinear relationship between condition score and estimated GR tissue depth evident in Stage 1 may be explained by the fact that estimation of condition score includes changes in eye muscle as well as tissue cover (fat & muscle) over the spine and short ribs. In Stage 1 eye muscle depth increased linearly with increasing condition whereas there was a lag of at least 5 mm in eye muscle depth before any increase in GR tissue depth occurred.

Stage 1 also identified a number of small differences in the various relationships between mature and young ewes. For example the estimated condition score of adult ewes was about 0.25 of a score greater than young ewes at the same estimated GR tissue depth (mm) over the critical range of 3 to 12 mm. However, it is likely that none of these small differences would have any great impact on how the industry currently used or contemplated using condition score or estimated GR tissue depth in the future.

Discussion of the results by MLA, AWI and agricultural departmental representatives from states that encouraged producers to use either condition scoring or fat scoring resulted in a decision to repeat the experiment to re-examine the curvilinear relationship observed and to examine whether the relationship was consistent in other ewe types (i.e. adult first cross and fine wool Merino ewes).

2 Project Objectives

1. To establish the relationship between CS and FS in adult Merino ewes (fine wool and medium wool) and adult First Cross ewes as assessed by skilled assessors recognised by industry.
2. To establish the relationship between subjectively assessed CS, FS and objectively measured C site fat and eye muscle depth in the live animal and measured GR site tissue depth, C site tissue depth, C site eye muscle depth (C EMD), lumbar site fat depth and lumbar site EMD in the hot carcass.

3 Methodology

3.1 Experimental Design

This experiment aimed to check the relationship found in Stage 1 over three common ewe breed types. It included extra measures intended to provide correlations between the condition scores assessed and live and carcase measures at the same site, between C site and GR site and between condition score and carcass GR (mm)

3.2 Selection and feeding of the sheep

1. 2 groups of mature Merino ewes (fine wool and medium wool)- (n = 45) and 1 group of 1st X ewes; were selected from within respective commercial flocks of adult and full-mouth ewes, to cover the range of FS and CS as much as possible from 1 to 5.
2. The medium wool and 1st X ewes were selected to represent the range of ewe condition as represented by fat scores and transported to Glen Innes Agricultural Research and Advisory Station six weeks prior to the experiment and divided into two groups based on fat score of 1 to 3 and 4 to 5, to be grazed on limited pasture and fed a maintenance ration to maintain their body condition. Liveweights were taken each fortnight to monitor for change. No significant change was observed.
3. The fine wool ewes were selected to represent as much of the fat score range as possible. Drought conditions in NSW and elsewhere restricted the range available to fat scores 1 to high 3.

3.3 Measurements

Condition score (CS) and fat score (FS) on the live animal were recorded for a group of 152 adult Merino and 1st X ewes. Wool growth was 1 month (approximately 1.5 cm) on the fine wool ewes and 11 months on the medium Merino (approx.7 to 8mm) and 1st X ewes (approx.8 to 10mm). All scores were done by four experienced assessors and repeated two times (runs) in a random order.

Objectively measured estimates of fatness and eye muscle depth on the live sheep were taken by two experienced ultrascanners. C-site ultrasound fat (C-site fat), C-site ultrasound eye muscle depth (C-site EM), lumbar (3rd) site fat and lumbar site EM were recorded twice by each operator for each sheep in random order. Immediately post live assessment the ewes were transported to Wallangarra abattoirs (Qld) for slaughter at a commercial abattoir the next morning. After slaughter, about 24 hours after live assessment, 5 objective measures were taken on the carcasses of:

i) Total tissue depth at the GR site (GR in mm) in the hot carcass
ii) Measured C site fat depth
iii) Measured C site eye muscle depth in the hot carcass.
iv) Measured 4th lumbar site fat depth;
v) Measured 4th lumbar site eye muscle depth in the hot carcass.

Each measure was done by two experienced operators using either standard GR knives or a Toland style probe and repeated two times in random order. Due to limitations on the time available in the abattoir chiller, repeated measures of (ii) to (iv) were not possible. Details and expertise of each assessor used are shown in *Table 1.*

Table 1. Details of experienced assessors used in the experiment

Measure		**Assessor**	**Address**	**Expertise**
Condition Score (subjective 1=thin & 5=fat)		Katrina Copping Tom Plaisted Darren Gordon Ian Rose	SARDI, Struan SA DAF, Albany WA DPI, Vic, Hamilton. Vic DAFWA, Katanning, WA	TO Lifetime wool project TO Lifetime wool project
Fat Score (subjective mm of tissue depth at the GR site; 1=thin to 20=fat)		Geoff Duddy Chris Shands Brent McLeod Michael Lollback	NSW DPI, Yanco, NSW DPI, Glen Innes, NSW DPI, Glen Innes NSW DPI, Tamworth	DLO NSW DPI DLO NSW DPI PDO, NSW DPI DLO, NSW DPI
C-site Fat depth **C-site Eye muscle** **Lumbar site Fat depth** **Lumbar site Eye**		Stephan Spiker Peter Moore	Advanced Livestock Services, Hamilton, Vic Scan West, Williams, WA	MLA accredited MLA accredited

muscle (Objective Real-time ultrasound in mm)				
GR tissue depth of carcass (Objective GR-knife in mm)	GR-Right GR-Left	Chris Shands Geoff Duddy	NSW DPI, Glen Innes NSW DPI, Yanco,	DLO NSW DPI DLO NSW DPI
C Fat depth Carcass **C site EM** **Lumbar site Fat depth** **Lumbar site EM**		Chris Shands Bill O'Halloran	NSW DPI, Glen Innes NSW DPI, Armidale	DLO NSW DPI Industry Leader, NSW DPI

4 Results and Discussion

With the exception of the fine wool ewes there was a good spread across both fat score and condition scores within the ewe groups. Within the fine wool ewe group the fat score range covered 1 to 3 (i.e. 0 to 15 mm) and condition score range 2 to 3.5.

4.1 Repeatability

Repeatability *refers to the agreement or variation between repeated independent measurements by the same person on the same animal.*

In this exercise the repeatability for a given assessor and measurement is determined by examining the results from the 2 runs, with a highly repeatable assessor often giving the same or very similar result in each run. Table 2 summarises repeatability using the following measures:

Correlation = correlation between 2 assessments of the same sheep (i.e. 50 fine wool merino ewes, 44 medium wool merino ewes, 48 first cross ewes).

MAE = mean absolute error = the average absolute difference between 2 assessments of the same sheep.

Table 2: Repeatability between live assessments and carcass measures

		Fine wool merino ewe		Medium wool Merino		First X ewes		all ewes	
Measure	Assessor	Correlation	MAE	Correlation	MAE	Correlation	MAE	Correlation	MAE
Fat Score	Brent McLeod	0.8989	1.00	0.9347	1.32	0.9348	1.58	0.9484	1.30
	Chris Shands	0.8016	1.48	0.9149	1.70	0.8900	1.60	0.9217	1.59
	Michael Lollback	0.9200	1.30	0.8910	1.64	0.9412	1.63	0.9497	1.51
	Geoff Duddy	0.6942	1.62	0.9378	1.59	0.9459	1.50	0.9314	1.57
Condition Score	Ian Rose	0.5570	0.24	0.7920	0.22	0.8572	0.21	0.8386	0.22
	Darren Gordon	0.7886	0.10	0.9127	0.10	0.9163	0.12	0.9311	0.11
	Tom Plaisted	0.6911	0.22	0.7866	0.33	0.8649	0.21	0.8919	0.25
	Katrina Copping	0.8691	0.15	0.8657	0.16	0.8238	0.20	0.8935	0.17
C-Site fat	Stefan Spiker	0.7629	0.30	0.9052	0.42	0.9367	0.47	0.9421	0.39
(ultrascan)	Peter Moore	0.6838	0.28	0.8301	0.63	0.9317	0.56	0.9198	0.49
C-Site EM	Stefan Spiker	0.5288	1.48	0.7991	1.14	0.8828	1.08	0.8457	1.24
(ultrascan)	Peter Moore	0.7029	1.13	0.8112	1.01	0.7545	1.14	0.8838	1.09
Lumbar fat	Stefan Spiker	0.7644	0.32	0.9352	0.32	0.9252	0.47	0.9444	0.37
(ultrascan)	Peter Moore	0.8026	0.39	0.7370	0.63	0.8525	0.65	0.8842	0.55
Lumbar EM	Stefan Spiker	0.6302	1.38	0.8229	1.00	0.8499	1.13	0.8714	1.18
(ultrascan)	Peter Moore	0.5249	1.30	0.8038	0.94	0.8095	1.10	0.8366	1.12
GR tissue	Chris Shands (r)	0.9055	0.76	0.9772	1.14	0.9811	0.88	0.9824	0.92
	Geoff Duddy (l)	0.9703	0.30	0.9911	0.55	0.9886	0.67	0.9931	0.50
CFAT (carcass)	Chris/Bill	0.5633	0.98	0.8294	2.34	0.8467	2.58	0.8947	1.94
CEMD (carcass)		0.6213	2.37	0.5713	3.12	0.4745	3.69	0.6077	3.05
LFAT (carcass)		0.5016	1.30	0.6887	2.58	0.8830	2.04	0.8797	1.94
LEMD (carcass)		0.2523	2.43	0.3902	2.95	0.3403	3.38	0.3616	2.91

- All fat and condition score assessors showed high repeatability in assessments on medium wool Merino ewes and 1st X ewes (individually for fat scorers 0. 89 to 0.94 and for condition scorers 0.78 to 0.91).
- Both fat scorers and condition scorers had less repeatability in assessments of the fine wool ewes (for fat scorers 0. 69 to 0.92 and for condition scorers 0.56 to 0.87).
- Across all ewe types the repeatability between assessments for fat scorers was 0.92 to 0.94 and for condition scorers was 0.83 to 0.93.
- Both assessors of GR tissue depth on the carcass were highly repeatable with correlations of 0.90 and 0.97. Assessors measured twice on one side of the

carcass. Although all live assessments were done on the right side of the animal both sides of the carcass were measured to examine differences between sides, as both sides were measured in comparison 1.The assessors used the same cut for each of the three runs (each assessor using their nominated side) and thus the runs were not completely independent and the repeatability is overstated.

- The subjective measures of condition and fat scores were just as repeatable as the objective measures of C-site fat and eye muscle depth.

Table 3 summarises the differences between the two replicates for the fat and condition scores.

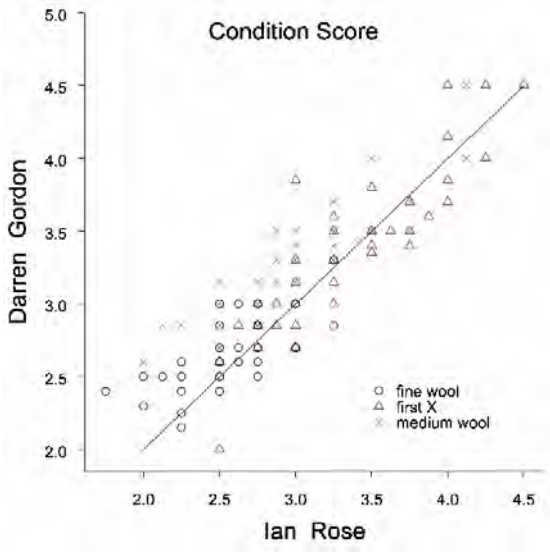
Table 3: Differences between replicates for the fat and condition scores.

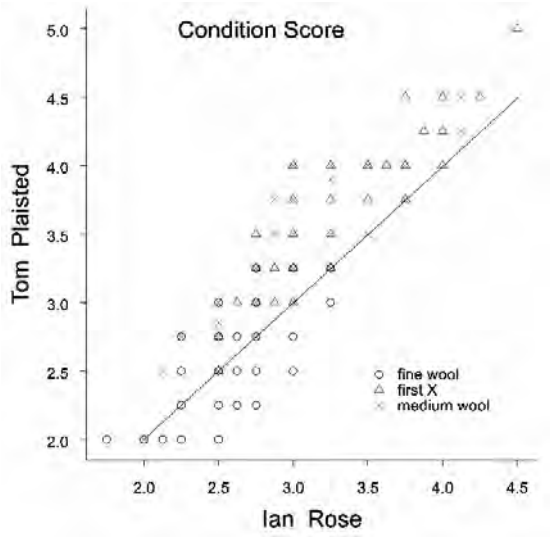
FS difference	Frequency (all FSers)	CS difference	Frequency (Ian/Tom)	Frequency (Darren/Katrina)
0 mm	26%	0	53%	53%
1 mm	34%	0.25	6%	**41%**
2 mm	20%	0.5	**39%**	4%
3 mm	11%	0.75	-	1%
4 mm	5%	1	1%	1%
5 mm	2%	>1	-	-
6 mm	1%			
6-9mm	1%			
>9mm	-			
Average	**1.5mm**	**Average**	**0.23**	**0.14**

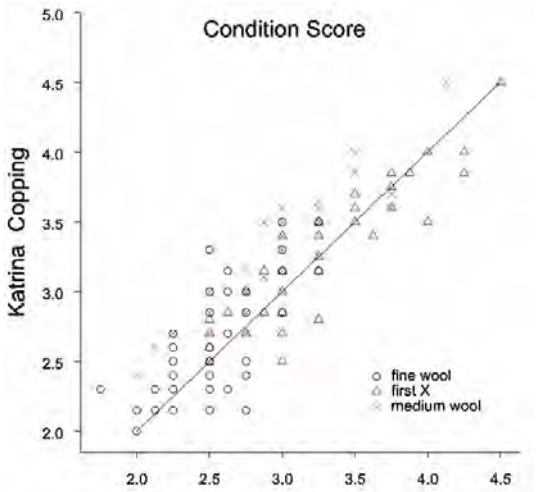
This shows that both condition scoring and fat scoring are highly repeatable, with generally small differences between repeated scores. This is similar to the results of Stage 1exercise. Within CS, Darren and Katrina were more repeatable, most likely because they scored in quarters, while Tom and Ian scored generally in halves. Thus condition scoring in quarters (*i.e.* 2.25, 2.5 etc) would seem to increase accuracy.

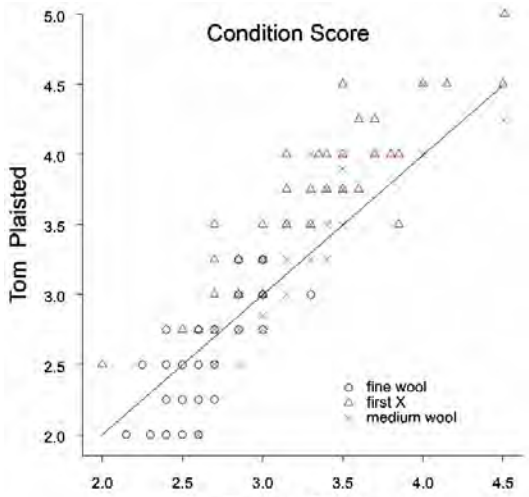
4.2 Comparisons between condition scorers

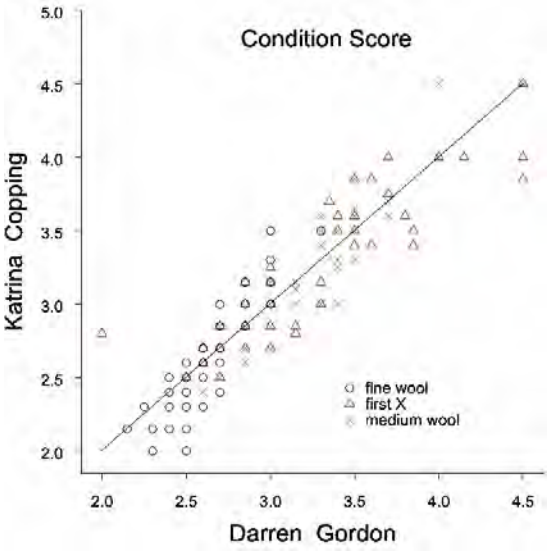
The following graphs show the average condition scores assigned to each sheep by each pair of assessors. The line represents perfect agreement.

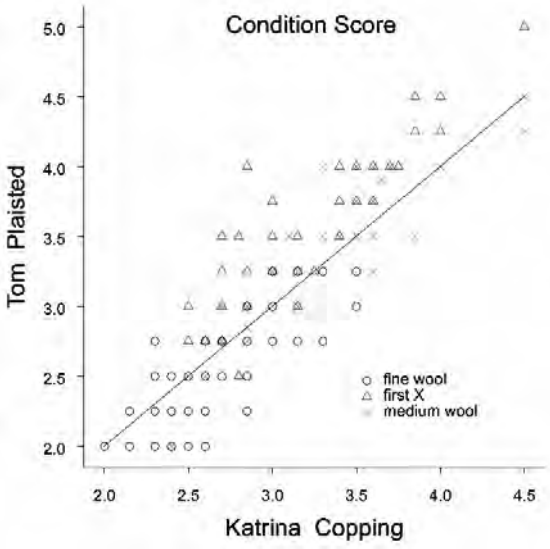

Condition Score
Darren Gordon
Ian Rose
fine wool
first X
medium wool


Condition Score
Tom Plaisted
Ian Rose
fine wool
first X
medium wool


Condition Score
Katrina Copping
fine wool
first X
medium wool


Condition Score
Tom Plaisted
fine wool
first X
medium wool


Condition Score
Katrina Copping
Darren Gordon
fine wool
first X
medium wool


Condition Score
Tom Plaisted
Katrina Copping
fine wool
first X
medium wool

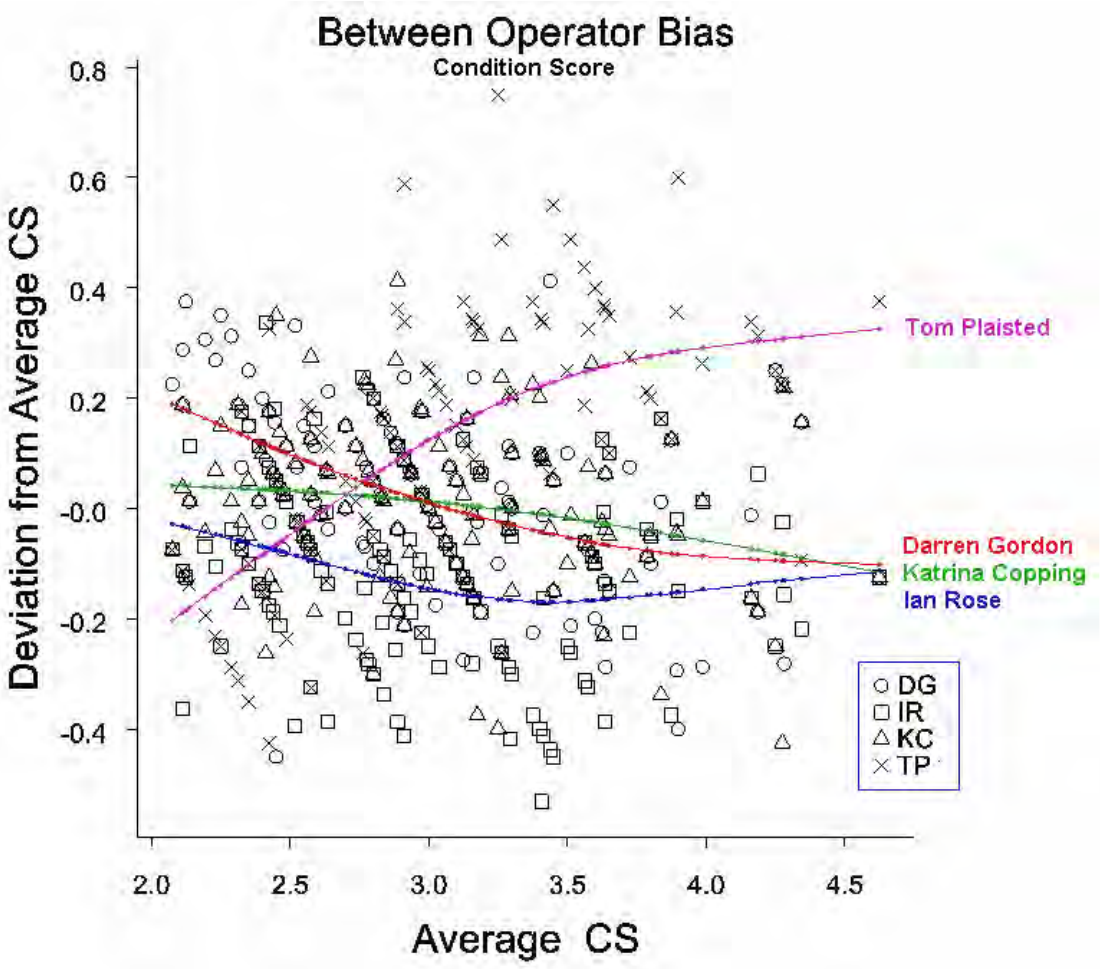
Correlation matrix

Ian_Rose	1.000			
Darren_Gordon	0.886	1.000		
Tom_Plaisted	0.898	0.899	1.000	
Katrina_Copping	0.888	0.915	0.901	1.000
	Ian	Darren	Tom	Katrina

- The correlations between condition score assessors were generally very good at about 0.9.

4.3 Bias between condition scorers (against average scores)

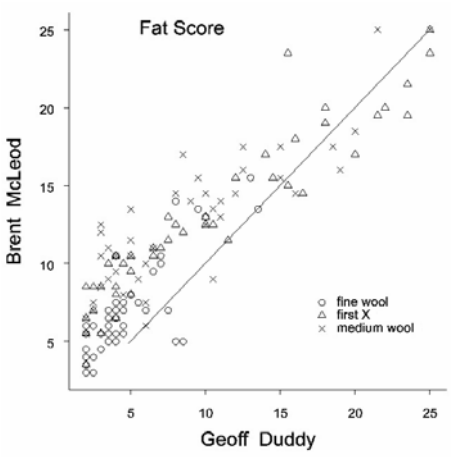
This graph (below) plots the average score assigned to each sheep (X axis) against how much each assessors average differs from that average (Y axis). A best fitting cubic spline is included for each assessor to show how the bias changed across the range of condition scores.

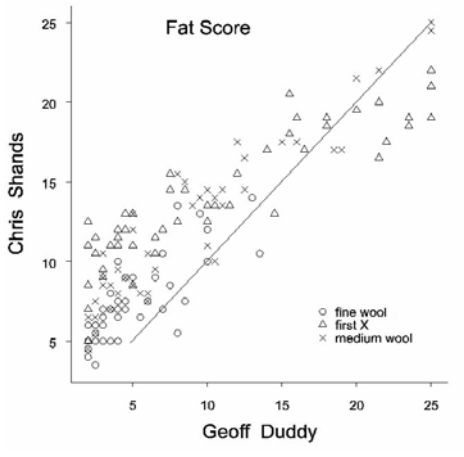


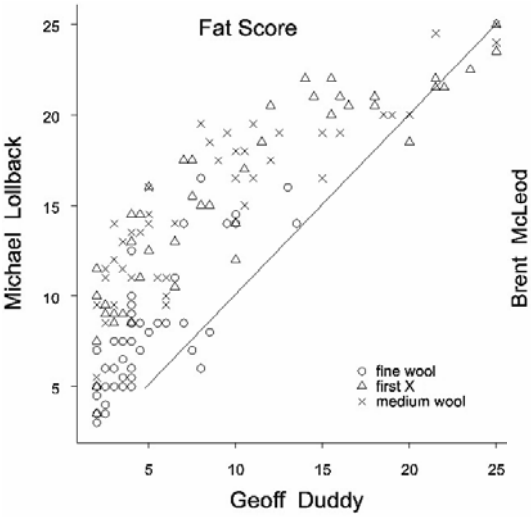
This shows that against average CS scores for all assessors one assessor was 0.4 of a condition score above the average.

