Report

FLEECESCAN and OFDA2000 Trial

Property: Alan Heitman - Mingenew

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Introduction

This paper reports the results of a trial between the FLEECESCAN and OFDA2000 on-farm testing technologies. The trial was run over 3 days at Alan Heitman's property at Mingenew (Arena). The stud has been run under the guidance of the Australian Merino Society (AMS) for over 30 years. Agriculture WA was approached by Mr Heitman and Chris Richardson to help design, supervise and analyze a trial in which both the FLEECESCAN and OFDA2000 were used to rank animals and prepare lines of wool based on mean fibre diameter (MFD). Commercial operators operated both instruments.

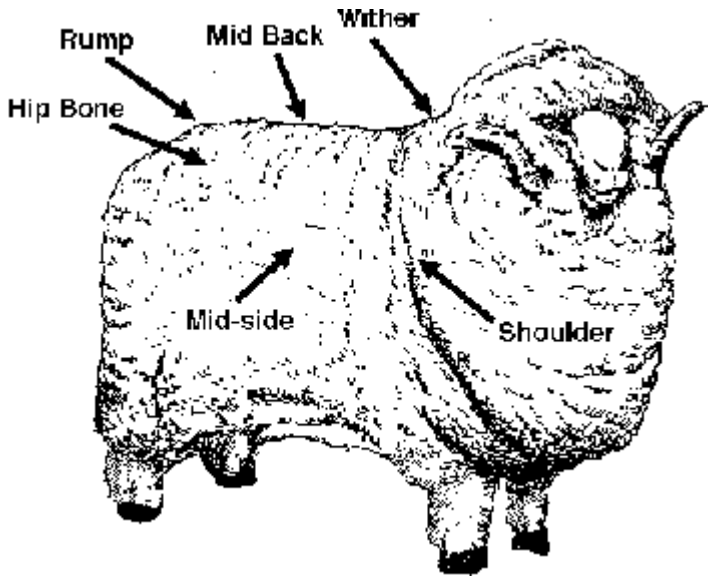
Method

OFDA2000 Measurements

A total of 600 ewe hoggets were used in the trial. The first 60 sheep were selected at random and sampled with hand shears at 8 sites around the animal (see Picture 1). Both left and right hand sides of the mid-side and shoulder was sampled. Each sample weighed approximately 20g. Three staples were chosen from the hipbone sample and one staple was chosen from the mid-side sample. Each staple was individually prepared and measured with the OFDA2000 so that there were 3 individual tests from the hipbone and 1 test from the mid-side for each animal. The remainder of each 20g sample was placed in an onion bag and sent to Australian Fibre Testing (AFT) for yield and fibre diameter measurements under standard laboratory conditions (20°C & 65% RH).

A further 40 sheep were selected at random and sampled (20g) at only the mid-side and hipbone. After OFDA2000 measurement of 3 staples from the hipbone and 1 staple from the mid-side, the remainder of these samples was sent to AFT for testing. All OFDA2000 testing was performed in the sheep yards.

Picture 1. The sites chosen for sampling sheep.



At the end of day 1, a grease test was performed on the last 30 sheep. The average MFD of each of 30 greasy staples was recorded prior to scouring the staples in an ultrasonic bath filled with solvent. Staples were then dried for 5 minutes at ambient environmental conditions and re-measured with the OFDA2000 with the grease correction factor (GCF) turned off. The difference in fibre diameter between the greasy and clean staples was 0.8 micron (19.9µm-19.1µm). The GCF and the MFD at which the GCF was calculated (19.9 µm) are entered into the OFDA2000 software via a special menu. The GCF was then automatically calculated for a range of diameters using the following equation;

$$GCF = 0.088 * \text{greasy micron} - 0.93$$

For the remaining 500 hoggets (day 2), one staple was removed from the hipbone site using a pair of curved scissors and measured with the OFDA2000. The automatic humidity correction was also used for all measurements in the field.

FLEECESCAN Measurements

The same 100 hoggets that were repeatedly measured with the OFDA2000 were also shorn first on day 2 of the trial. Immediately after shearing and skirting, each fleece was cored and measured three times by the FLEECESCAN. Each fleece was taken out of the coring chamber and turned around on each successive coring. Fleeces were classed using the third and final MFD measurement of each fleece. The remaining 500 hoggets were shorn (day 2 and 3) and fleeces were cored and measured once with the FLEECESCAN.

Splitting of Lines

Based on special classing software (WOOLCLASSER, Agriculture NSW), the clip was separated into three lines (<18.7, 18.7 to 19.8 and >19.8 µm). The first 300 fleeces were classed into three lines based on the FLEECESCAN fibre diameter measurement of the fleece. At the completion of the last fleece, lines were closed and pressed into bales.

The last 300 hoggets were classed on the OFDA2000 fibre diameter measurement of a staple taken from the hipbone. Because the hipbone MFD measurements were expected to be broader than the skirted fleece MFD, a simple correction was made to hipbone measurements prior to classing on this value. To derive this value for each fleece, the fibre diameter measurement from the hipbone was adjusted by -0.3 µm. The basis for this adjustment is as follows. The difference between hipbone MFD and mid-side MFD was 0.45 µm for the first 100 hoggets. In another flock (A.D. Peterson, unpublished) the hip-bone was found to be 0.6 µm broader than the skirted fleece MFD and the difference between the hip-bone MFD and mid-side MFD was 0.9 µm. Because the difference between hip-bone and mid-side was only 0.45 µm (half that of past research), the correction between skirted fleece MFD and hip-bone was also halved from 0.6 to the 0.3 µm. Once all fleeces had been shorn and classed, lines were closed and baled.

Some fleeces were not placed into the three selected lines because they were coloured, cotted or tender. Lines were core tested at Standard Wool Australia (Fremantle, WA) under IWTO test guidelines and subsequently measured by Laserscan using normal certification procedures (IWTO-12-00).

Data Analysis

Data files were swapped at the end of the trial between AGWEST and FLEECESCAN operators to maintain integrity of the information. Statistical analysis was performed using the software package Genstat for Windows 5.0. The IWTO guidelines for calculation and reporting of statistical data (IWTO-0 Appendix B) were used for much of the analysis. The variance components were estimated from a