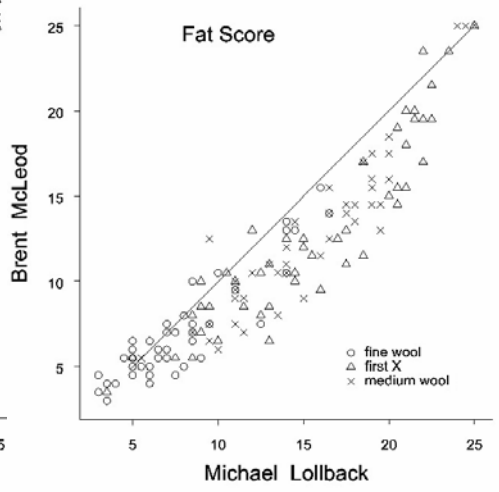
4.4 Comparisons between fat scorers (against average fat scores)

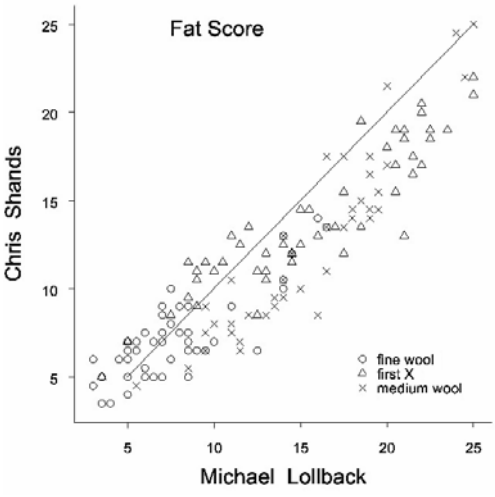
These graphs show the average fat scores assigned to each sheep by each pair of assessors. The line represents perfect agreement.

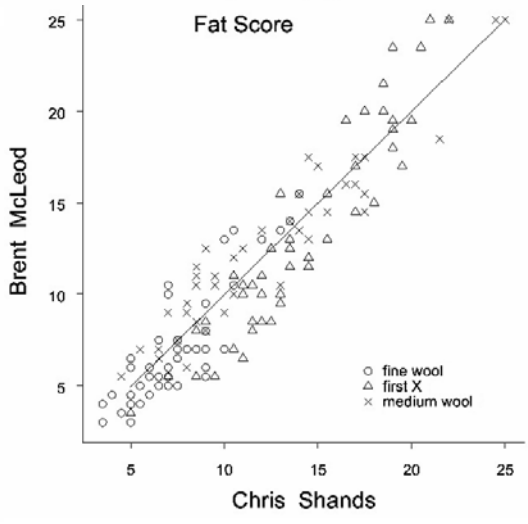












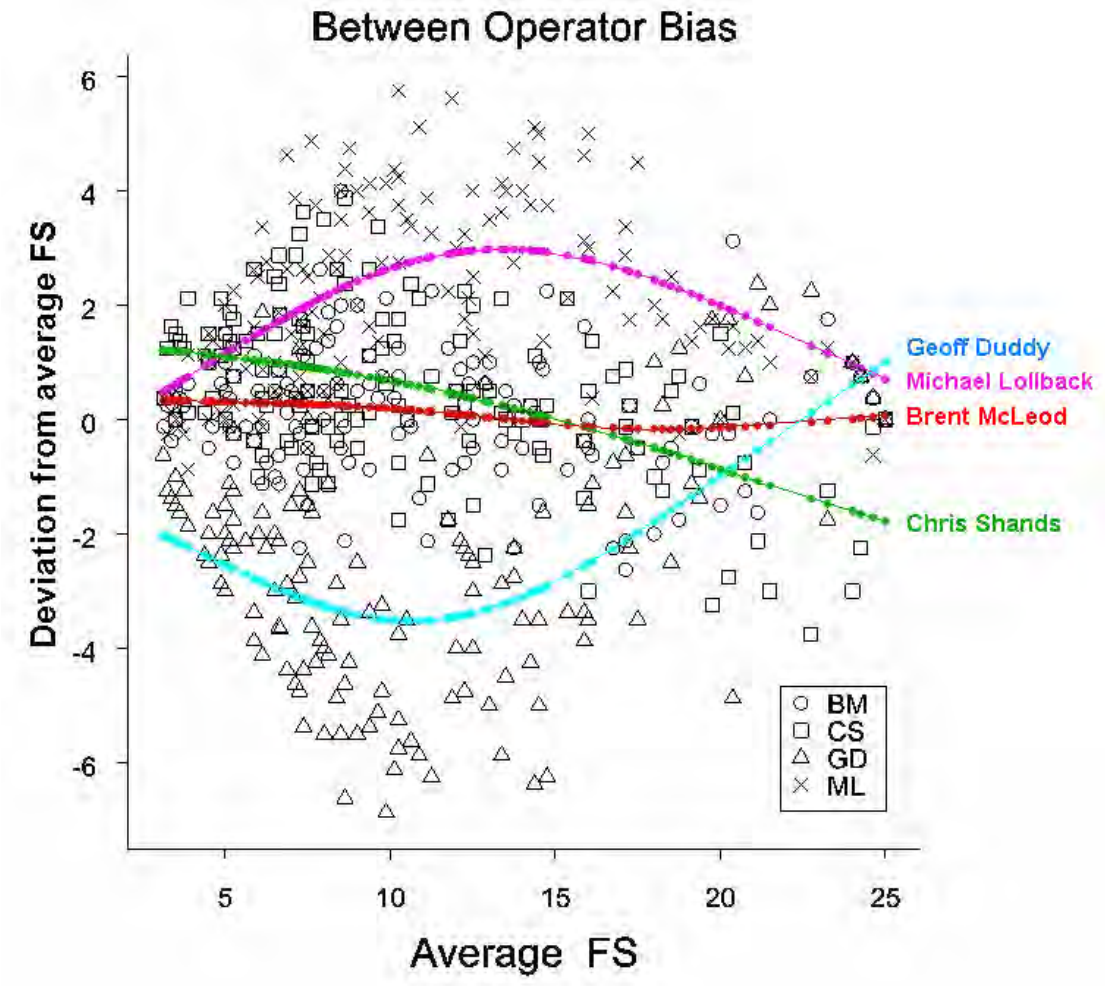
Correlation matrix

Brent_McLeod	1.000			
Chris_Shands	0.933	1.000		
Geoff_Duddy	0.911	0.883	1.000	
Michael_Lollback	0.939	0.921	0.859	1.000
	Brent	Chris	Geoff	Michael

- The correlation between fat score assessors was generally very good at about 0.9

4.5 Bias between fat scorers (against average scores)

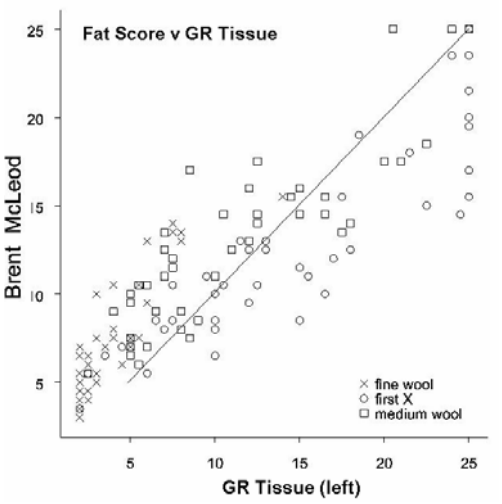
This graph (below) plots the average score assigned to each sheep (X axis) against how much each assessors average differs from that average (Y axis). A best fitting cubic spline is included for each assessor to show how the bias changed across the range of fat scores.

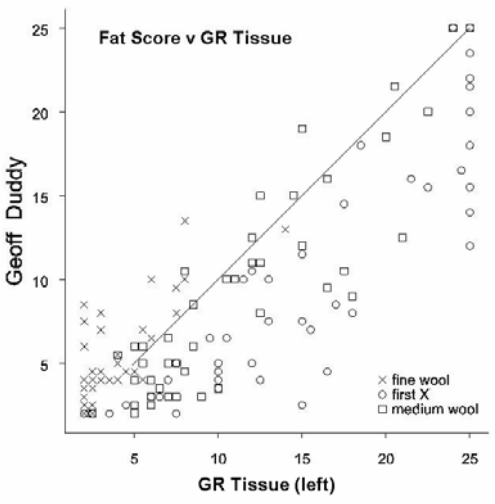


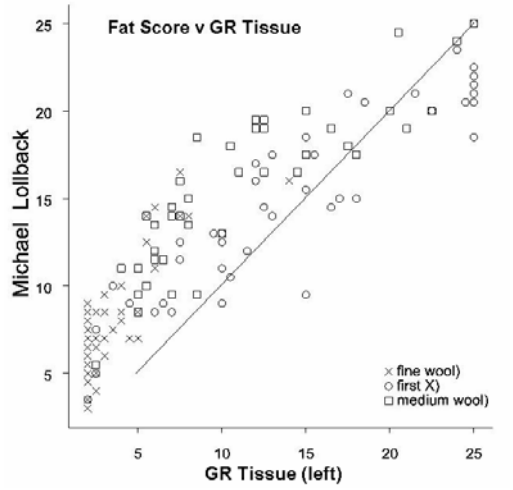
This shows that one assessor showed a bias of 3 mm above the average fat score assessed in mm GR live and another 3 mm below.

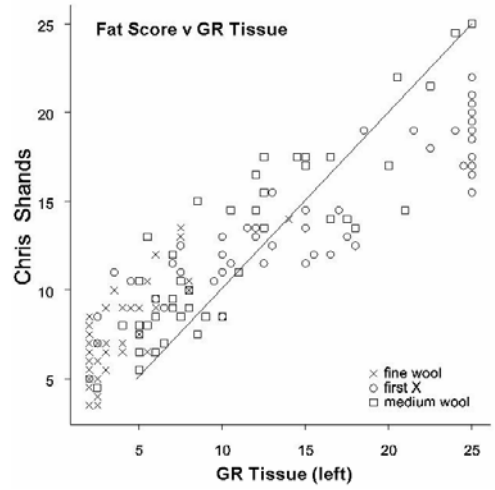
4.6 Comparison between fat score assessments and actual GR tissue depth measured on the carcass

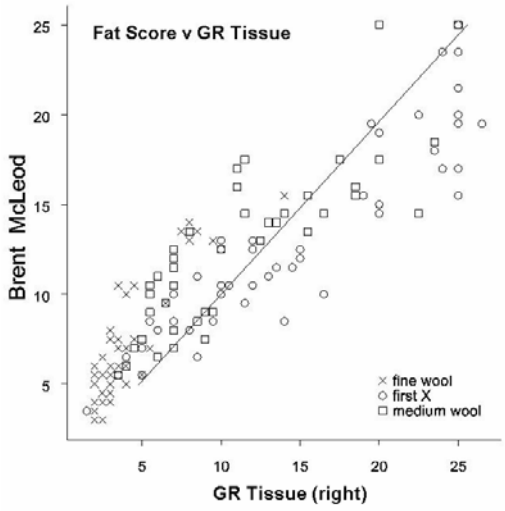
These graphs compare each assessors fat score (GR mm) with the GR Tissue depths (GR mm) measured on the carcasses for each ewe genotype by Geoff Duddy (left side), Chris Shands (right side) and the average of those GR Tissue depths. The line represents perfect agreement.

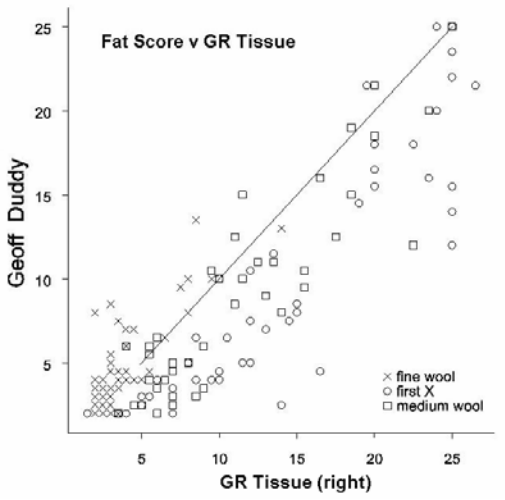


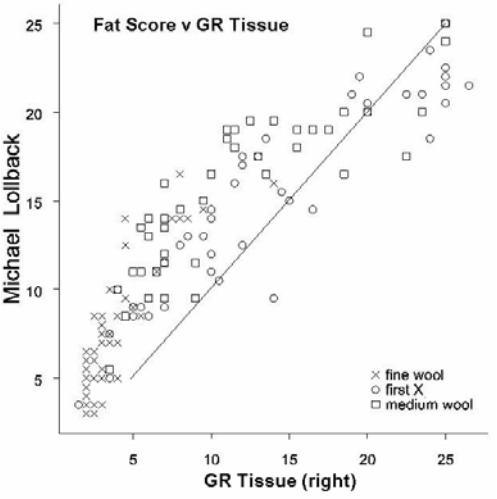


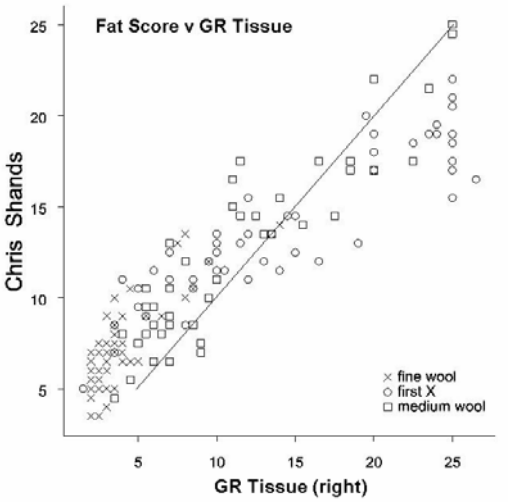


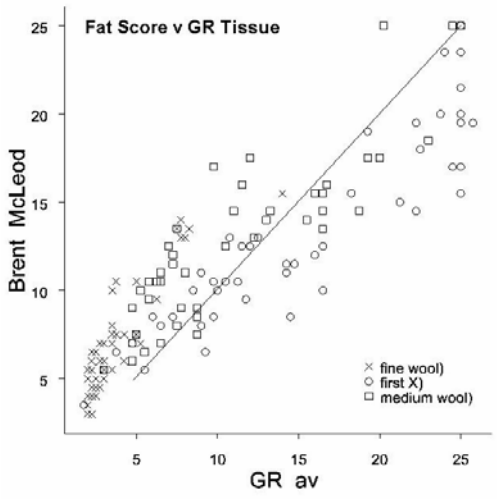


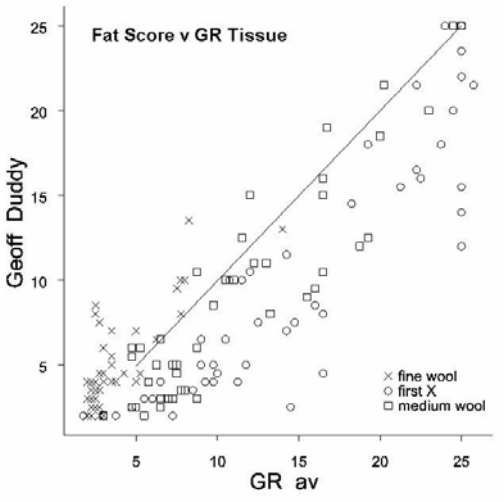

Fat Score v GR Tissue
Brent McLeod
GR Tissue (right)
fine wool
first X
medium wool


Fat Score v GR Tissue
Geoff Duddy
GR Tissue (right)
fine wool
first X
medium wool


Fat Score v GR Tissue
Michael Lollback
GR Tissue (right)
fine wool
first X
medium wool


Fat Score v GR Tissue
Chris Shands
GR Tissue (right)
fine wool
first X
medium wool


Fat Score v GR Tissue
Brent McLeod
GR av
fine wool)
first X)
medium wool)


Fat Score v GR Tissue
Geoff Duddy
GR av
fine wool
first X
medium wool

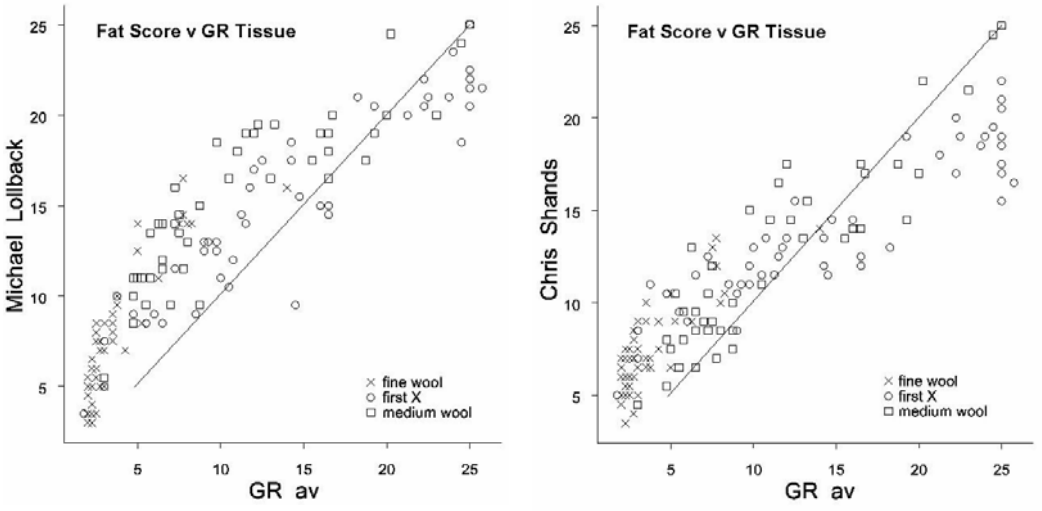


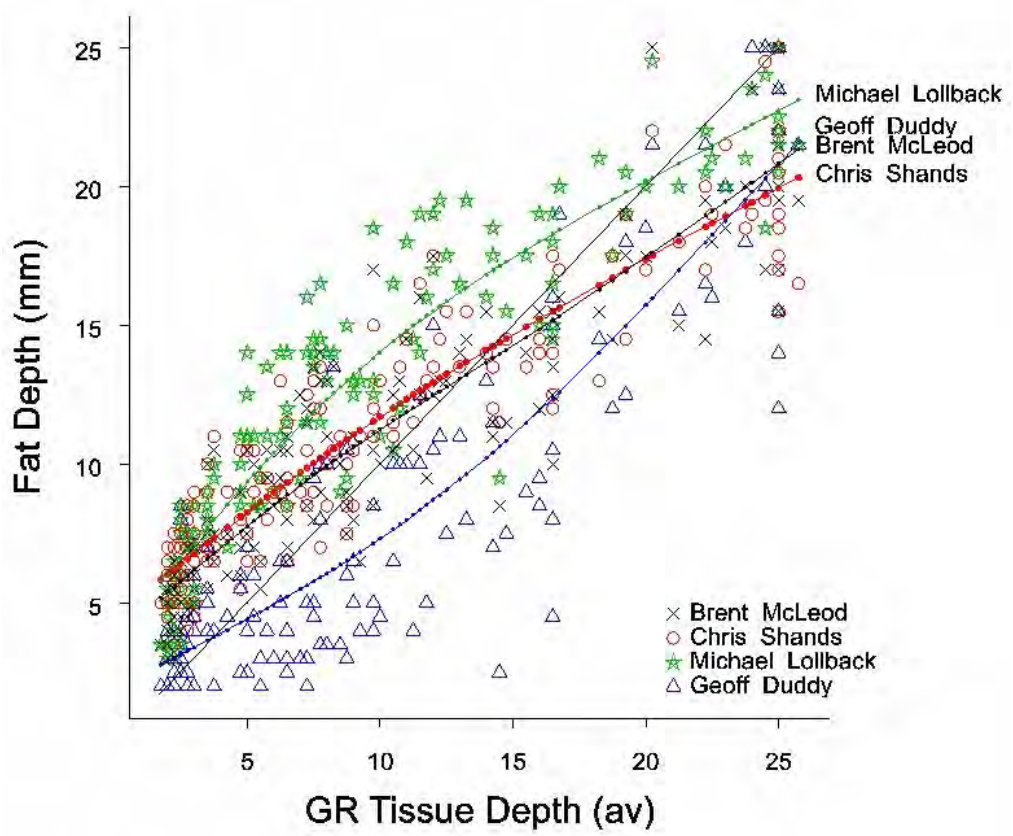
Table 4: Average fat scorer bias against average carcass GR tissue depth

	Average bias			Root mean squared error		
	fine wool	medium wool	first X	fine wool	medium wool	first X
Brent McLeod	3.275	1.670	-1.823	3.585	3.307	3.749
Chris Shands	3.595	1.341	-0.917	3.866	2.778	4.338
Michael Lollback	4.025	4.273	0.760	4.457	5.183	3.146
Geoff Duddy	1.125	-2.102	-4.427	1.954	3.295	5.560

Table 4 quantifies what can be seen in section 4.6 for each ewe breed where each assessors fat score (GR mm) is compared with the GR Tissue depths (GR mm) measured on the carcasses for each ewe genotype. The assessors tend to overestimate fat scores for lighter (*i.e.* fine wool) sheep – average bias is positive. They tend to underestimate fat scores for heavier (*i.e.* medium wool and first cross) sheep – average bias is negative. Root mean squared error is a measure of consistency for the assessors within each class of sheep – Brent McLeod and Chris Shands had similar variation in all three classes, Michael Lollback and Geoff Duddy were a bit less consistent.

4.7 Fat scorer bias compared to actual GR measured on the carcass

This graph plots the average manual fat score (in mm GR and described as Fat depth mm) assigned to each sheep by palpation by each fat scorer against the actual GR tissue depth (mm) measured at the corresponding site on the carcass. All ewe breeds are combined.



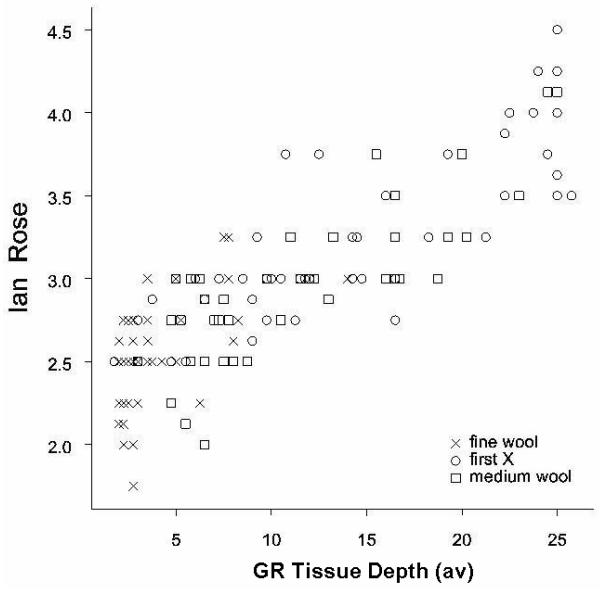
Fat depth refers to the average assessed fat score in GR mm for each assessor.

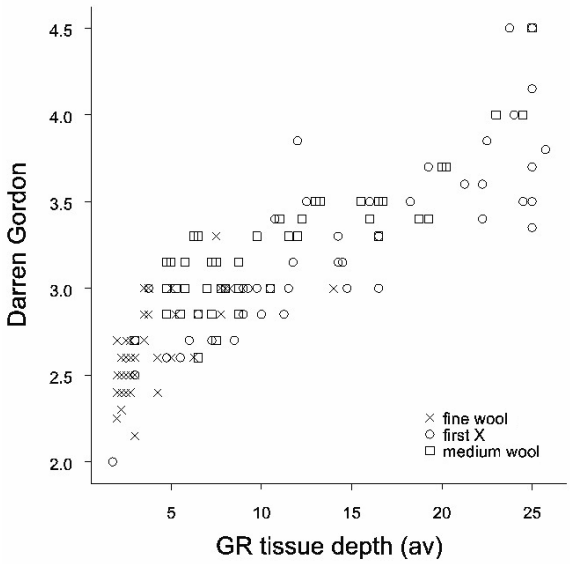
The below graph is another representation of the fat scorer biases, compared to actual carcass GR measures using data from all three genotypes.

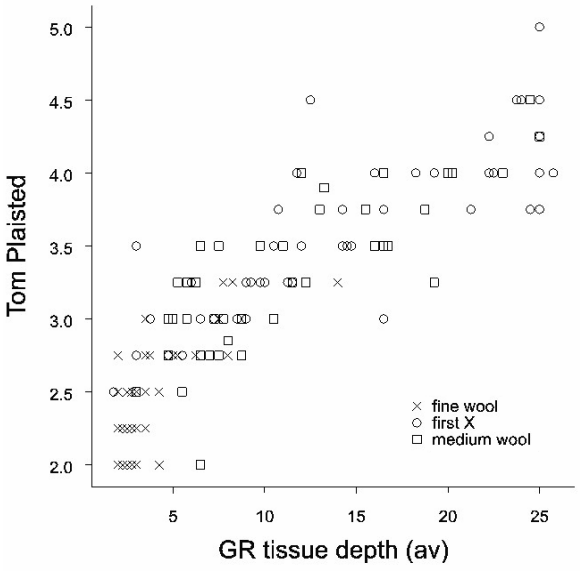
Each operator's bias changes depending on the fatness of the animal. Geoff had lower bias for the low fat sheep, while the other operators had less bias for the very fat sheep.

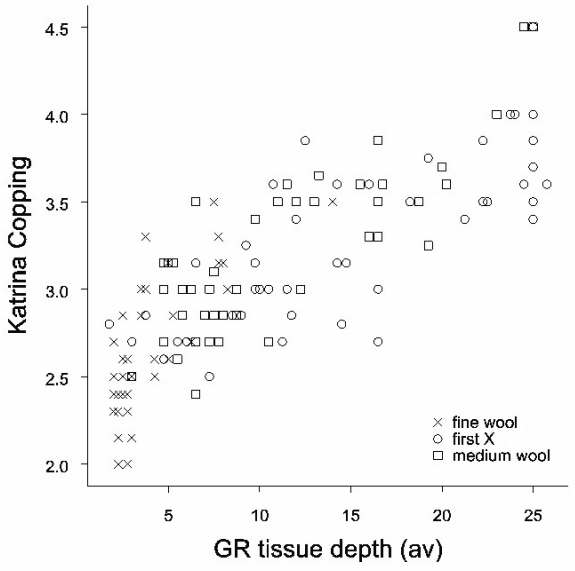
4.8 Comparison between condition score assessments and actual GR tissue depth measured on the carcass

These graphs (below) compare each assessors condition score with the average GR tissue depth.

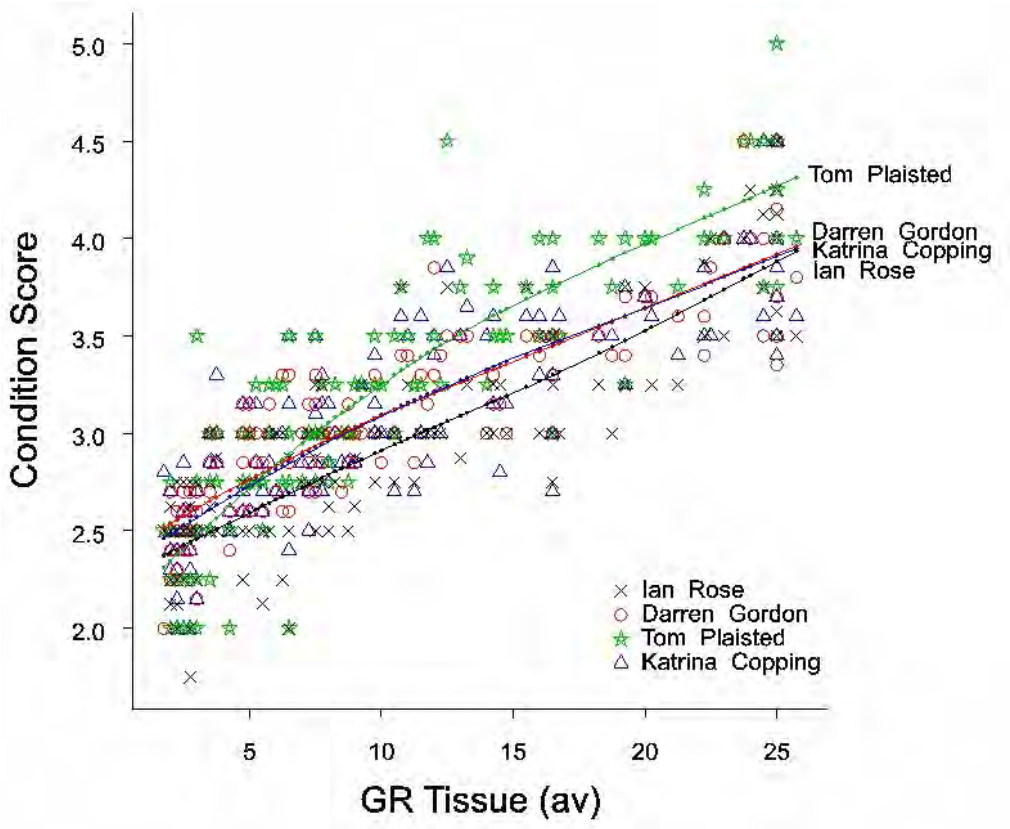






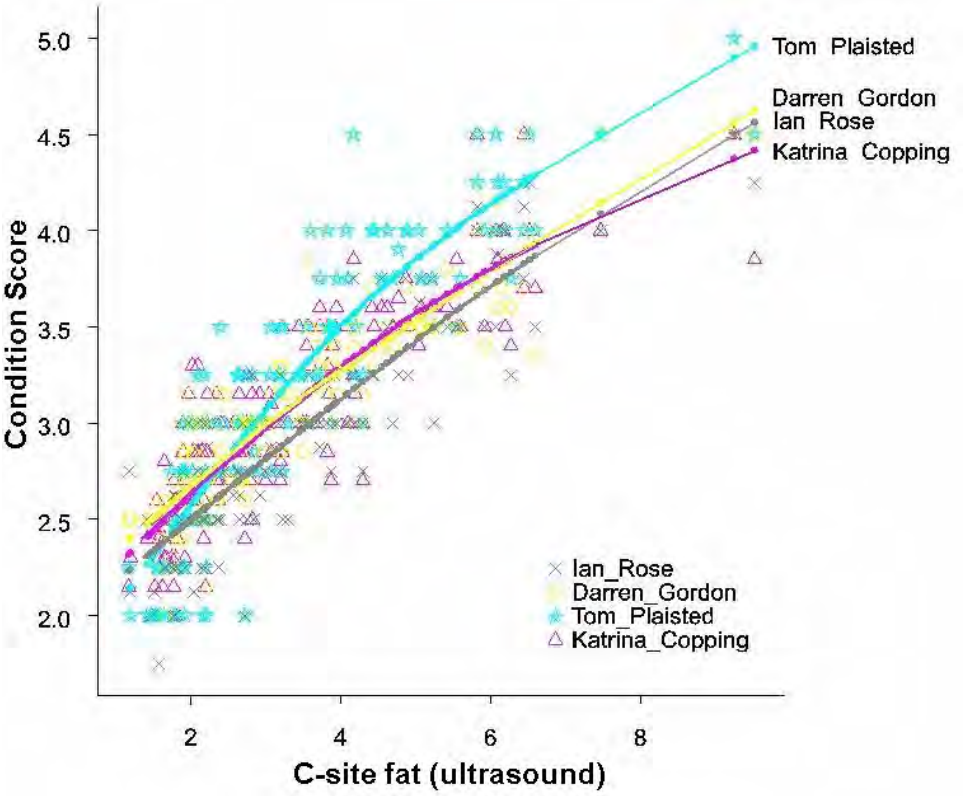


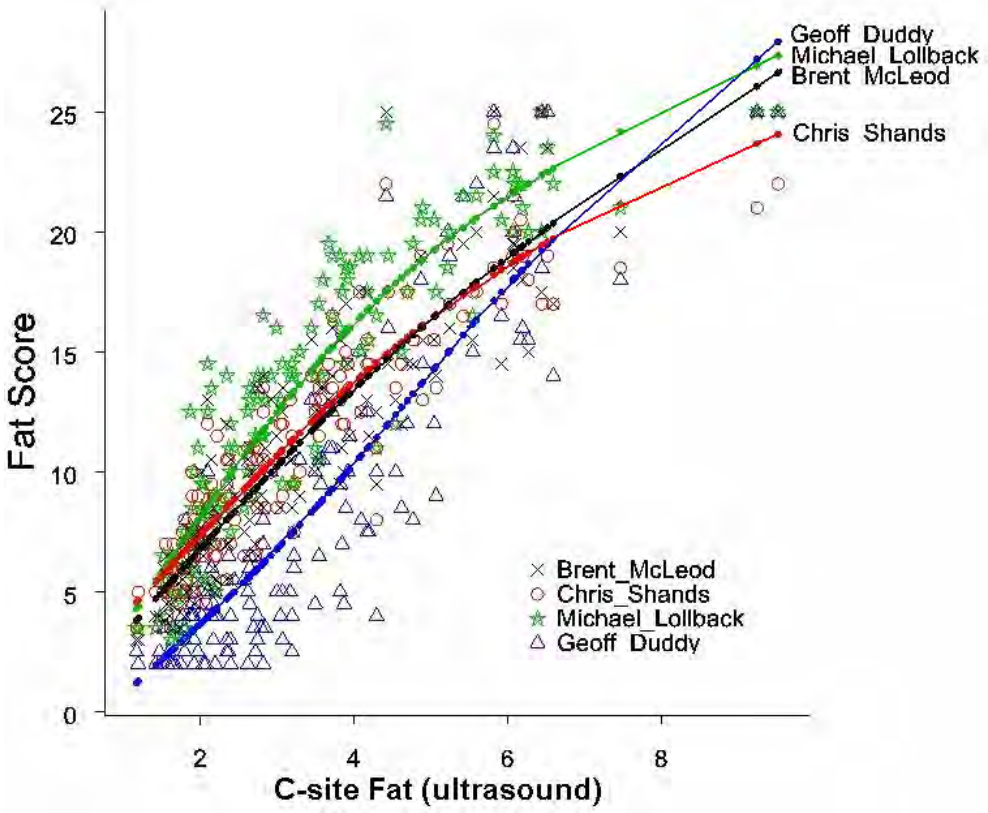
4.9 Condition scorer bias compared to actual GR measured on the carcass



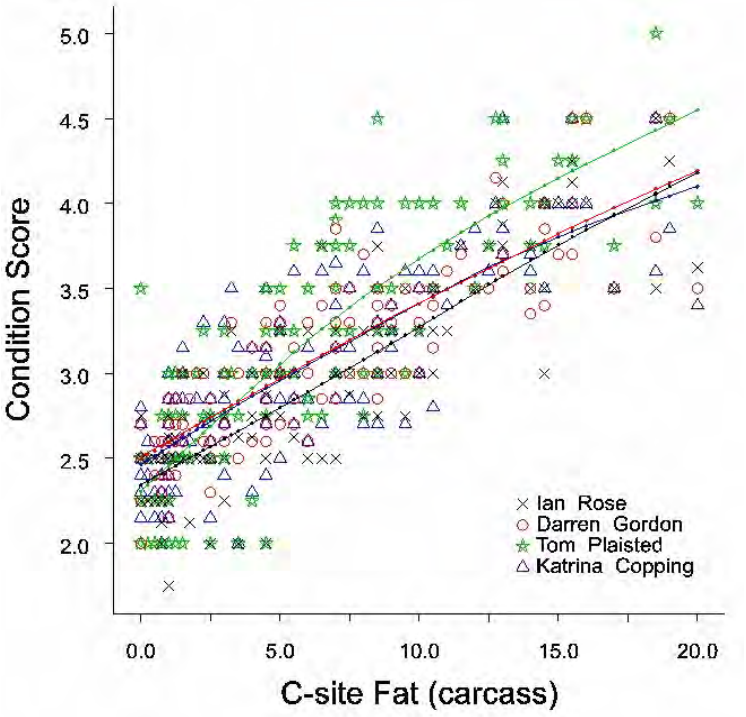
4.10 The relationships between individual condition scores or fat scores and the average C-site fat, measured by ultrasound

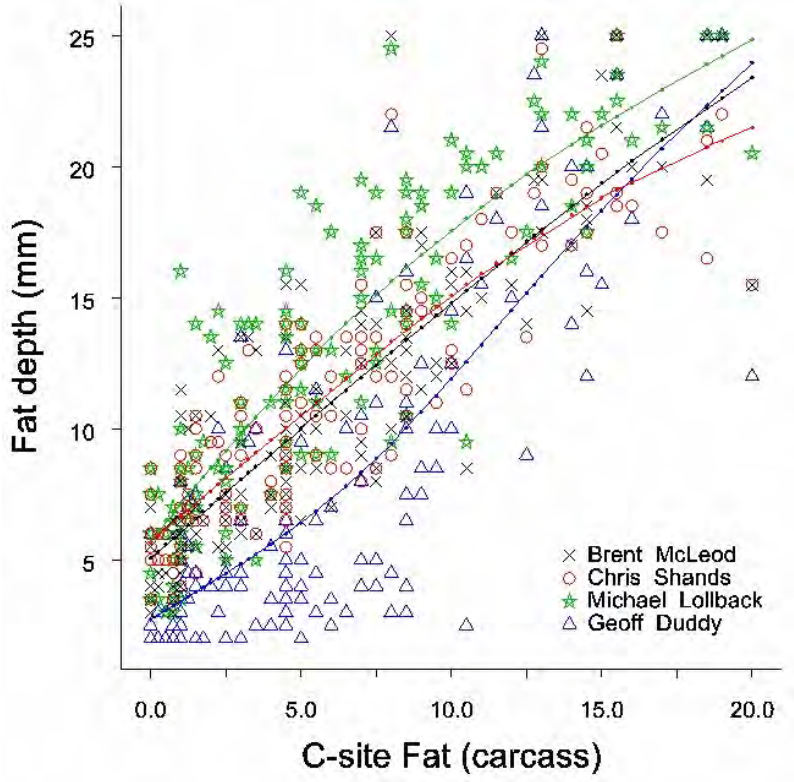
These graphs show that there is a good relationship between condition score, fat score and c-site fat measured by ultrasound or on the carcass. To compare the relationships for the four assessors for condition score and fat score a smoothing spline was fitted for each.


Condition Score
C-site fat (ultrasound)
Tom Plaisted
Darren Gordon
Ian Rose
Katrina Copping
Ian_Rose
Darren_Gordon
Tom_Plaisted
Katrina_Copping


Fat Score
C-site Fat (ultrasound)
Geoff Duddy
Michael Lollback
Brent McLeod
Chris Shands
Brent_McLeod
Chris_Shands
Michael_Lollback
Geoff Duddy

4.11 The relationships between individual condition scores or fat scores and the average C-site fat measured on the carcass





Tables 5 and 6 focus on the relationships between individual condition scores or fat scores and the average C-site fat, measured by ultrasound or on the carcass.
Average prediction error in these tables is calculated as the absolute difference between the predicted C-site fat (from a spline fit of C-site fat v condition/fat score) and the average C-site fat measured by ultrasound or on the carcass.

Table 5: Relationships between individual condition scores or fat scores and the average C-site fat, measured by ultrasound

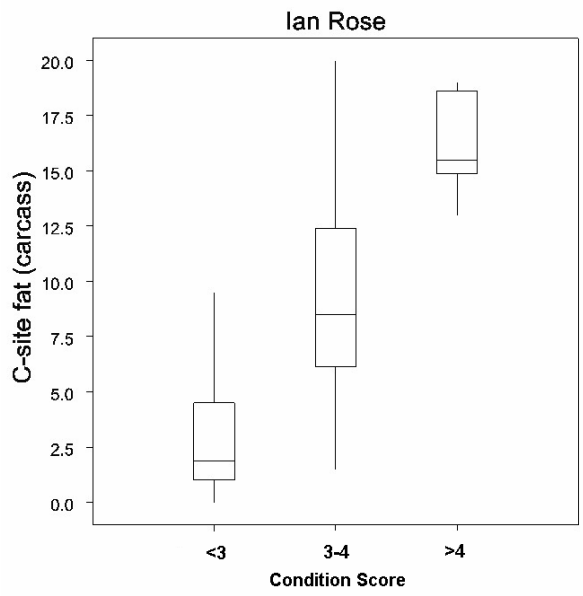
C-site fat (ultrasound)		Average Prediction Error			Approx. 95% C.I. (+/- 2*SD)		
	Assessor	Fine wool	Medium wool	First X	Fine wool	Medium wool	First X
CS	Ian Rose	0.45	0.55	0.66	±0.76	+/-0.90	+/-1.06
	Darren Gordon	0.31	0.58	0.62	±0.58	+/-0.77	+/-1.07
	Tom Plaisted	0.32	0.61	0.53	±0.54	+/-0.91	+/-0.94
	Katrina Copping	0.43	0.54	0.70	±0.78	+/-0.94	+/-1.10
FS	Brent McLeod	0.38	0.68	0.63	±0.72	+/-1.42	+/-0.96
	Chris Shands	0.31	0.63	0.57	±0.54	+/-1.00	+/-1.23
	Michael Lollback	0.26	0.57	0.48	±0.56	+/-0.83	+/-0.87
	Geoff Duddy	0.56	0.55	0.77	±0.80	+/-0.89	+/-1.11

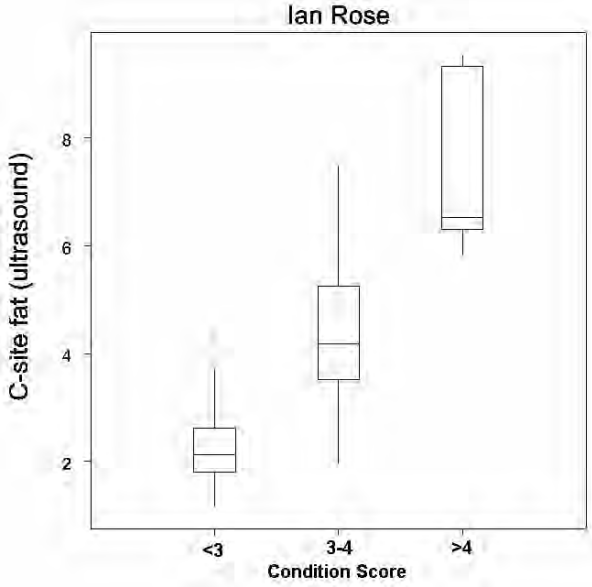
Table 6: Relationships between individual condition scores or fat scores and the average C-site fat, measured on the carcass

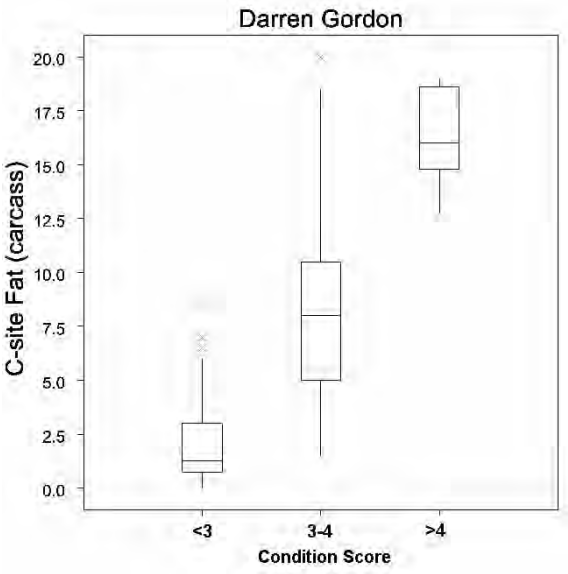
C-site fat (carcass)		Average Prediction Error			Approx. 95% C.I. (+/- 2*SD)		
	Assessor	Fine wool	Medium wool	First X	Fine wool	Medium wool	First X
CS	Ian Rose	1.78	1.93	2.16	+/-2.71	+/-3.39	+/-3.84
	Darren Gordon	1.47	1.90	2.43	+/-2.24	+/-2.59	+/-4.03
	Tom Plaisted	1.25	2.43	1.73	+/-2.07	+/-2.59	+/-2.33
	Katrina Copping	1.97	1.94	2.77	+/-3.18	+/-2.79	+/-4.64
FS	Brent McLeod	1.49	1.75	1.73	+/-3.07	+/-2.99	+/-2.89
	Chris Shands	1.25	1.96	1.73	+/-2.17	+/-2.80	+/-2.63
	Michael Lollback	1.25	1.94	2.05	+/-2.31	+/-3.25	+/-3.65
	Geoff Duddy	2.39	2.01	2.48	+/-2.63	+/-3.47	+/-4.14

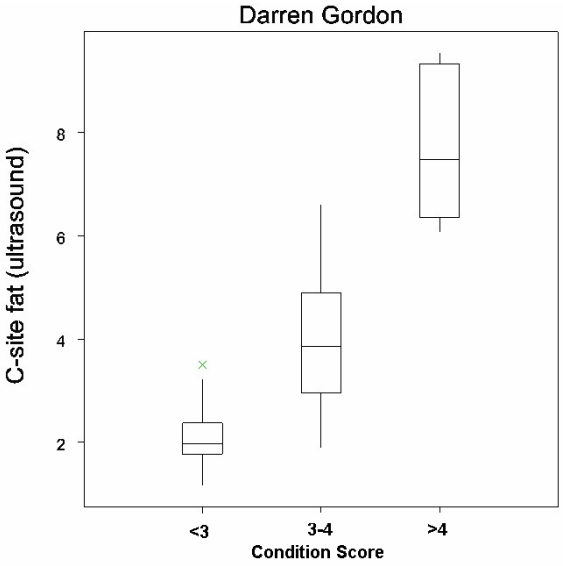
There is clearly little difference between condition scoring and fat scoring – average prediction errors and confidence intervals are about the same for both (Tables 5 & 6). Both condition scores and fat scores tend to predict ultrasound measurements of C-site fat better than they predict the carcass measurements (*i.e.* average prediction errors and confidence intervals are smaller for ultrasound than for carcass measurements).

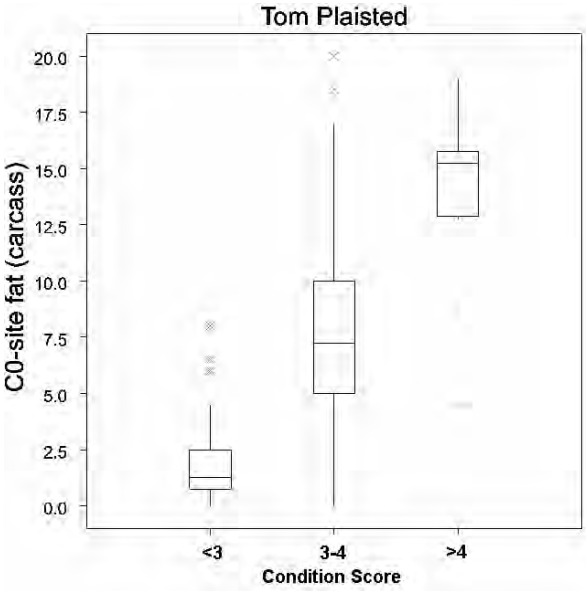
The boxes in these plots (below) represent the middle half of the values in each class, the lines in each box represent the median value and the vertical lines reach out to the maximum and minimum values. The Condition Score classes for each box plot reflect the available data - <3 is predominantly >2, and >4 is predominantly <5.

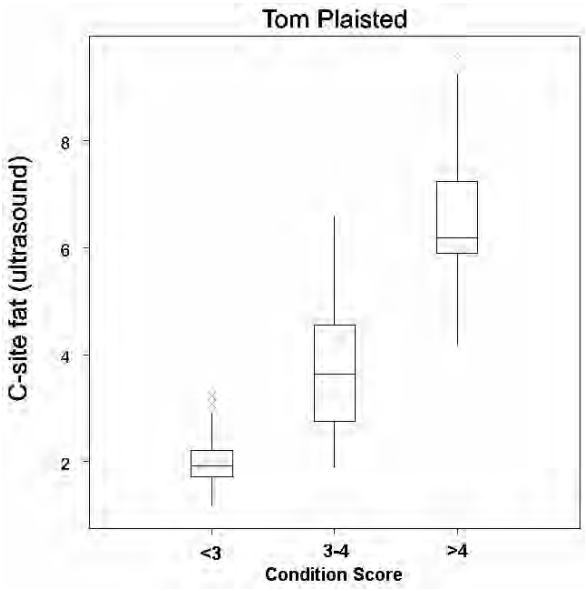

Ian Rose
C-site fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
<3
3-4
>4
Condition Score

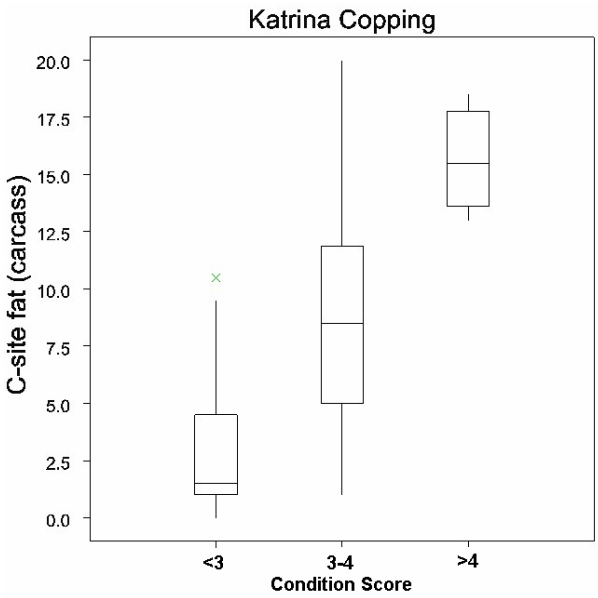

Ian Rose
C-site fat (ultrasound)
8
6
4
2
<3
3-4
>4
Condition Score

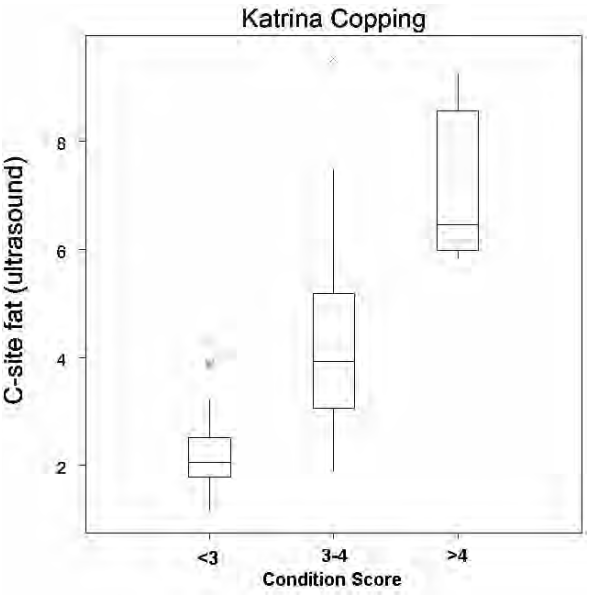

Darren Gordon
C-site Fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
<3
3-4
>4
Condition Score

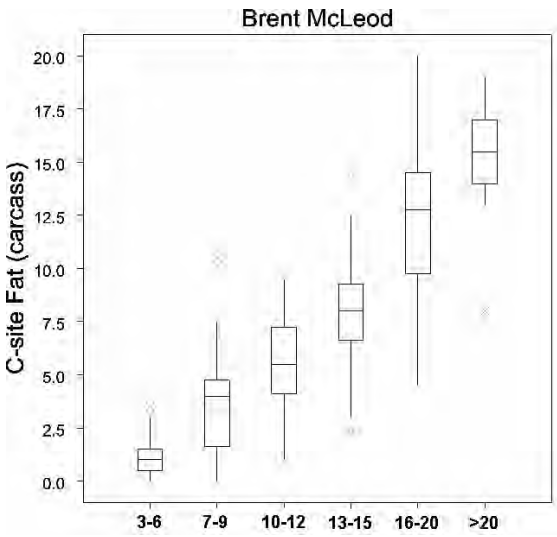

Darren Gordon
C-site fat (ultrasound)
8
6
4
2
<3
3-4
>4
Condition Score

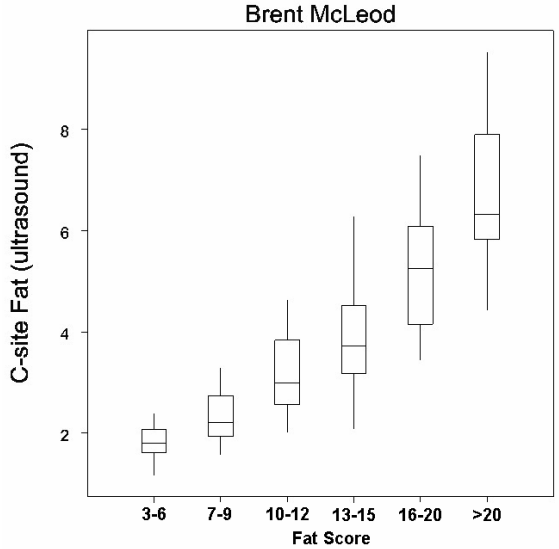

Tom Plaisted
C0-site fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
<3
3-4
>4
Condition Score

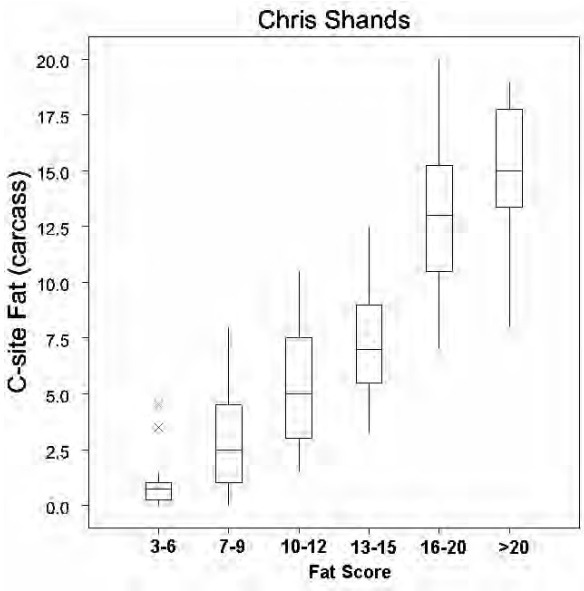

Tom Plaisted
C-site fat (ultrasound)
8
6
4
2
<3
3-4
>4
Condition Score

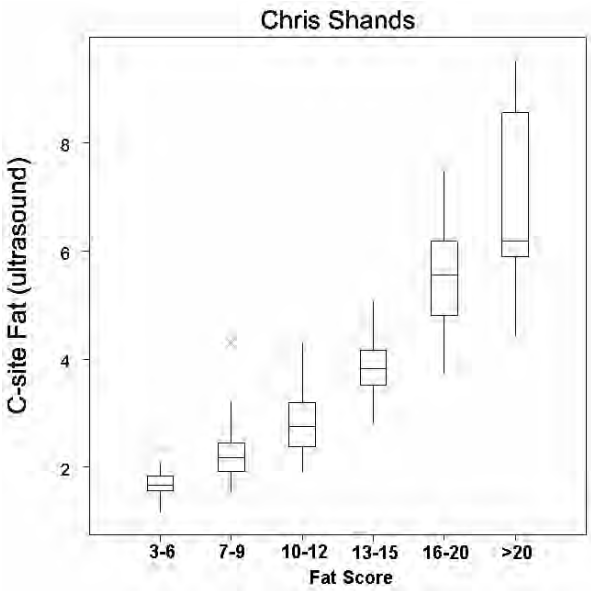

Katrina Copping
C-site fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
<3
3-4
>4
Condition Score

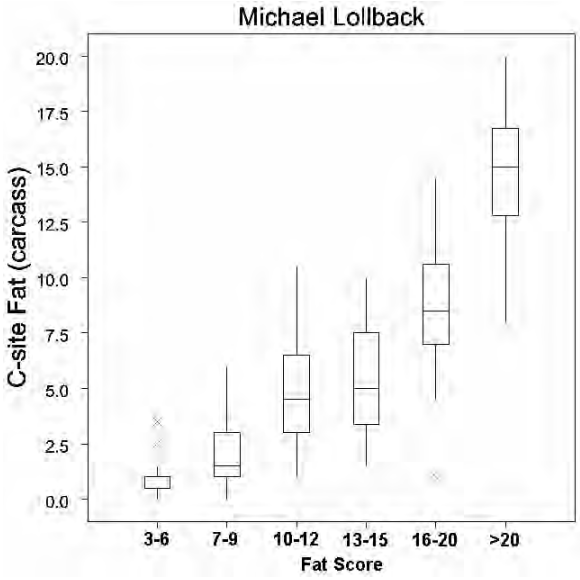

Katrina Copping
C-site fat (ultrasound)
8
6
4
2
<3
3-4
>4
Condition Score

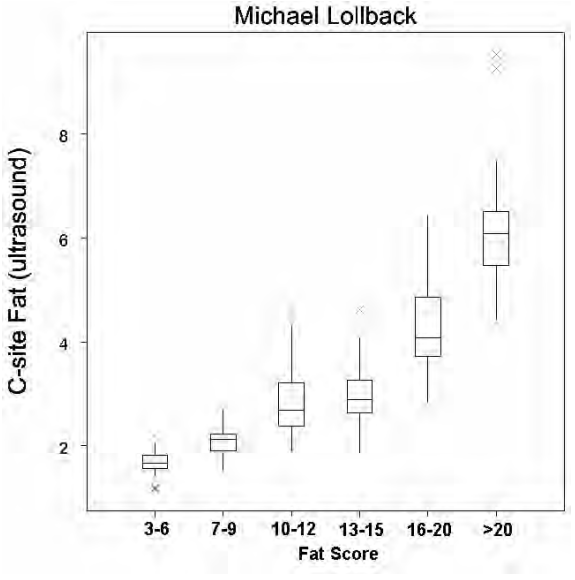

Brent McLeod
C-site Fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
3-6
7-9
10-12
13-15
16-20
>20

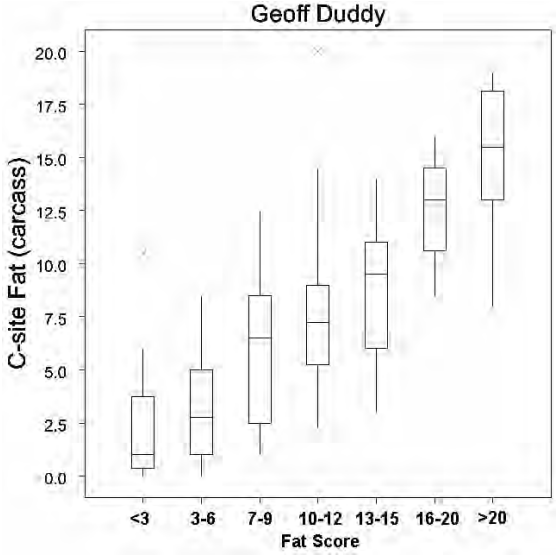

Brent McLeod
C-site Fat (ultrasound)
8
6
4
2
3-6
7-9
10-12
13-15
16-20
>20
Fat Score

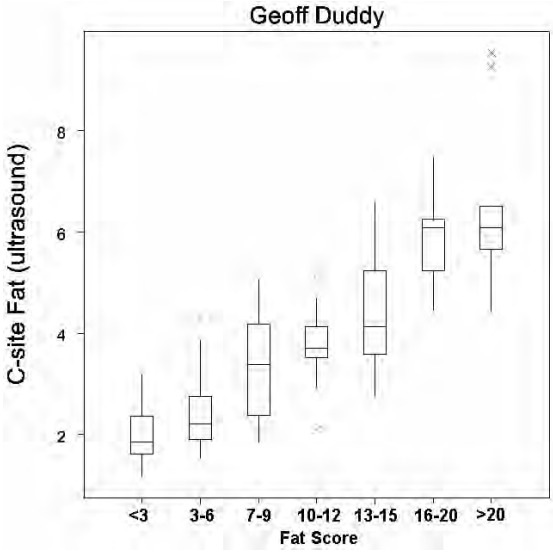

Chris Shands
C-site Fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
3-6
7-9
10-12
13-15
16-20
>20
Fat Score


Chris Shands
C-site Fat (ultrasound)
8
6
4
2
3-6
7-9
10-12
13-15
16-20
>20
Fat Score


Michael Lollback
C-site Fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
3-6
7-9
10-12
13-15
16-20
>20
Fat Score

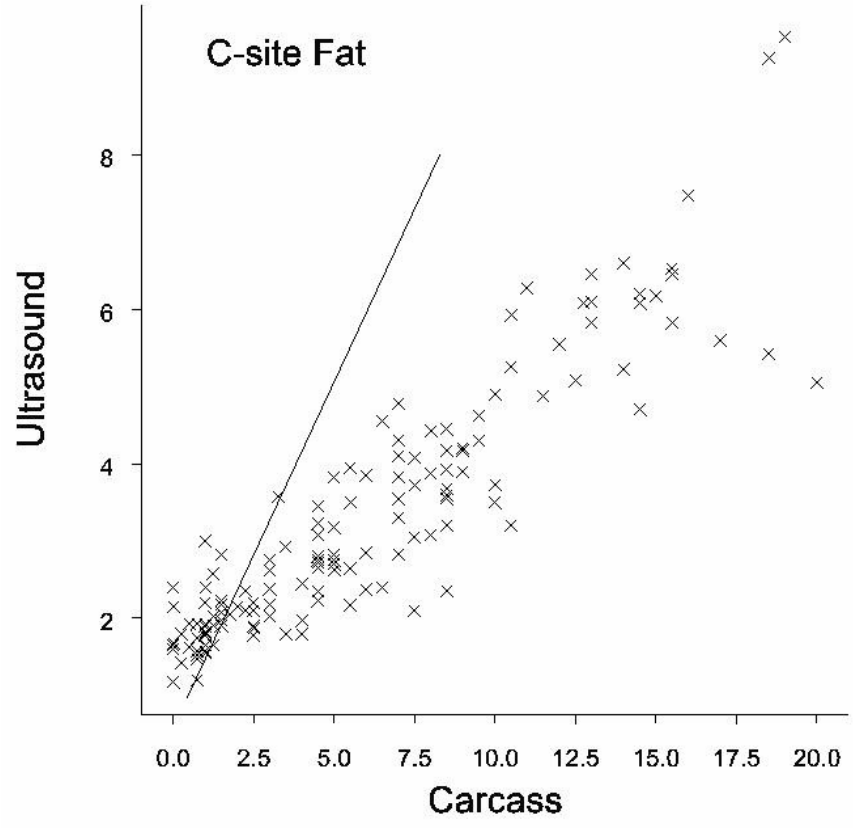

Michael Lollback
C-site Fat (ultrasound)
8
6
4
2
3-6
7-9
10-12
13-15
16-20
>20
Fat Score


Geoff Duddy
C-site Fat (carcass)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
<3
3-6
7-9
10-12
13-15
16-20
>20
Fat Score


Geoff Duddy
C-site Fat (ultrasound)
8
6
4
2
<3
3-6
7-9
10-12
13-15
16-20
>20
Fat Score

4.12 Comparison of ultrasound and carcass measurements of C-site fat on the same sheep

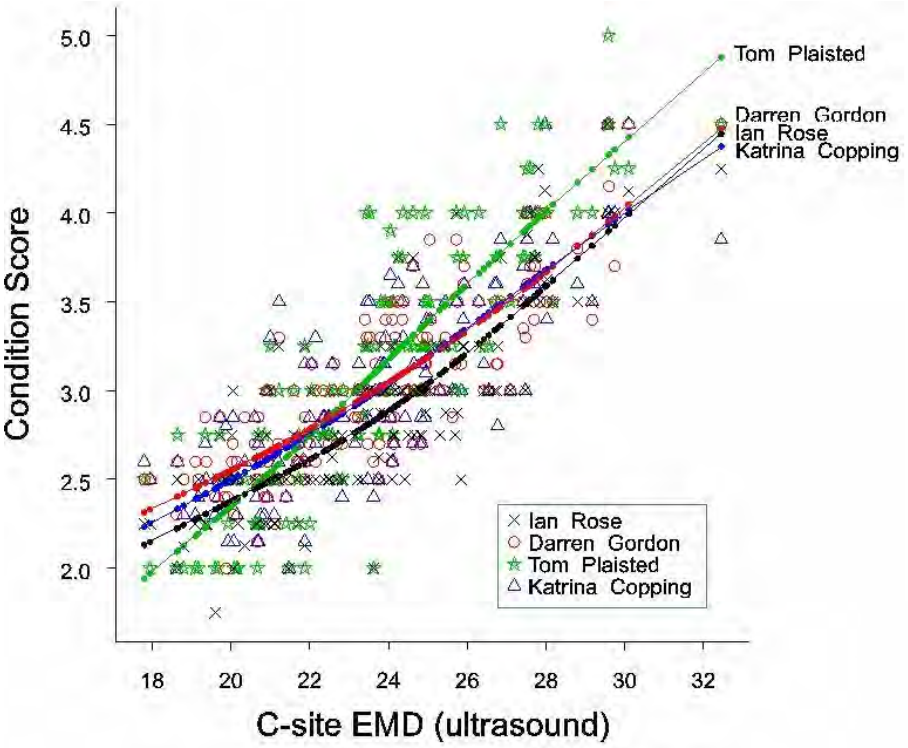
This graph shows a comparison of ultrasound and carcass measurements of C-site fat on the same sheep – the ultrasound measurements appear to be detecting about half the fat measured on the carcasses. The sonographers would normally work with sheep that were in the range of 0 to 7 mm C Fat. There is a possible question as to the calibration capability of the scanners at high fat levels.

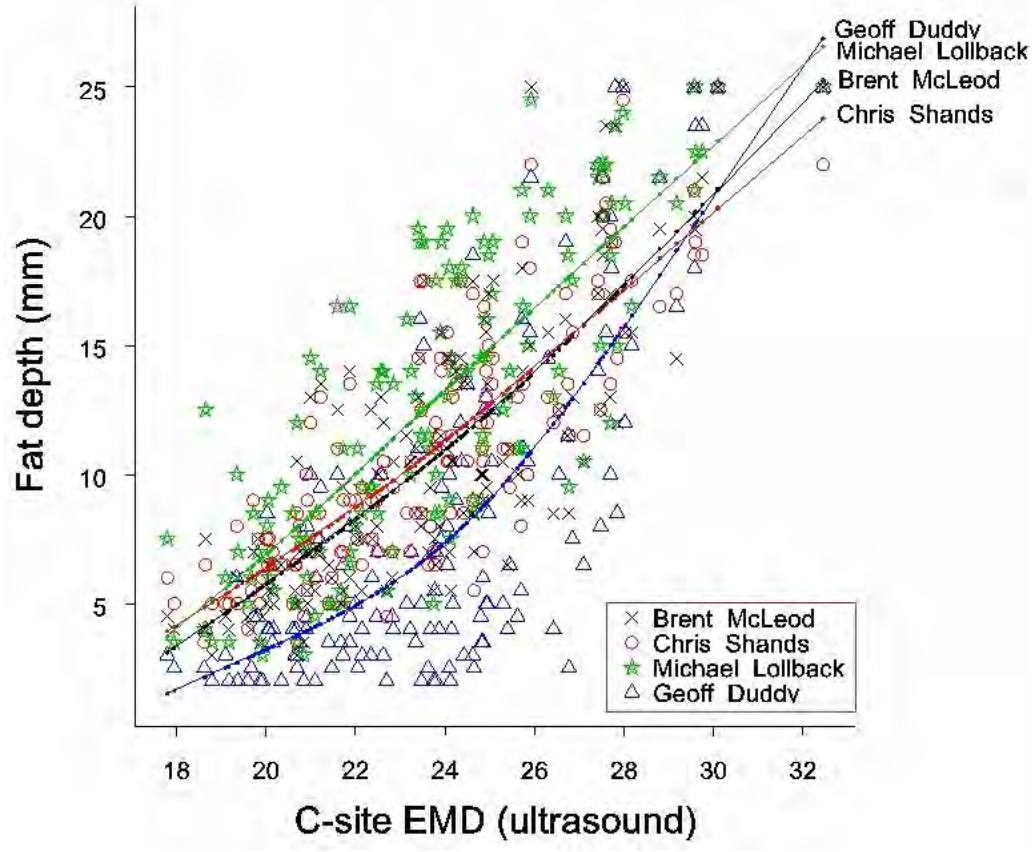


4.13 The relationship between condition score, fat score and C-site eye muscle depth measured by ultrasound on the live sheep

These graphs and tables evaluate the relationship between condition score, fat score and c-site muscle depth measured by ultrasound on the live sheep. To compare the relationships for the four assessors for condition score and fat score a smoothing spline was fitted for each.

Condition score, fat score and C Site EMD Ultrasound

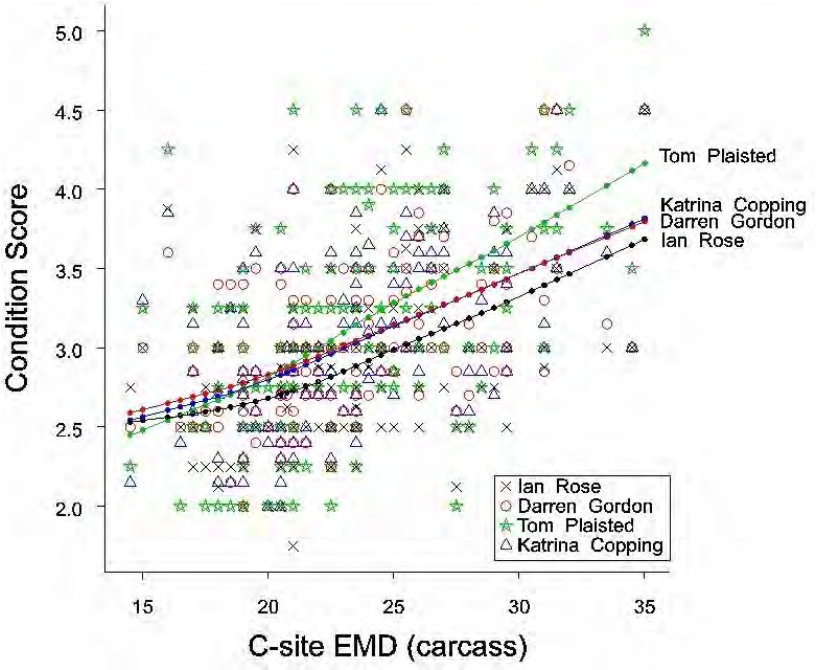




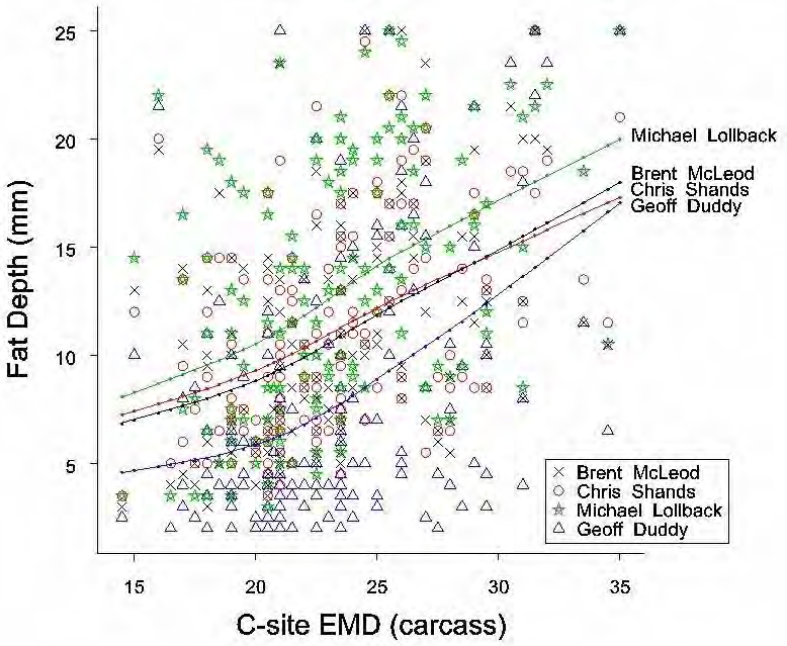
4.14 The relationship between condition score, fat score and C-site eye muscle depth measured on the carcass

These graphs and tables evaluate the relationship between condition score, fat score and c-site muscle depth measured on the carcass. To compare the relationships for the four assessors for condition score and fat score a smoothing spline was fitted for each.

Condition score and C Site EMD Carcass



Fat score and C Site EMD Carcass



These above graphs and tables 7 & 8 show the relationships between individual condition, or fat, scores and the average C-site eye muscle depth, measured by ultrasound or on the carcass. The average prediction error in tables 7 & 8 was calculated as the absolute difference between the predicted C-site EMD (from a spline fit of C-site EMD v condition/fat score) and the average C-site EMD measured by ultrasound or on the carcass.

Table 7 Relationships between individual condition, or fat, scores and the average C-site eye muscle depth, measured by ultrasound

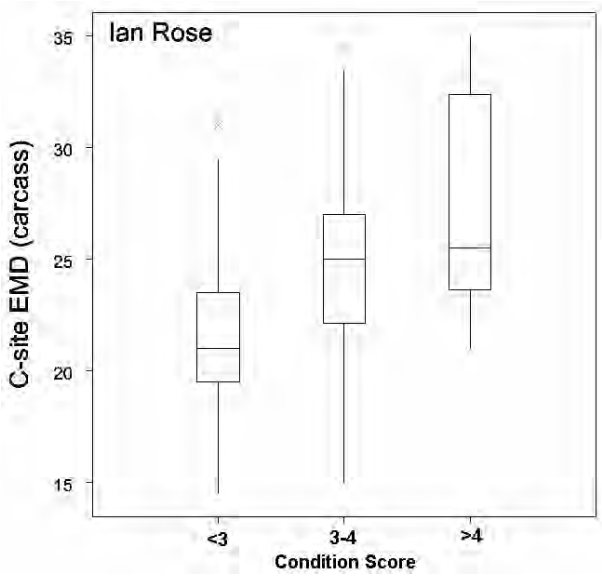
C-site EMD (ultrasound)		Average Prediction Error			Approx. 95% C.I. (+/- 2*SD)		
	Assessor	Fine wool	Medium wool	First X	Fine wool	Medium wool	First X
CS	Ian Rose	1.45	1.32	1.25	+/-4.70	+/-1.97	+/-1.75
	Darren Gordon	1.22	1.23	1.64	+/-3.81	+/-1.55	+/-1.84
	Tom Plaisted	1.09	1.53	2.67	+/-3.70	+/-3.00	+/-8.21
	Katrina Copping	1.38	1.15	1.60	+/-4.74	+/-1.70	+/-2.34
FS	Brent McLeod	1.25	1.46	1.62	+/-3.94	+/-1.76	+/-2.24
	Chris Shands	1.32	1.55	1.36	+/-3.68	+/-2.09	+/-1.92
	Michael Lollback	1.24	1.67	2.56	+/-4.13	+/-2.64	+/-6.90
	Geoff Duddy	1.76	1.35	1.87	+/-4.39	+/-1.97	+/-2.47

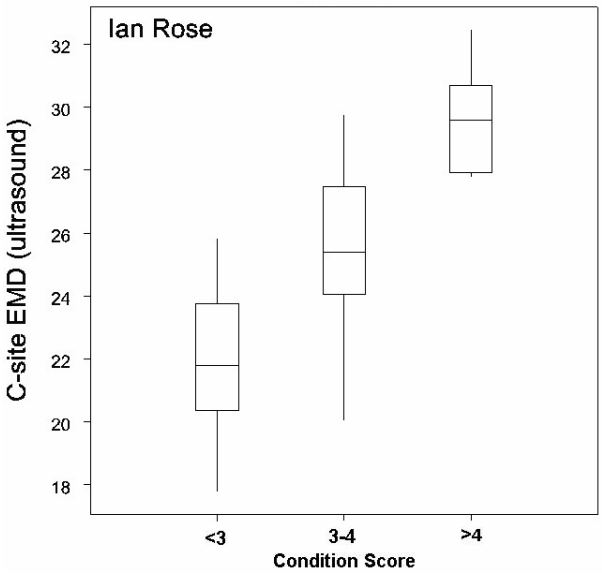
Table 8 Relationships between individual condition, or fat, scores and the average C-site eye muscle depth, measured on the carcass

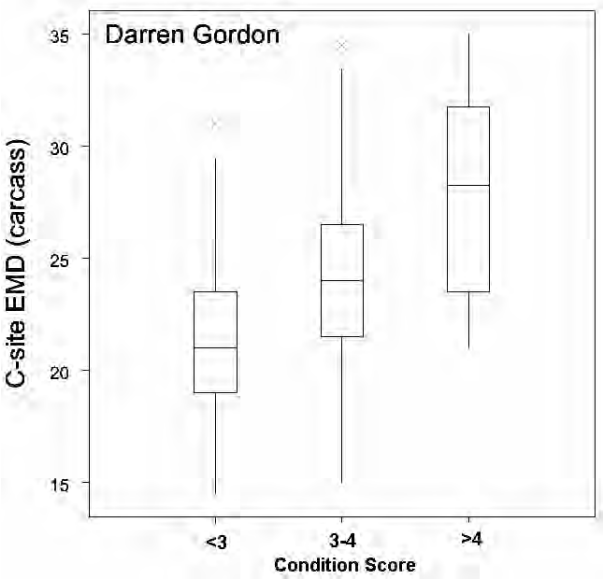
C-site EMD (carcass)		Average Prediction Error			Approx. 95% C.I. (+/- 2*SD)		
	Assessor	Fine wool	Medium wool	First X	Fine wool	Medium wool	First X
CS	Ian Rose	2.43	2.99	2.98	+/-8.37	+/-4.29	+/-5.72
	Darren Gordon	2.25	3.01	2.86	+/-7.78	+/-3.92	+/-5.65
	Tom Plaisted	2.29	2.98	4.37	+/-8.17	+/-4.09	+/-9.29
	Katrina Copping	2.30	3.07	2.91	+/-7.96	+/-3.90	+/-5.55

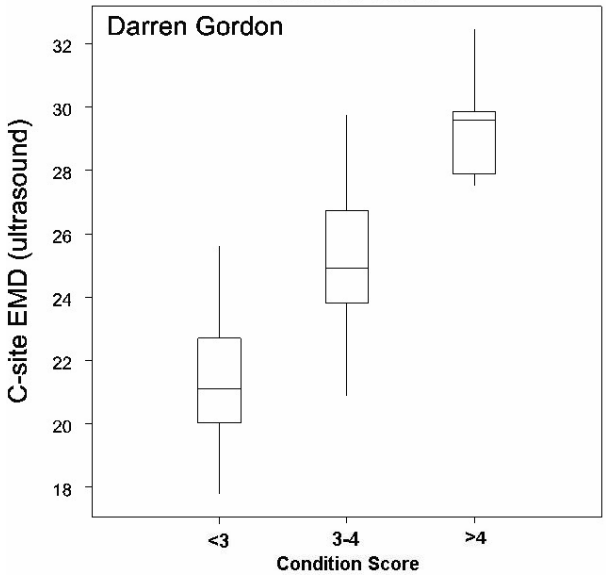
FS	Brent McLeod	2.31	3.06	3.10	+/-8.34	+/-3.80	+/-5.79
	Chris Shands	2.32	3.21	2.94	+/-7.92	+/-4.01	+/-5.92
	Michael Lollback	2.31	2.95	4.21	+/-8.06	+/-3.90	+/-9.46
	Geoff Duddy	2.59	2.99	3.12	+/-8.06	+/-4.10	+/-5.94

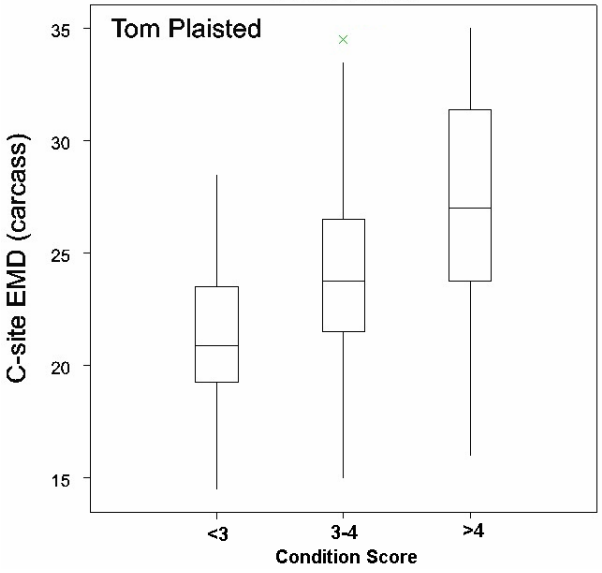
The boxes in these plots (below) represent the middle half of the values in each class, the lines in each box represent the median value and the vertical lines reach out to the maximum and minimum values. The Condition Score classes for each box plot reflect the available data - <3 is predominantly >2, and >4 is predominantly <5.

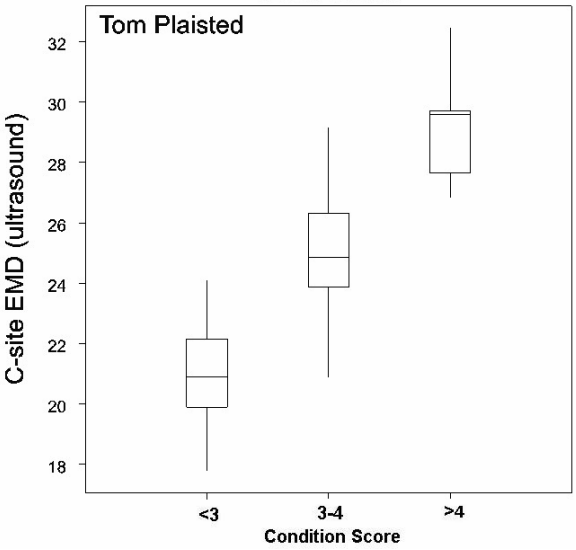


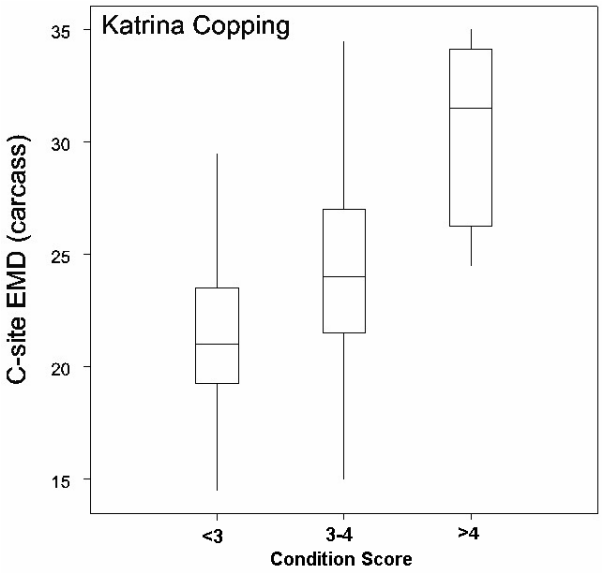


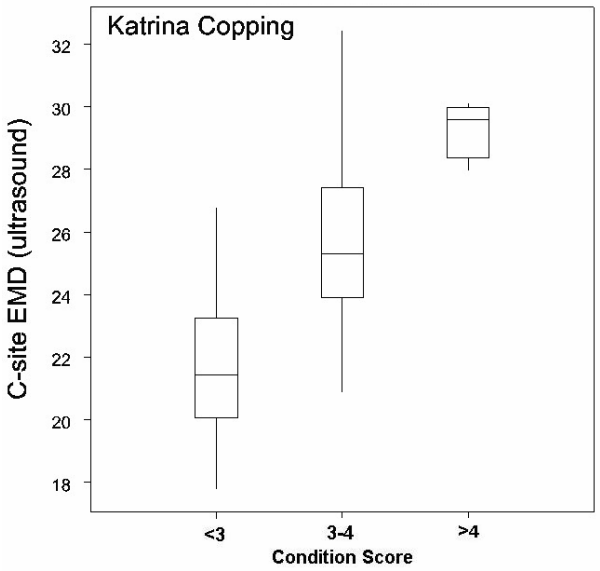

Darren Gordon
C-site EMD (carcass)
35
30
25
20
15
<3
3-4
>4
Condition Score

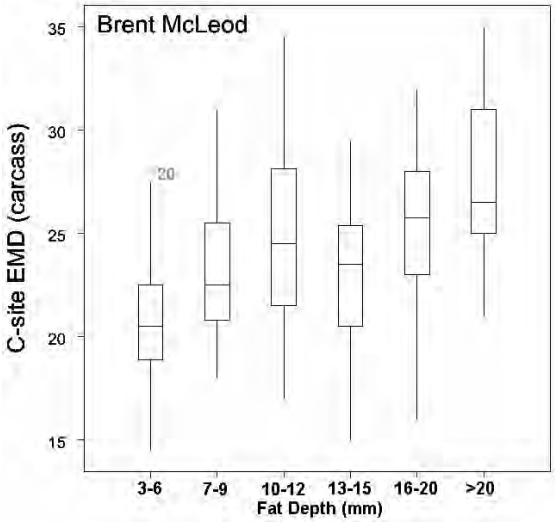

Darren Gordon
C-site EMD (ultrasound)
32
30
28
26
24
22
20
18
<3
3-4
>4
Condition Score

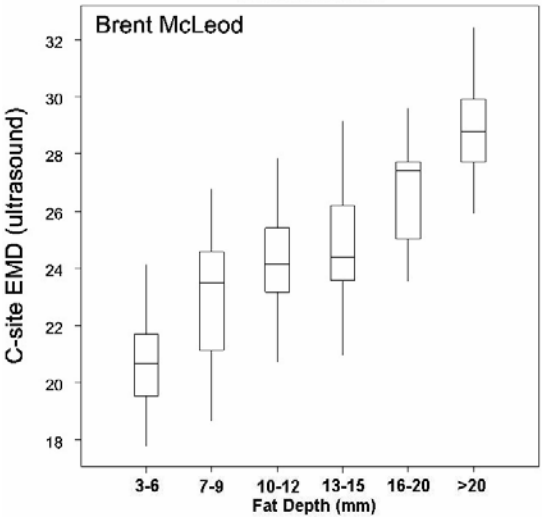

Tom Plaisted
C-site EMD (carcass)
35
30
25
20
15
<3
3-4
>4
Condition Score

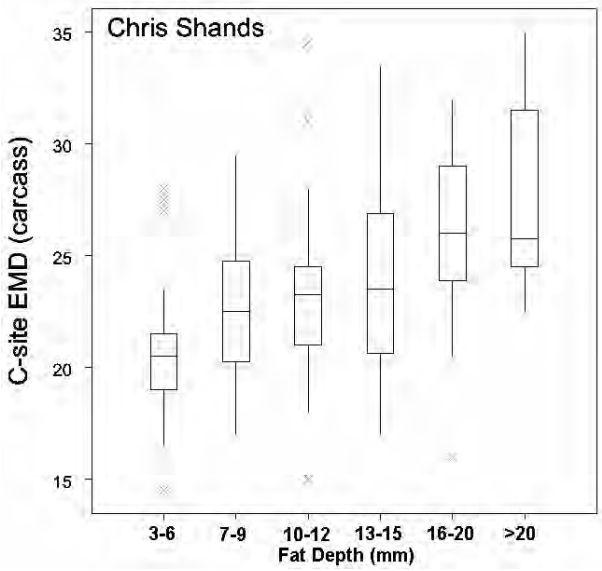

Tom Plaisted
C-site EMD (ultrasound)
32
30
28
26
24
22
20
18
<3
3-4
>4
Condition Score

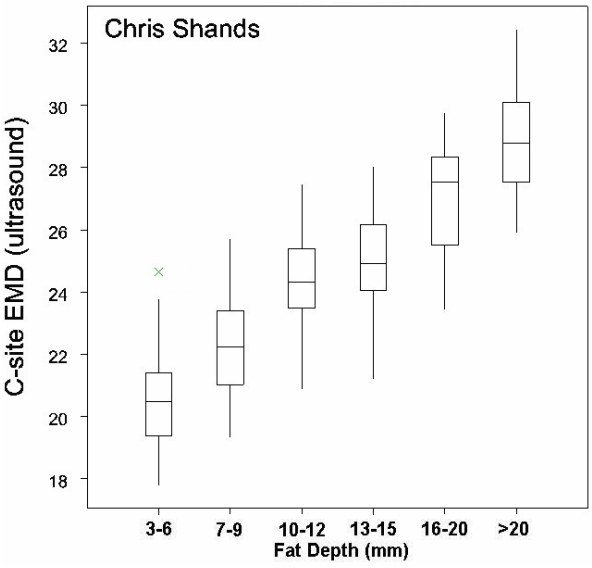

Katrina Copping
C-site EMD (carcass)
35
30
25
20
15
<3
3-4
>4
Condition Score

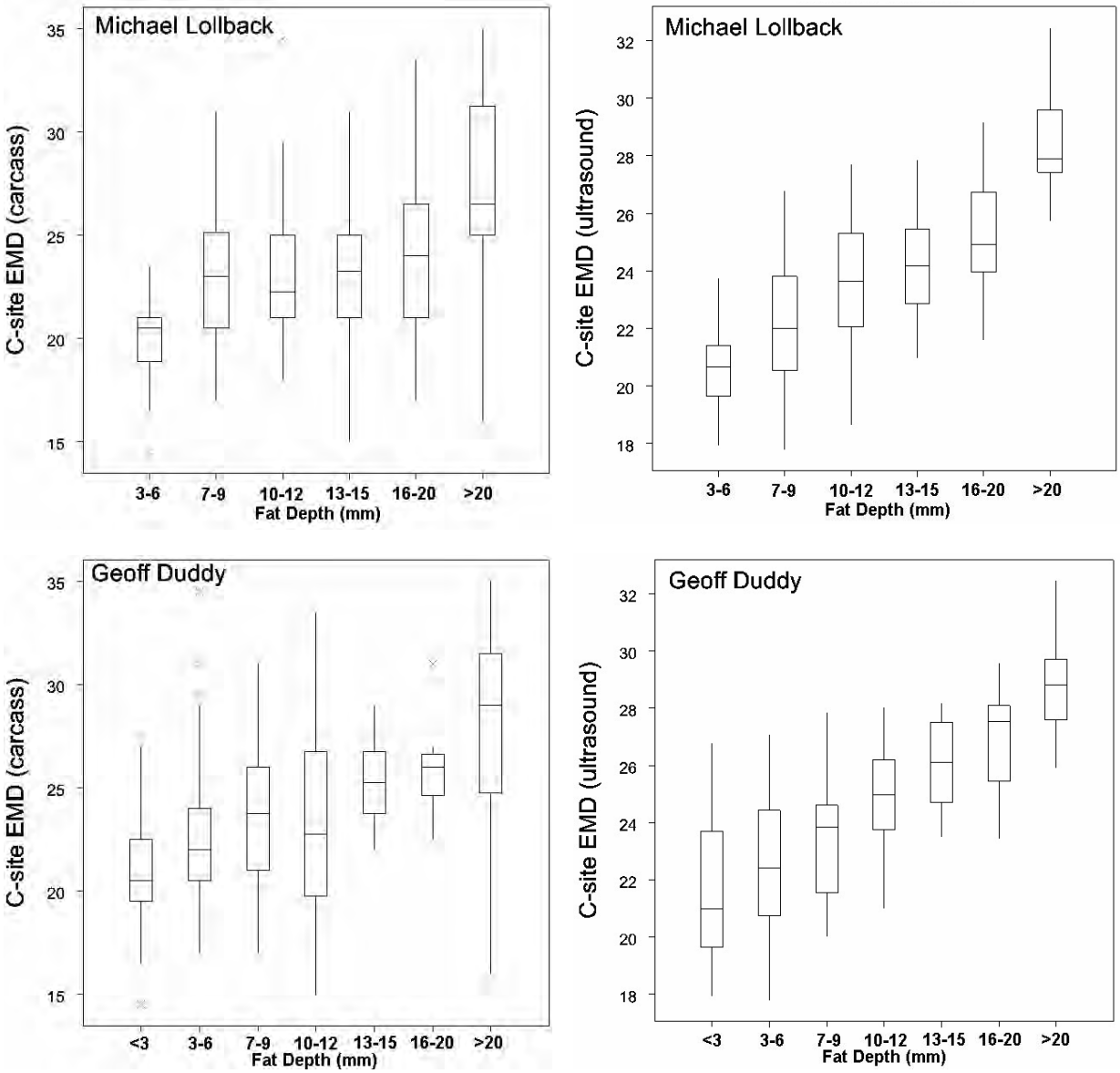

Katrina Copping
C-site EMD (ultrasound)
32
30
28
26
24
22
20
18
<3
3-4
>4
Condition Score


Brent McLeod
C-site EMD (carcass)
35
30
25
20
15
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)


Brent McLeod
C-site EMD (ultrasound)
32
30
28
26
24
22
20
18
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)

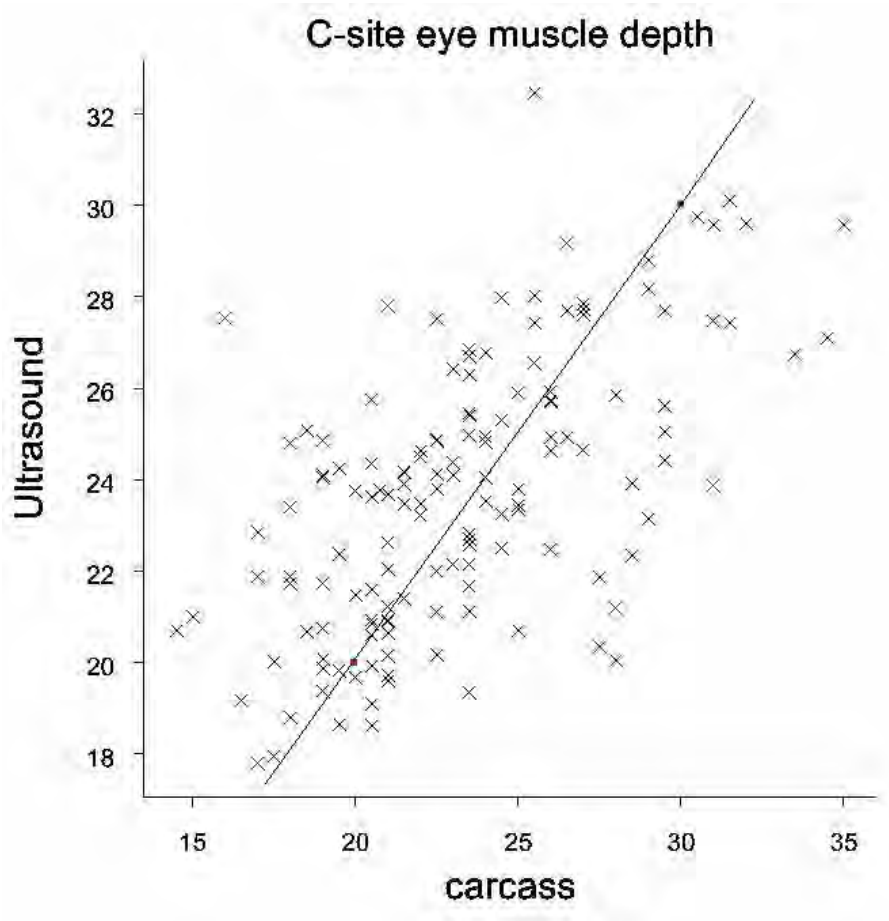

Chris Shands
C-site EMD (carcass)
35
30
25
20
15
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)


Chris Shands
C-site EMD (ultrasound)
32
30
28
26
24
22
20
18
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)



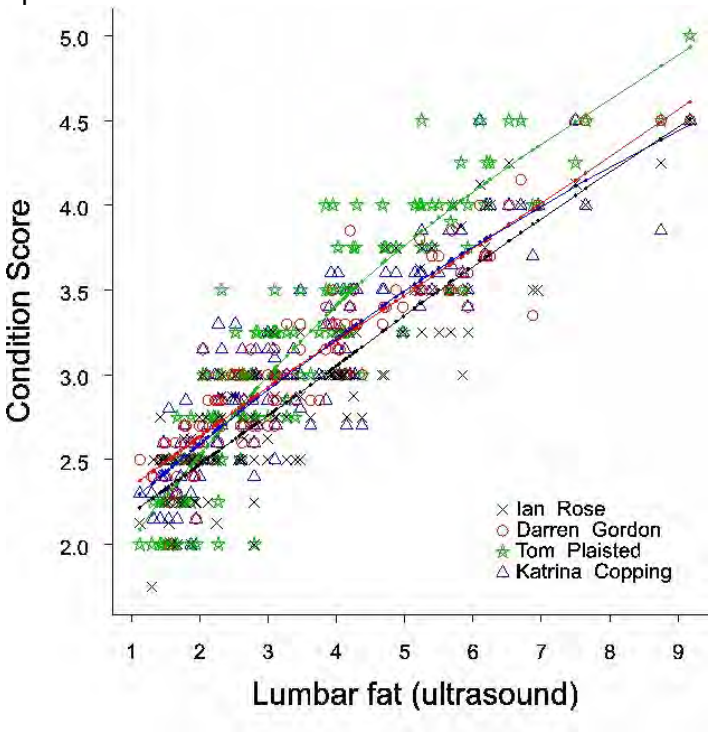
4.15 Comparison of ultrasound and carcass measurements of C-site eye muscle depths on the same sheep

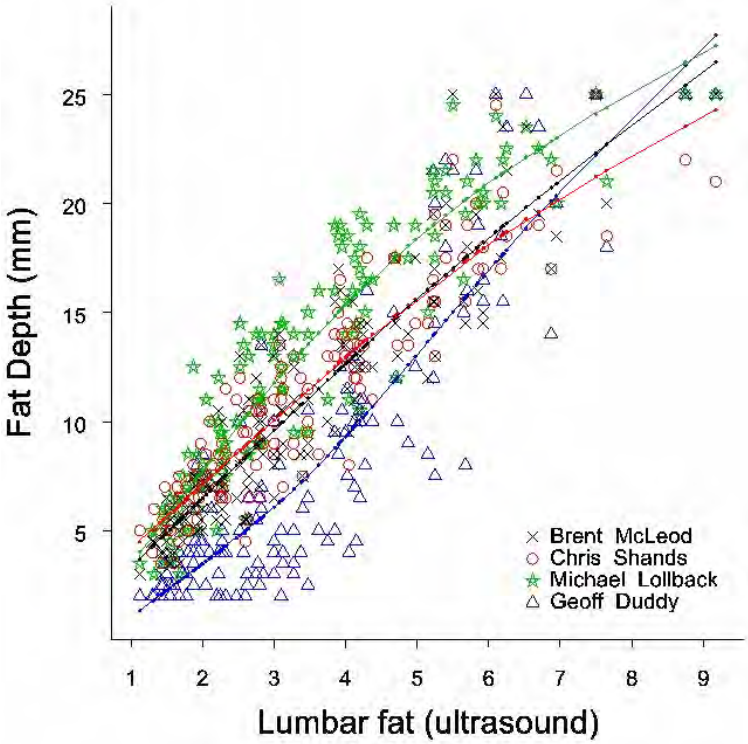
This graph shows a comparison of ultrasound and carcass measurements of C-site eye muscle depths on the same sheep – the line represents perfect agreement.


C-site eye muscle depth
Ultrasound
32
30
28
26
24
22
20
18
15
20
25
30
35
carcass

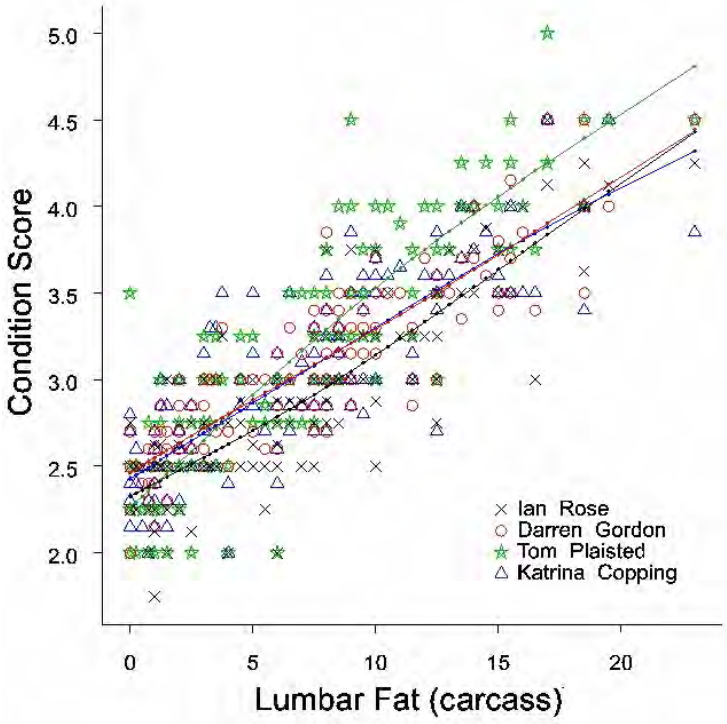
4.16 The relationship between condition score, fat score and the depth of lumbar fat measured by ultrasound on the live sheep

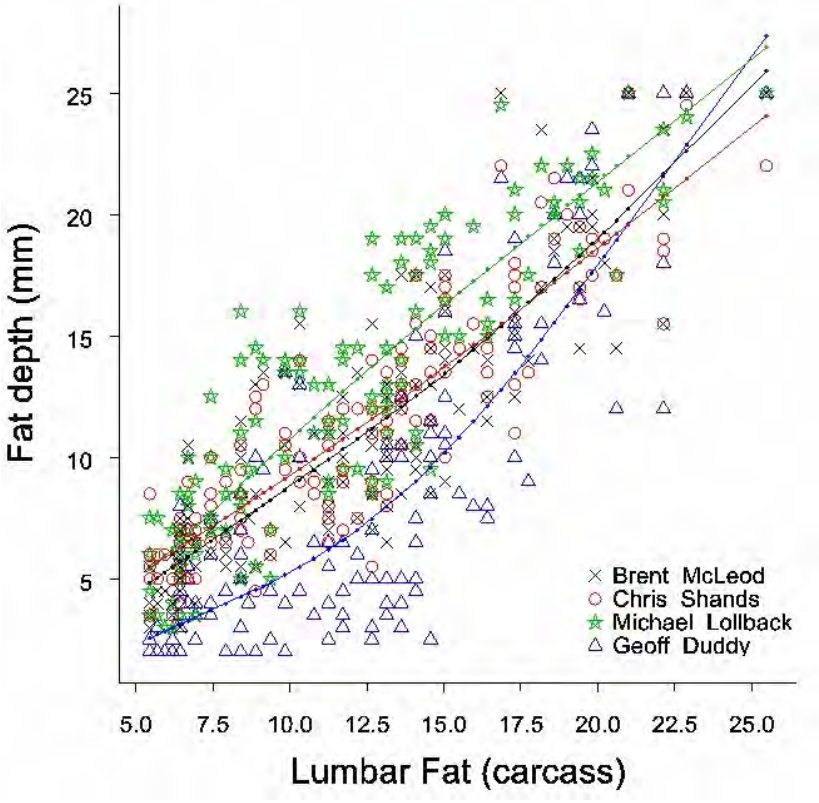
These graphs evaluate the relationship between condition score, fat score and the depth of lumbar fat measured by ultrasound or on the carcass. To compare the relationships for the four assessors for condition score and fat score a smoothing spline was fitted for each.





The relationship between condition score, fat score and the depth of lumbar fat measured on the carcass.




Fat depth (mm)
25
20
15
10
5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
Lumbar Fat (carcass)
Brent McLeod
Chris Shands
Michael Lollback
Geoff Duddy

The average prediction error in tables 9 & 10 is calculated as the absolute difference between the predicted lumbar fat depth (from a spline fit of lumbar fat v condition/fat score) and the average lumbar fat depth measured by ultrasound or on the carcass.

Table 9

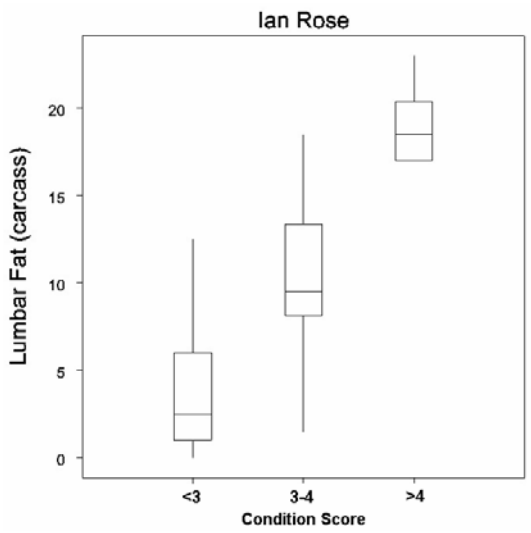
Lumbar fat (carcass)		Average Prediction Error			Approx. 95% C.I. (+/- 2*SD)		
	Assessor	Fine wool	Medium wool	First X	Fine wool	Medium wool	First X
CS	Ian Rose	1.43	5.64	7.37	+/-4.67	+/-6.87	+/-8.47
	Darren Gordon	1.50	5.50	7.25	+/-4.56	+/-6.88	+/-8.53
	Tom Plaisted	1.38	5.33	7.03	+/-4.41	+/-6.68	+/-8.32
	Katrina Copping	1.48	5.50	7.25	+/-4.56	+/-6.88	+/-8.55
FS	Brent McLeod	1.83	2.09	2.02	+/-6.50	+/-3.13	+/-3.20
	Chris Shands	1.56	2.24	1.84	+/-4.73	+/-3.18	+/-3.25
	Michael Lollback	1.41	2.30	1.98	+/-5.12	+/-3.17	+/-3.01
	Geoff Duddy	2.90	2.28	2.39	+/-5.35	+/-3.26	+/-3.82

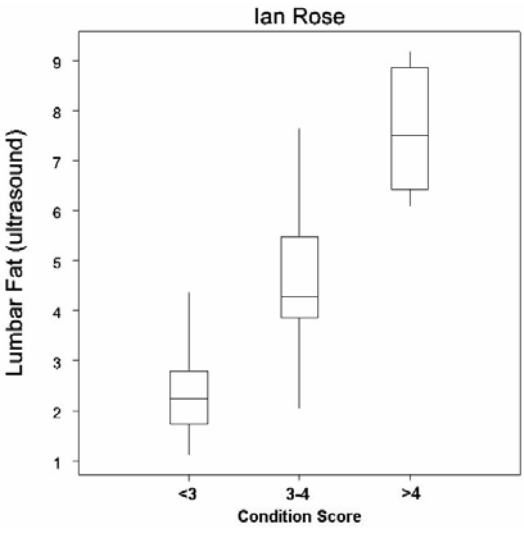
Table 10

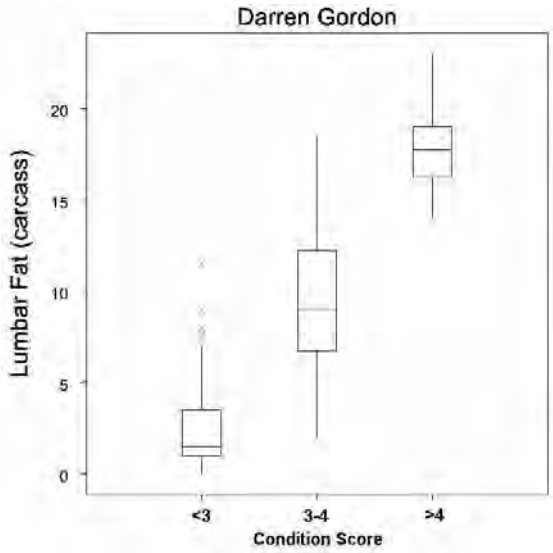
Lumbar fat (ultrasound)		Average Prediction Error			Approx. 95% C.I. (+/- 2*SD)		
	Assessor	Fine wool	Medium wool	First X	Fine wool	Medium wool	First X
CS	Ian Rose	0.51	0.66	0.62	+/-1.61	+/-1.03	+/-0.84
	Darren Gordon	0.38	0.54	0.56	+/-1.03	+/-0.68	+/-0.92
	Tom Plaisted	0.35	0.67	0.53	+/-1.07	+/-0.94	+/-0.99
	Katrina Copping	0.47	0.59	0.66	+/-1.52	+/-0.91	+/-1.13
FS	Brent McLeod	0.39	0.58	0.62	+/-1.44	+/-0.90	+/-0.89
	Chris Shands	0.33	0.66	0.54	+/-1.04	+/-0.79	+/-1.04
	Michael Lollback	0.28	0.67	1.24	+/-1.17	+/-1.40	+/-2.39
	Geoff Duddy	0.67	0.54	0.78	+/-1.57	+/-0.88	+/-1.03

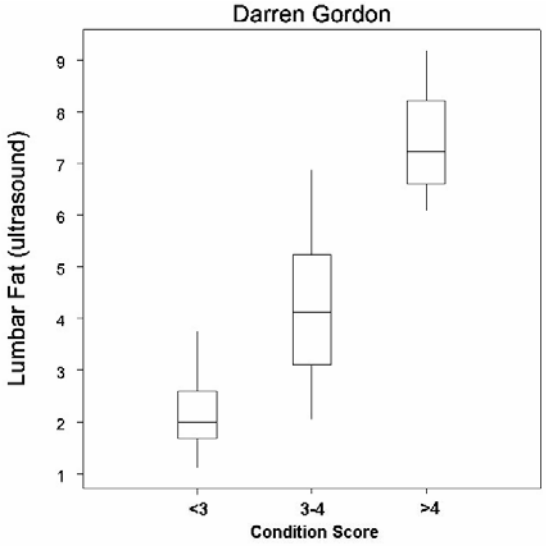
Both condition scores and fat scores tend to predict ultrasound measurements of lumbar fat better than they predict the carcass measurements (*i.e.* average prediction errors and confidence intervals are smaller for ultrasound than for carcass measurements).

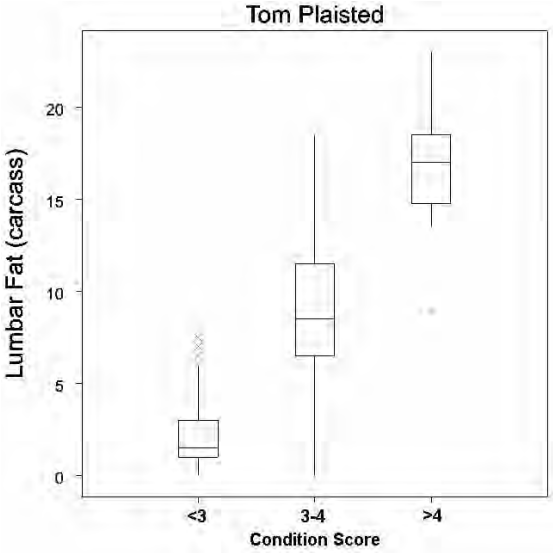
The boxes in these plots (below) represent the middle half of the values in each class, the lines in each box represent the median value and the vertical lines reach out to the maximum and minimum values. The Condition Score classes for each box plot reflect the available data - <3 is predominantly >2, and >4 is predominantly <5.

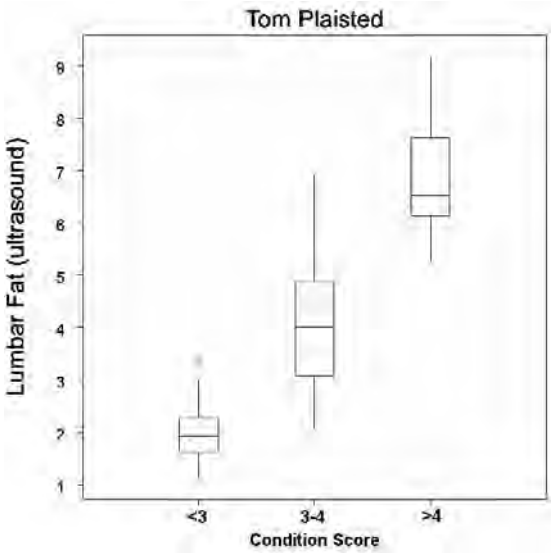

Ian Rose
Lumbar Fat (carcass)
0
5
10
15
20
<3
3-4
>4
Condition Score

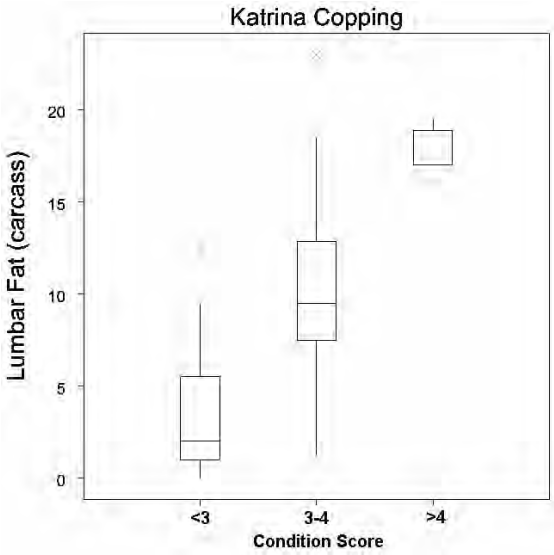

Ian Rose
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
<3
3-4
>4
Condition Score

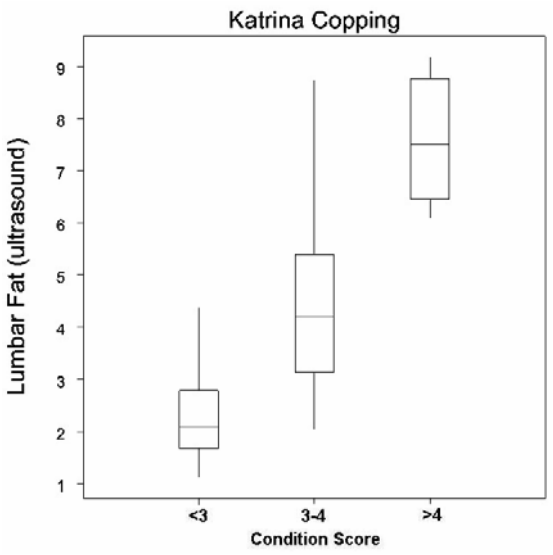

Darren Gordon
Lumbar Fat (carcass)
0
5
10
15
20
<3
3-4
>4
Condition Score

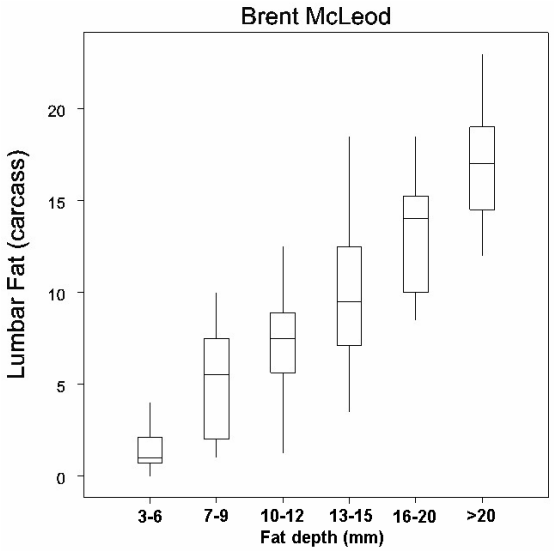

Darren Gordon
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
<3
3-4
>4
Condition Score

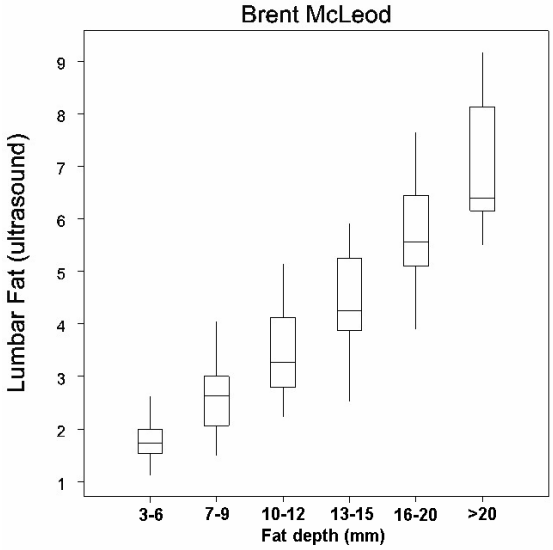

Tom Plaisted
Lumbar Fat (carcass)
0
5
10
15
20
<3
3-4
>4
Condition Score

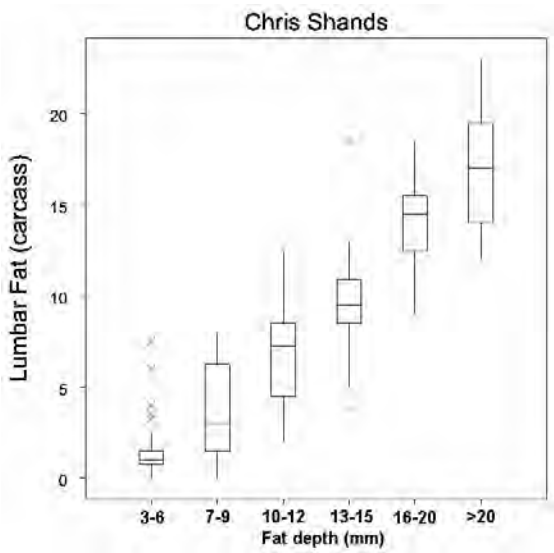

Tom Plaisted
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
<3
3-4
>4
Condition Score

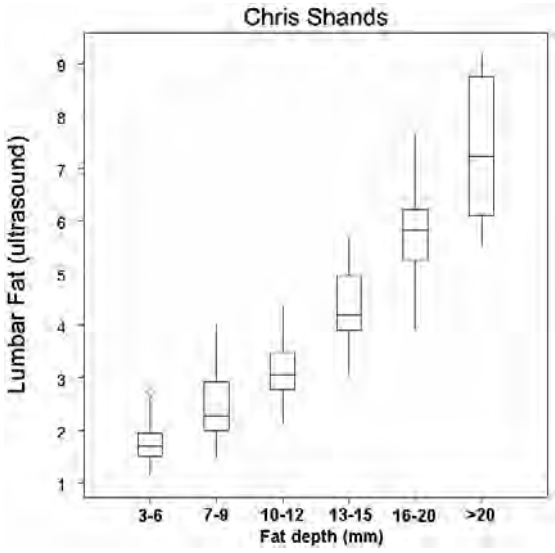

Katrina Copping
Lumbar Fat (carcass)
0
5
10
15
20
<3
3-4
>4
Condition Score

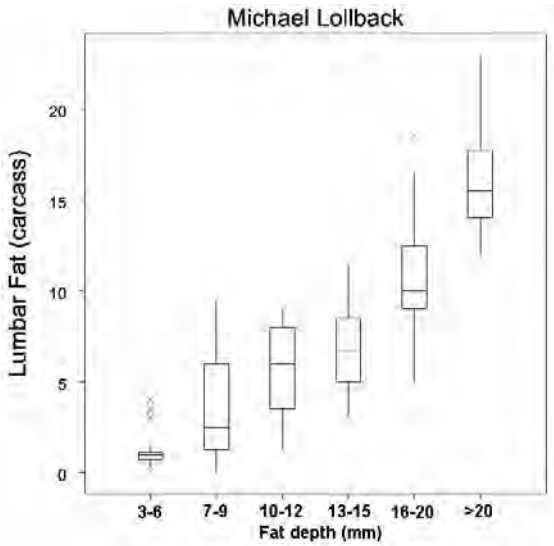

Katrina Copping
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
<3
3-4
>4
Condition Score

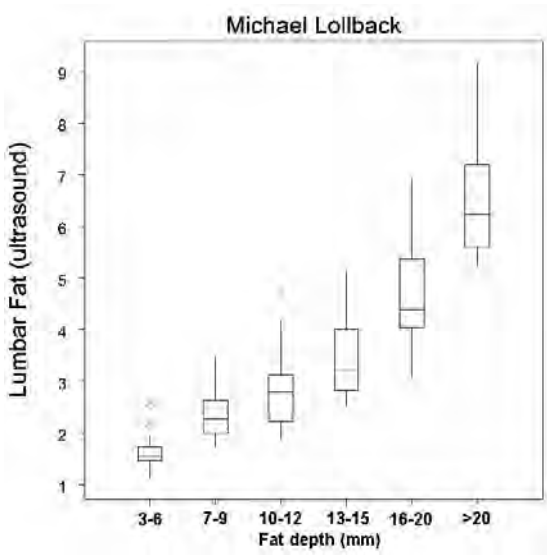

Brent McLeod
Lumbar Fat (carcass)
0
5
10
15
20
3-6
7-9
10-12
13-15
16-20
>20
Fat depth (mm)

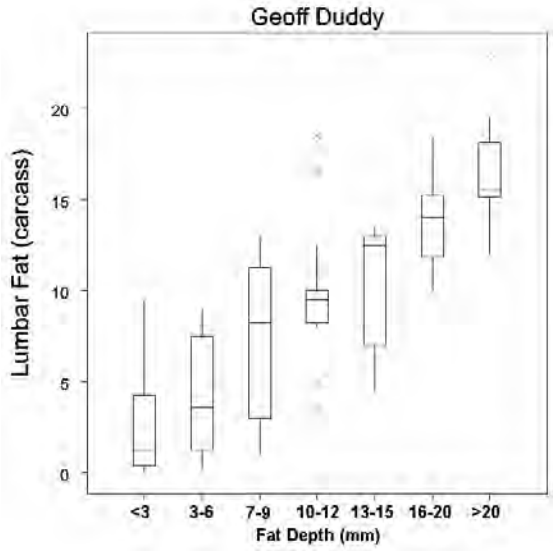

Brent McLeod
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
3-6
7-9
10-12
13-15
16-20
>20
Fat depth (mm)

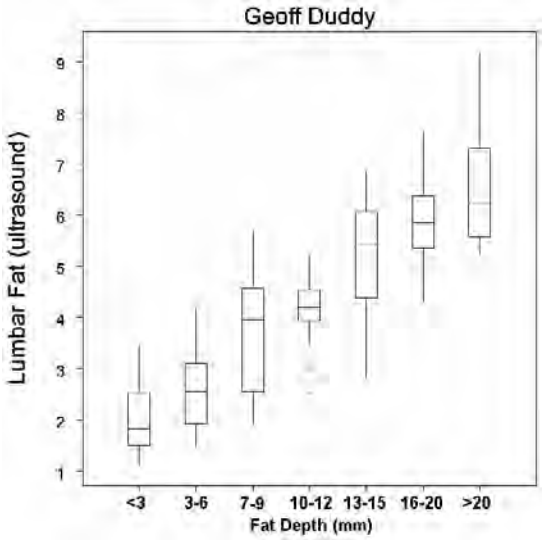

Chris Shands
Lumbar Fat (carcass)
0
5
10
15
20
3-6
7-9
10-12
13-15
16-20
>20
Fat depth (mm)


Chris Shands
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
3-6
7-9
10-12
13-15
16-20
>20
Fat depth (mm)


Michael Lollback
Lumbar Fat (carcass)
0
5
10
15
20
3-6
7-9
10-12
13-15
16-20
>20
Fat depth (mm)

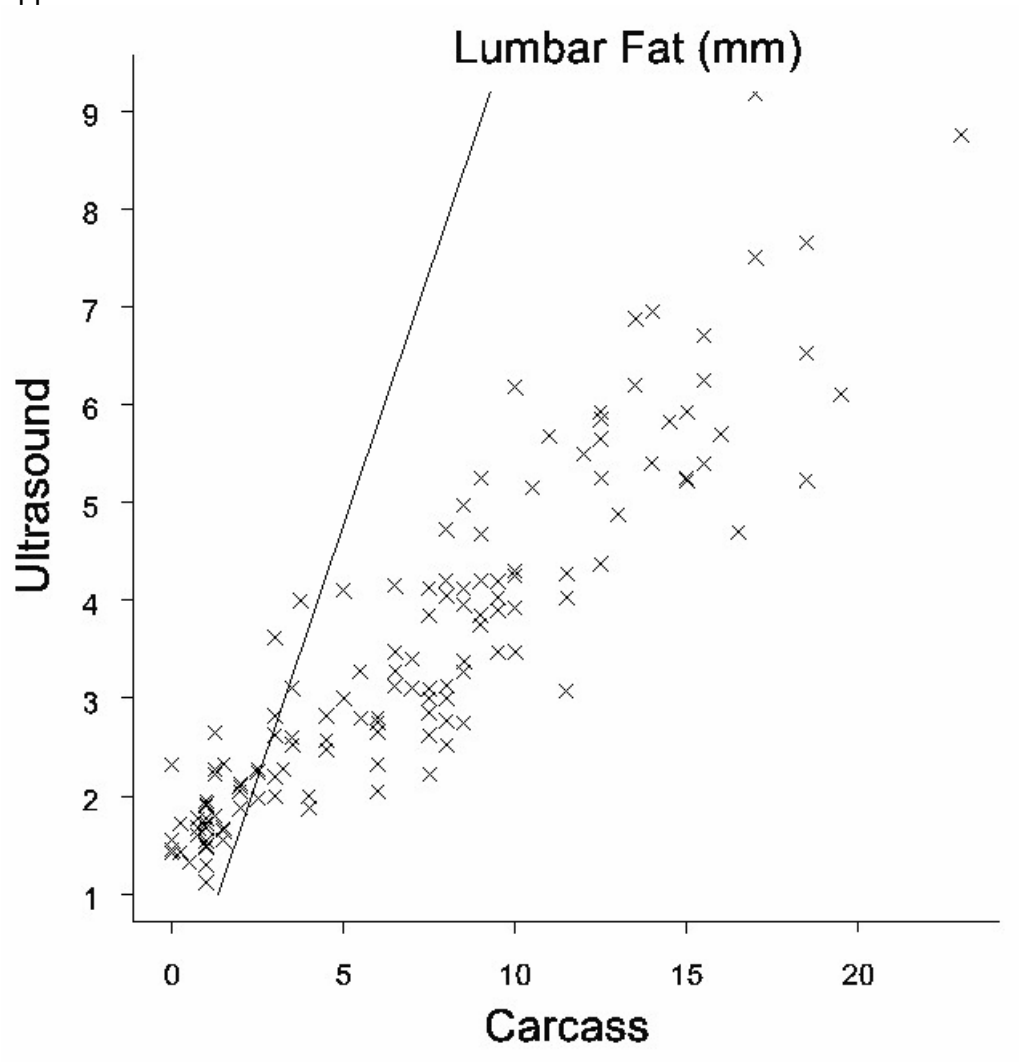

Michael Lollback
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
3-6
7-9
10-12
13-15
16-20
>20
Fat depth (mm)


Geoff Duddy
Lumbar Fat (carcass)
0
5
10
15
20
<3
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)


Geoff Duddy
Lumbar Fat (ultrasound)
1
2
3
4
5
6
7
8
9
<3
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)

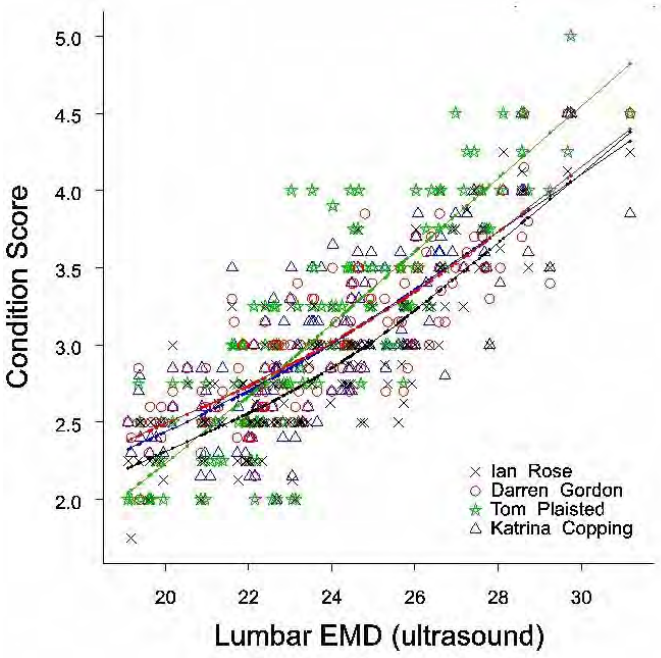
4.17 Comparison of average ultrasound and carcass measurements of Lumbar fat on the same sheep

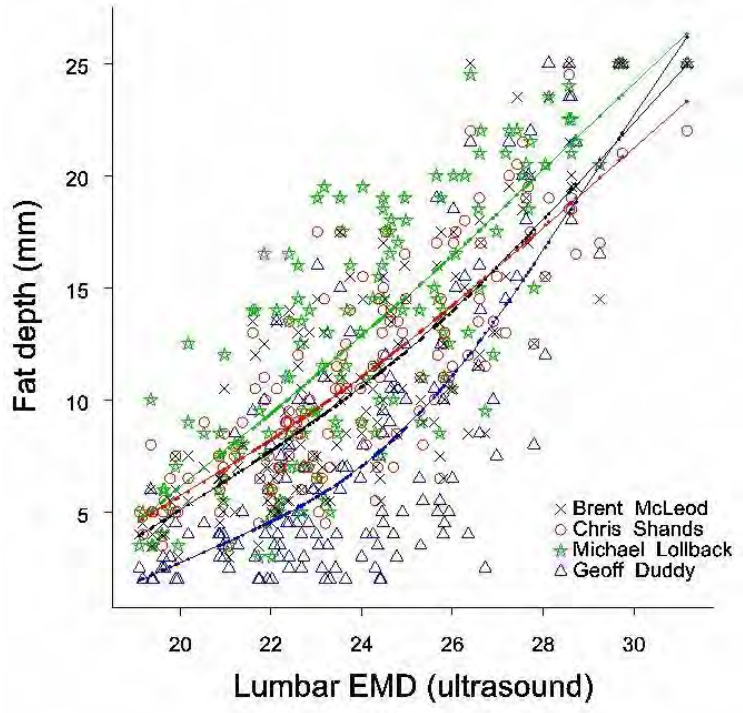
This graph shows a comparison of average ultrasound and carcass measurements of Lumbar fat on the same sheep – the line represents perfect agreement between carcass and ultrasound measurements. As with C-site fat the ultrasound measurement appears to detect about half the lumbar fat measured on the carcass.



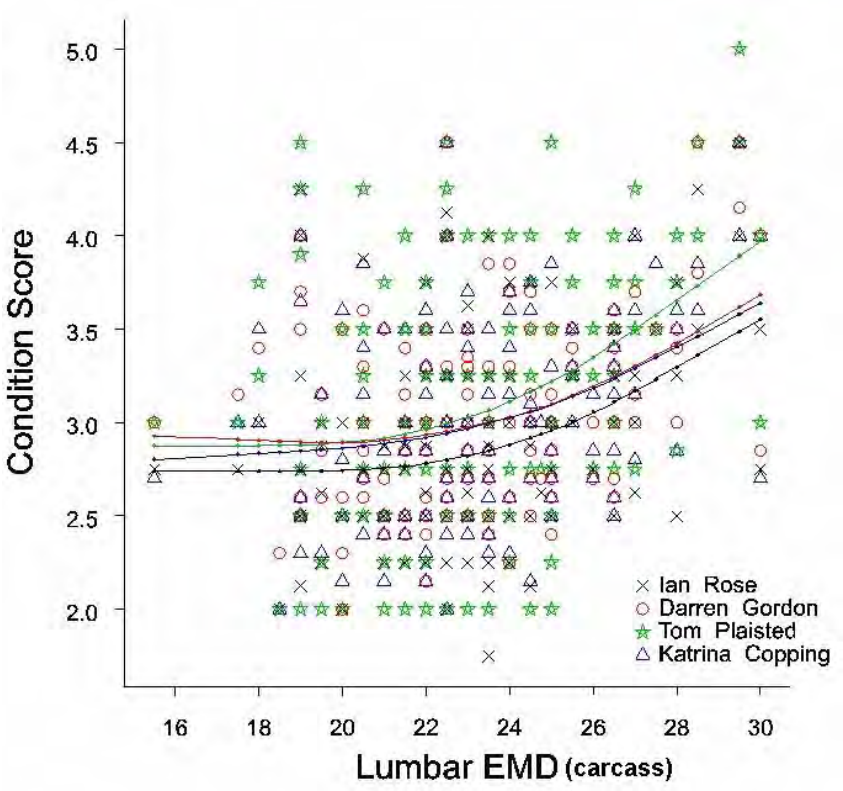
4.18 The relationship between condition score, fat score and lumbar eye muscle depth measured by ultrasound on the live animal

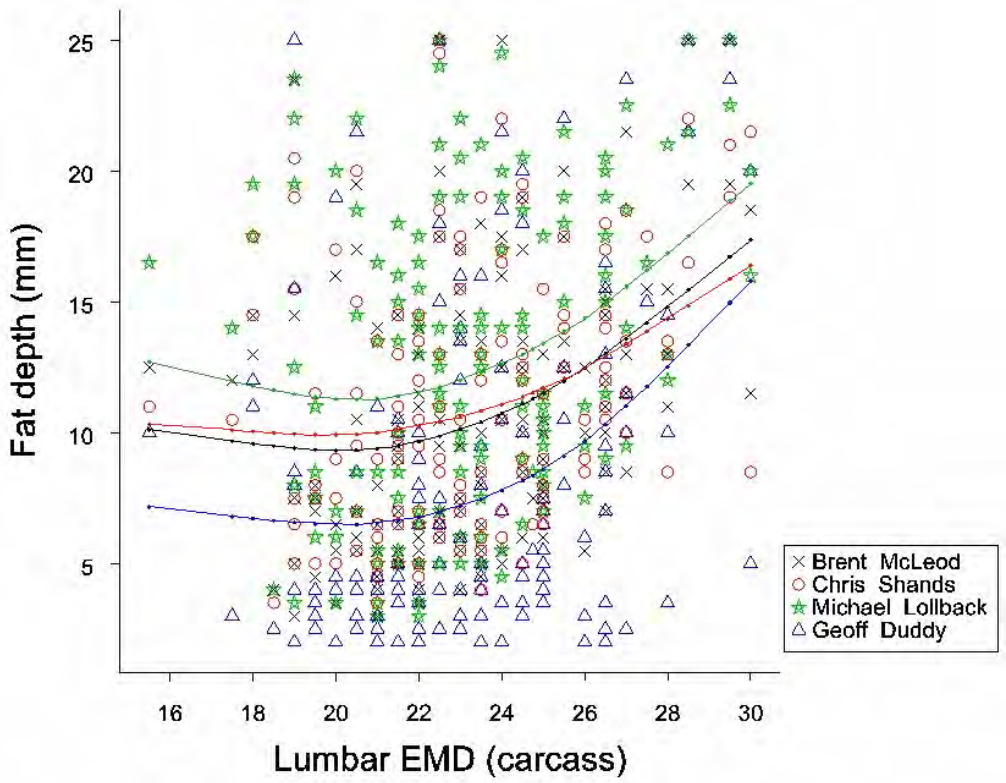
These graphs evaluate the relationship between condition score, fat score and the depth of lumbar eye muscle tissue measured by ultrasound or on the carcass. To compare the relationships for the four assessors for condition score and fat score a smoothing spline was fitted for each.





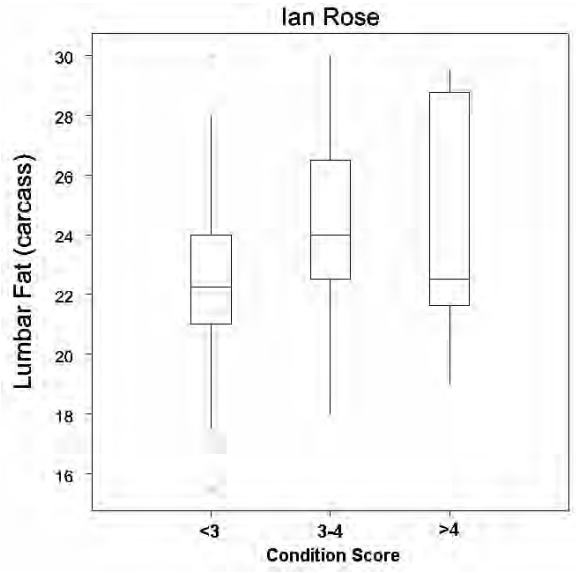
4.19 The relationship between condition score, fat score and lumbar eye muscle depth measured on the carcass.

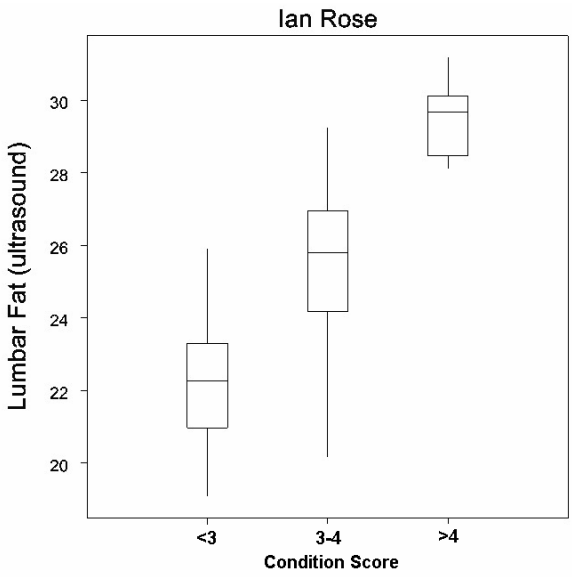


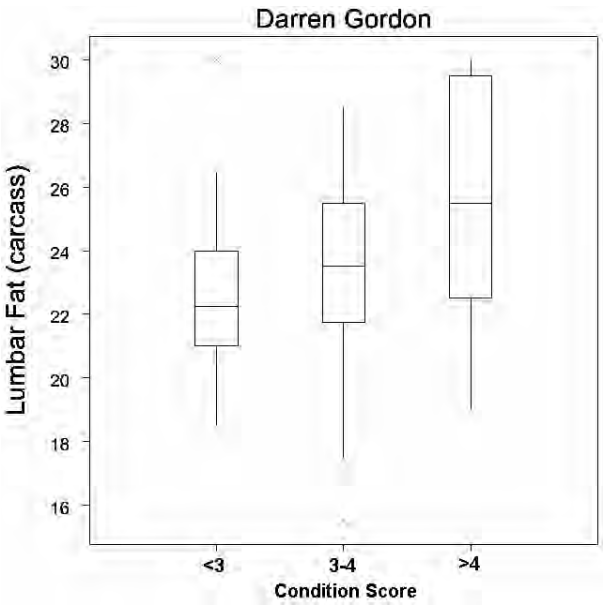


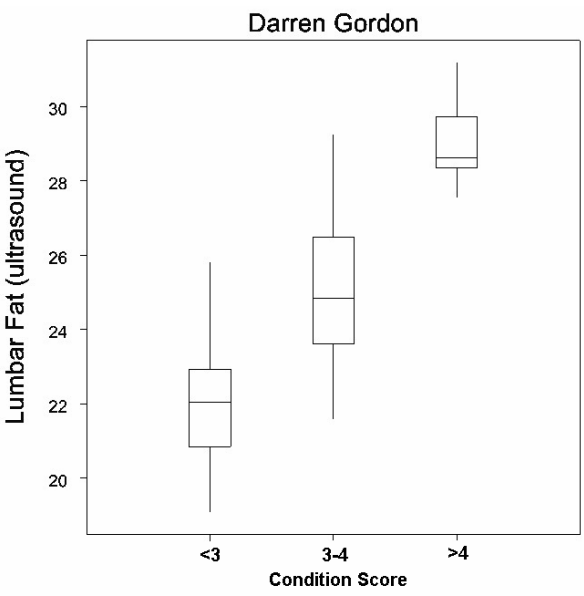
It is obvious that there is a poor relationship between live assessment of condition score or fat score and measurement of lumbar eye muscle depth on the carcass. This is to be expected as lumbar EMD is only a secondary component of the assessment of condition score at the same site and is only an indirect relationship with fat score assessed at a separate site. Error in measurement of EMD at the 3rd lumbar site could also have contributed to the poor relationship. A Tolland style probe was used to measure the depth of muscle at the 3rd lumbar rib over the top of the rib. The repeatability between measurers of lumbar EMD was not high and there was no opportunity to conduct repeatability measures for each operator because of abattoir requirements.

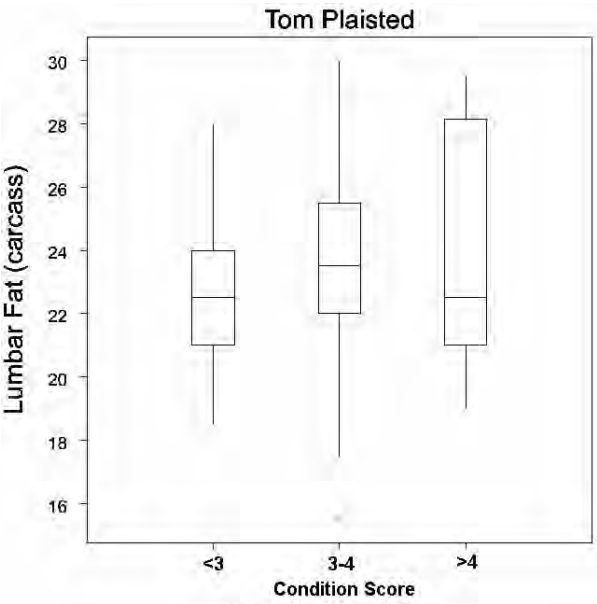
The following box plots indicate that fat depth and condition score are predicting the ultrasound measurement of lumbar fat better than the carcass measurement – the boxes rise left to right when plotted against ultrasound measurements, there is a less distinct pattern when the boxes are plotted against carcass measurements.

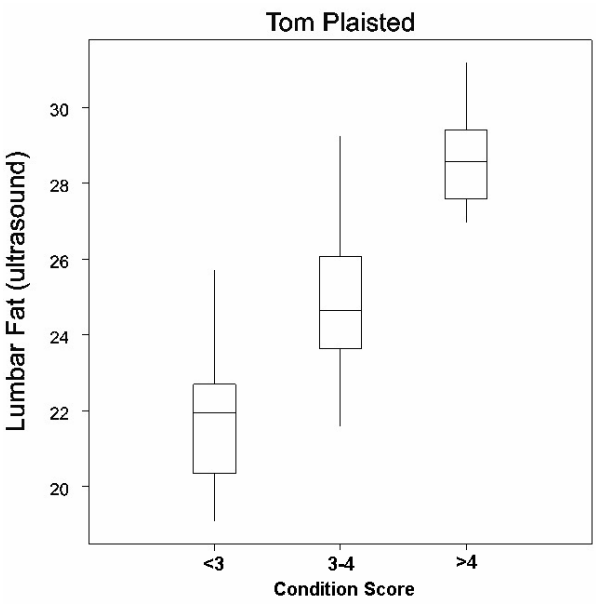

Ian Rose
Lumbar Fat (carcass)
30
28
26
24
22
20
18
16
<3
3-4
>4
Condition Score

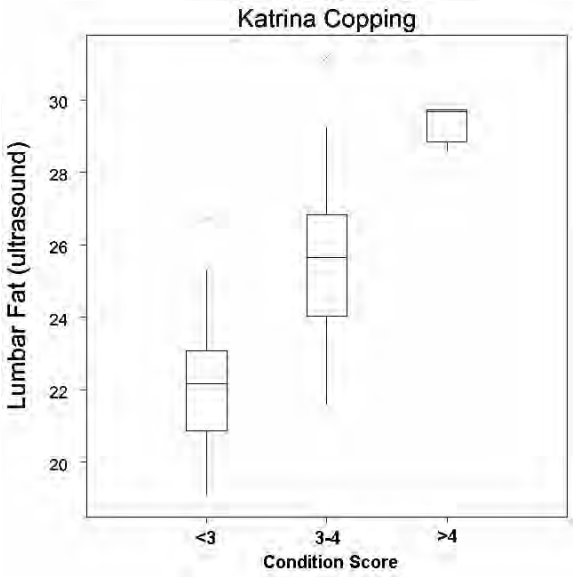

Ian Rose
Lumbar Fat (ultrasound)
30
28
26
24
22
20
<3
3-4
>4
Condition Score

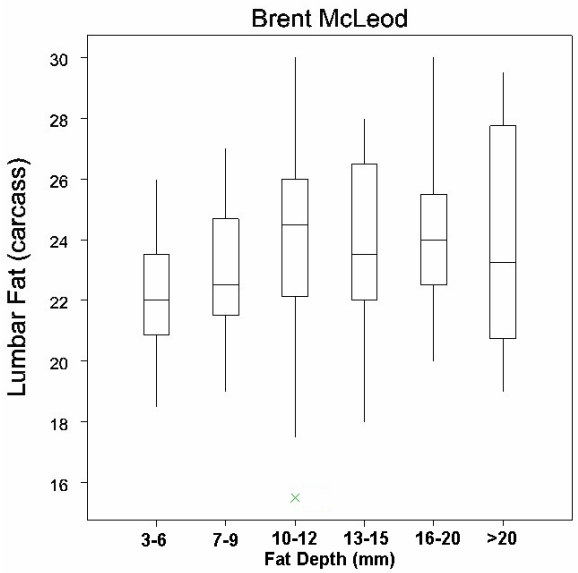

Darren Gordon
Lumbar Fat (carcass)
30
28
26
24
22
20
18
16
<3
3-4
>4
Condition Score

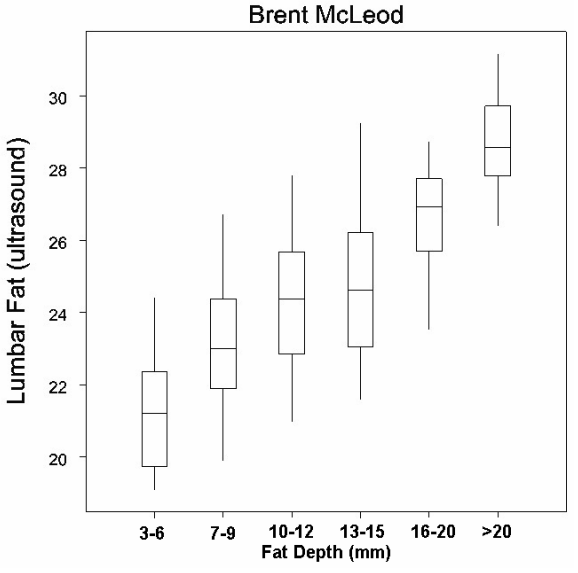

Darren Gordon
Lumbar Fat (ultrasound)
30
28
26
24
22
20
<3
3-4
>4
Condition Score

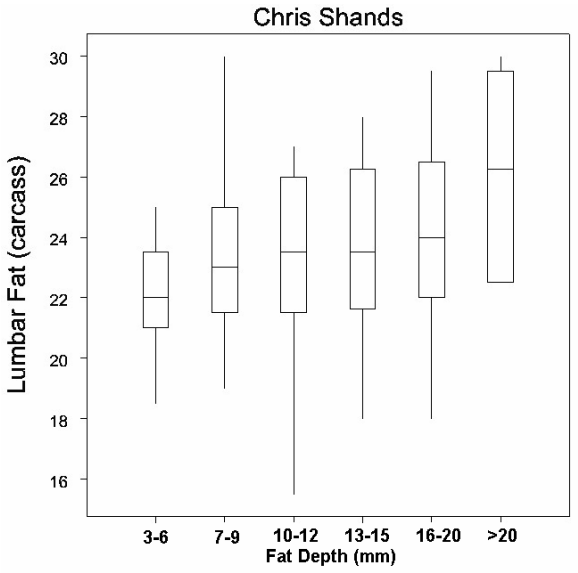

Tom Plaisted
Lumbar Fat (carcass)
30
28
26
24
22
20
18
16
<3
3-4
>4
Condition Score

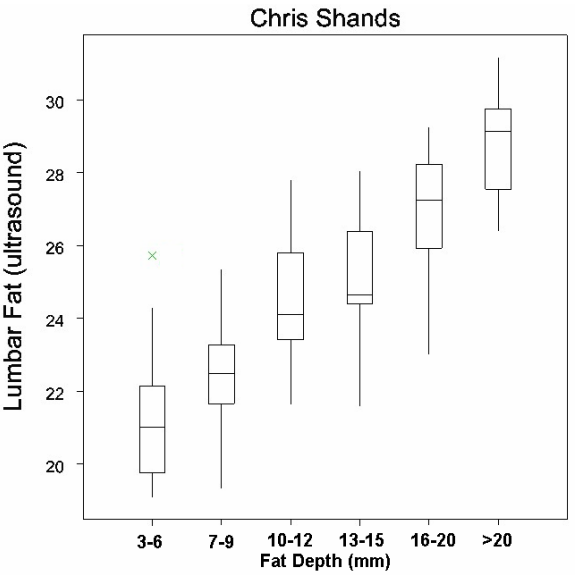

Tom Plaisted
Lumbar Fat (ultrasound)
30
28
26
24
22
20
<3
3-4
>4
Condition Score

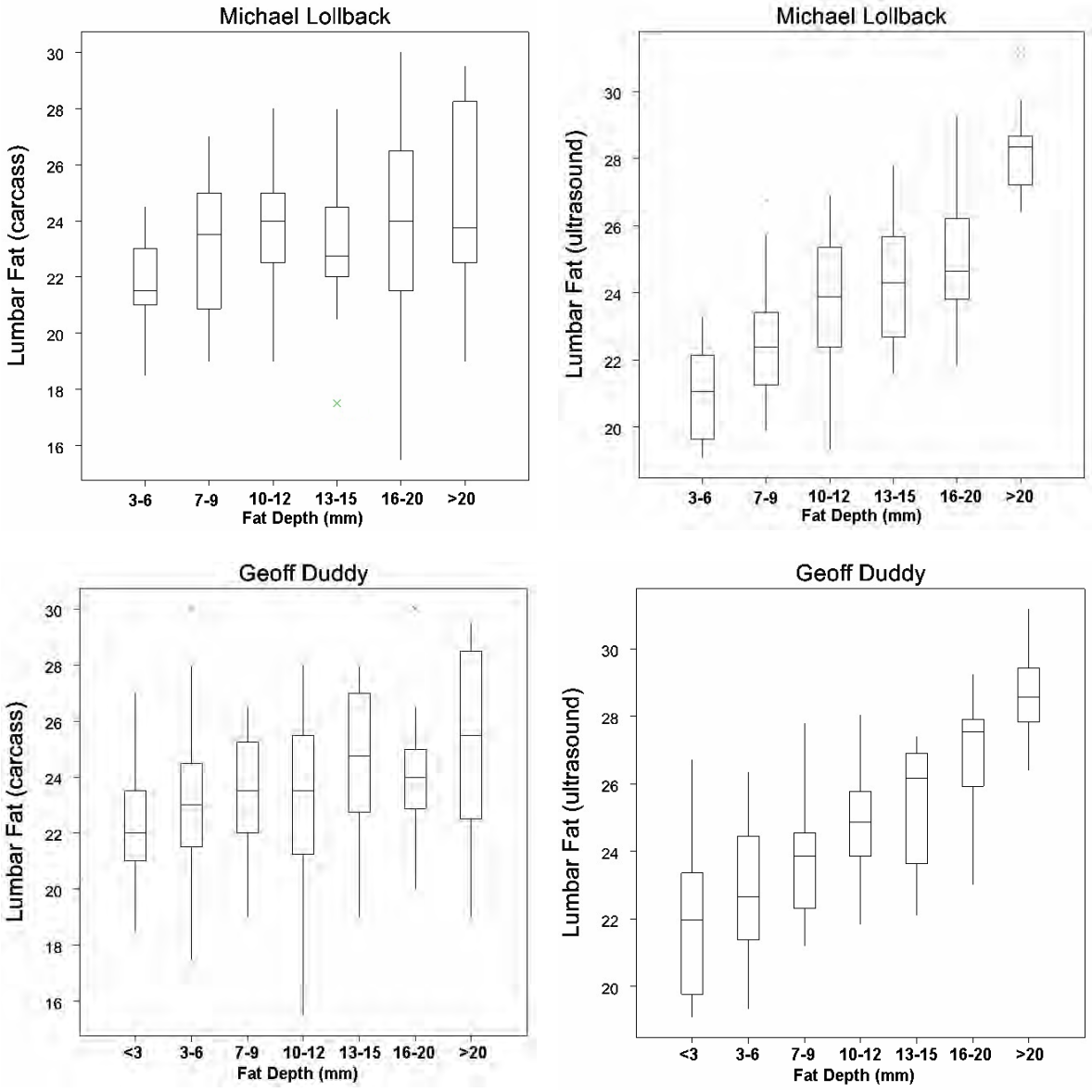

Katrina Copping
Lumbar Fat (ultrasound)
30
28
26
24
22
20
<3
3-4
>4
Condition Score


Brent McLeod
Lumbar Fat (carcass)
30
28
26
24
22
20
18
16
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)


Brent McLeod
Lumbar Fat (ultrasound)
30
28
26
24
22
20
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)

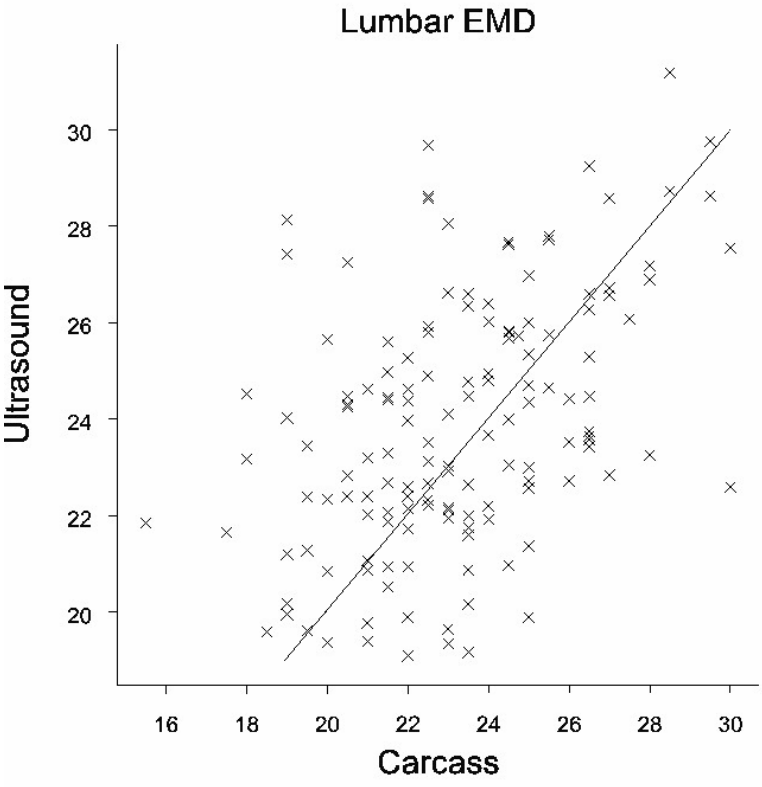

Chris Shands
Lumbar Fat (carcass)
30
28
26
24
22
20
18
16
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)


Chris Shands
Lumbar Fat (ultrasound)
30
28
26
24
22
20
3-6
7-9
10-12
13-15
16-20
>20
Fat Depth (mm)



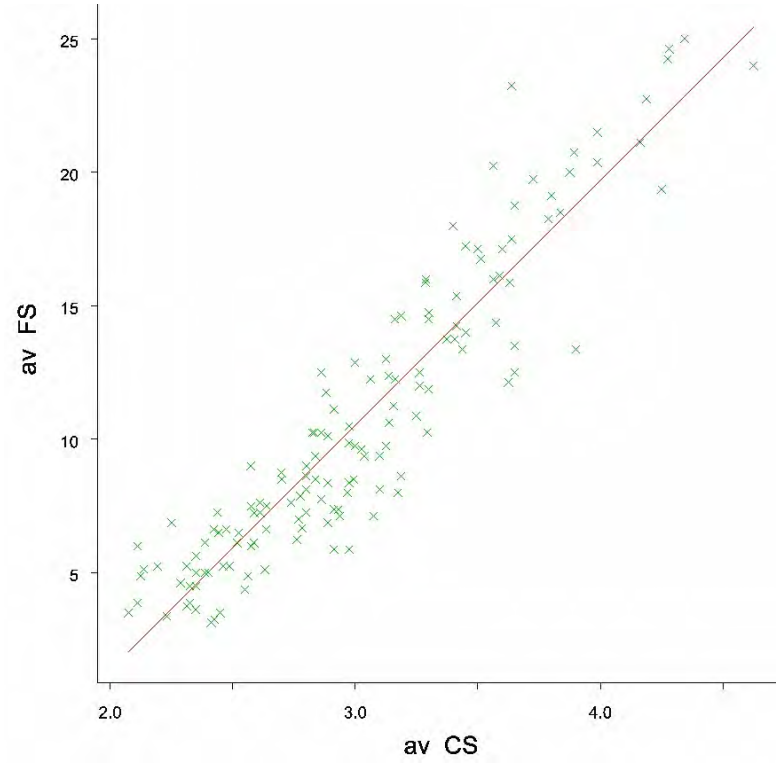
Comparison of average ultrasound and carcass measurements of Lumbar eye muscle depth on the same sheep

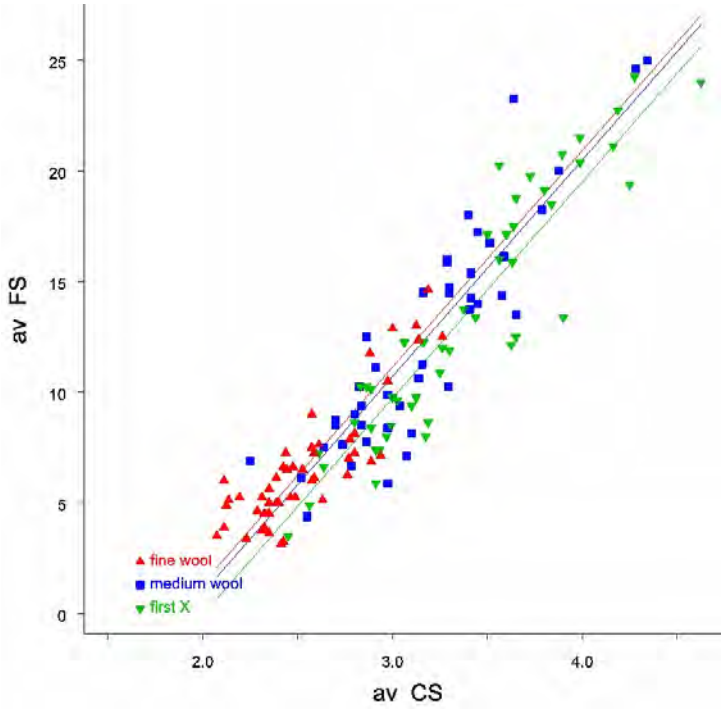
This graph shows a comparison of average ultrasound and carcass measurements of Lumbar fat on the same sheep – the line represents perfect agreement between carcass and ultrasound measurements. While there appears to be about as much variation above the line as below ultrasound does not appear to give a reliable indication of lumbar eye muscle depth in these animals. Again the accuracy of lumbar EMD measurement on the carcass must be considered.



4.20 Comparison of average fat score and average condition score

The graphs below show a good relationship between average fat score and average condition score.




av FS
av CS
25
20
15
10
5
0
2.0
3.0
4.0
fine wool
medium wool
first X

4.21 Correlation between assessors

The correlation between any two assessors for either fat score or condition score or between any two assessor for the two types of assessment (for their average assessments) is above 0.78 and generally around 0.9.

Correlation matrix

McLeod	1							
Shands	0.933	1						
Lollback	0.939	0.921	1					
Duddy	0.911	0.883	0.859	1				
Rose	0.854	0.88	0.832	0.809	1			
Gordon	0.904	0.891	0.905	0.844	0.886	1		
Plaisted	0.868	0.892	0.895	0.788	0.898	0.899	1	
Copping	0.891	0.893	0.884	0.836	0.888	0.915	0.901	1
	McLeod	Shands	Lollback	Duddy	Rose	Gordon	Plaisted	Copping

Relationship between C fat depth and GR (mm) carcass measures

The following table looks at the relationship between GR and C Fat as measured on the carcass in mm. The GR measurements taken for the right side of the carcass have been used as the comparison as all assessors worked on the right side of the sheep and C fat measures were also taken on the right side of the carcase.

Table 11:

Fat score	1	2	3	4	5
GR tissue depth - right (mm)	1 to 5	5.5 to 10	10.5 to 15	15.5 to 20	20.5+
av C fat (carcass) (mm)	1.48	5.20	7.93	9.89	15.75
C fat range (mm)	0 - 6	1 - 10	4.5 - 12.5	5 - 13	12.75 - 20

The relationship appears to be in the order of 1.5 (GR) to1(C fat). This would seem reasonable as the established relationship for sheep up to yearling age is about 3:1. As adult sheep have completed their growth and have experienced mature fat deposition the relative level of C Fat could be expected to be much higher than the juvenile 3:1 ratio seen in lambs.

4.22 Relationship between condition scores and fat scores and carcass measures (GR mm)

The established relationship between CS and FS and GR (mm) is shown in the following table along with the ranges established in this experiment. The table indicates that for the range of ewe types in this experiment the average GR mm carcass measure found for CS 3 was at the higher end of the expected range for that condition score and for condition score 4 the GR mm average was what would have been expected for score 5 ewes. This is a concern as the range of GR measures suggested previously appeared to allow easy interchange between the GR ranges for FS and CS .It is also not consistent with the fact that the correlations between FS and CS found in the experiment were high.

Fat score and condition score descriptors

		1	2	3	4	5
Fat score	Assessed on the long ribs at the GR site.	Individual ribs felt very easily. Cannot feel any tissue over the ribs	Individual ribs easily felt but some tissue present.	Individual ribs can still be felt but can feel tissue.	Can just feel ribs and fluid movement of tissue	Ribs barely felt. Tissue movement very fluid.
GR tissue depth for each fat score		Up to 5 mm	6 to 10 mm	11 to 15 mm	16 to 20mm	21 mm +
Average GRmm tissue depth founf in this study for each fat **score**[1]		**2.35 (range 1.75 to 3)**	**6.00 (range 2.25 to 16.5)**	**11.95 (6.25 to 18.75)**	**20.65 (11.5 to 25.75)**	**24.00 (20.25 to 25)**

[1]**based on the average fat score of the 4 operators**

		1	2	3	4	5
Condition score	**Backbone**	The bones form a sharp narrow ridge. Each vertebra can be easily felt as a bone under the skin. There is only a very small eye muscle. The sheep is quite thin (virtually unsaleable	The bones form a narrow ridge but the points are rounded with muscle. It is easy to press between each bone. There is a reasonable eye muscle. Store condition- ideal for wethers and lean meat.	The vertebrae are only slightly elevated above a full eye muscle. It is possible to feel each rounded bone but not to press between them. (Forward store condition ideal for most lamb markets now. No excess fat).	It is possible to feel most vertebrae with pressure. The back bone is a smooth slightly raised ridge above full eye muscles and the skin floats over it.	The spine may only be felt (if at all) by pressing down firmly between the fat covered eye muscles. A bustle of fat may appear over the tail (wasteful and uneconomic).
	Short ribs	The ends of the short ribs are very obvious. It is easy to feel the squarish shape of the ends. Using fingers spread 1cm apart, it feels like the fingernail under the skin with practically no covering	The ends of the short ribs are rounded but it is easy to press between them. Using fingers spread 0.5cms apart, the ends feel rounded like finger ends. They are covered with flesh but it is easy to press under and between them.	The ends of short ribs are well rounded and filled in with muscle. Using 4 fingers pressed tightly together, it is possible to feel the rounded ends but not between them. They are well covered and filled in with muscle	It is only possible to feel or sense one or two short ribs and only possible to press under them with difficulty. It feels like the side of the palm, where maybe one end can just be sensed	It is virtually impossible to feel under the ends as the triangle formed by the long ribs and hip bone is filled with meat and fat. The short rib ends cannot be felt.
Accepted GR mm for condition score (after Webb Ware 1997. MacKinnon Project Newsletter)		**0-2mm**	**3-7mm**	**8-15mm**	**16-22mm**	**23+mm**
Average GR mm tissue depth found in this study for each condition score[1]		**no sheep with average condition score 1**	**4.67**	**14.83**	**24.5**	**No sheep with average condition score 5**

[1]**based on the average fat score of the 4 operators**

GR tissue depth is measured 110 mm from backbone on 12th rib)

4.23 Relationship found in this comparison between condition score and carcass GR (mm)

Average Condition Score (all operators)	1	2 - <3	3 - <4	4 - <5	5
Av.GR tissue depth (right - mm)	-	4.67	14.83	24.50	-
GR tissue depth (range)	-	1.5 - 16.5	5 - 26.5	22.5 - 25	-

In this comparison only one condition score assessor scored any ewes as either 1 or 5 score. When scores were averaged across all four scorers to calculate this table these individual scores disappeared. By comparison there were many ewes scored as either 1 or 5 score by fat scorers.

5 Conclusions and recommendations

5.1 Conclusions

The recommendation made from Stage 1 in 2005 *"Therefore in future recommendations for management of ewe flocks it is our conclusion that targets framed in terms of condition score would offer far greater control over predicted effects on the performance of the ewes and future performance of their progeny than targets framed in terms of estimated GR tissue depth"* does not appear to be relevant to the results from Stage 2 across three ewe genotypes.

The major conclusion from Stage 2 across three ewe genotypes is that fat score and condition score have a similar ability to assess reproductive fitness in ewes and the relationship between them is linear in all but very lean sheep. The curvilinear relationship between FS and CS found in Stage 1 was not found in the Stage 2 in any of the ewe types to any significant degree. This could indicate something peculiar to the group of WA medium wool used in Stage 1.

The primary concern of either assessment technique in relation to ewe reproductive fitness is their ability to assess body fat reserves. As both techniques in this comparison equally assessed fatness, the two techniques are interchangeable for this purpose. The contention from Stage 1 that muscle mobilisation in thinner ewes (FS I) is best assessed by condition scoring needs re-considering. Experience in eastern Australia has been that for ewe reproductive fitness FS 1 ewes are not fit to join and low FS 2 ewes would have very poor conception. Ewes in these fat scores would be expected to have some muscle emaciation. Therefore FS is considered to already assess both fat and depleted muscle within fat scores 1 and 2.

The results of this comparison indicate that the industry priority for extension should be to encourage producers to adopt either technique to enable them to achieve the benefits of meeting recommended fat score or condition score targets for breeding ewes. These benefits include increased progeny numbers and survival rates in addition to improving the lifetime fleece value of wool producing sheep.

In Stage 1 ultrascan measures were used as the base comparison for CS and there were no carcass measures taken to establish the relationship between the ultrascan assessments of C fat. The accuracy of the ultrascanners in the Stage 2 comparison was reasonable for C fat and lumbar fat but consistently only detecting about half the fat depth, particularly in ewes with fat depths over 5mm. It was unreliable for eye muscle depth but the accuracy of the carcass muscle measures is open to some question as no repeatability measures were possible and the carcass measurement technique was not one in which either operator was practised.

Fat scoring is the assessment on the live sheep of the total tissue depth (mostly fat tissue) at the GR site, 110 mm from the centre of the backline on the 12 rib. It has been shown to be the best site measure from which to predict average fat deposition over the rest of the carcass. Consequently comparison of fat score in this comparison is most relevant to carcass GR measurement. Previous research has shown that the relationship between GR and C fat measures is usually about 3:1 but has generally been conducted on immature sheep. In this comparison a ratio of 1.5:1 was found reflecting the fat deposition of mature ewes.

Condition scoring is the assessment of fat and muscle over the short ribs (lumbar region) and therefore should have a strong relationship with lumbar fat and lumbar EMD carcass measures. It should also have a very strong relationship with C fat as the correlation between lumbar and C fats (carcass) is high - in this comparison (r = 0.955). In this comparison the relationship between CS and C fat and lumbar fat was good.

However in this comparison the relationship between both FS and CS and EMD at either C or lumbar sites was poor. This invites the question as to the relative importance or otherwise of muscle assessment in the overall CS assessment and the accuracy with which it can be assessed. However, as stated above the accuracy of the carcass muscle measures is open to some question as no repeatability measures were possible.

5.2 Recommendations

1. That MLA and AWI accept the major conclusion of Stage 2 that fat score and condition score have a similar ability to assess reproductive fitness in ewes and the relationship between them is linear in all but very thin sheep (those under 2mm GR).
2. That the sheep industry be informed through extension media that both fat score and condition score are acceptable and interchangeable for the assessment of reproductive fitness in ewes.
3. Publications that recommend assessment of ewes include a clear description of both fat scoring and condition scoring and how the two assessment techniques relate in terms of a common measure *i.e*. GR tissue depth, which can be readily measured on carcasses.

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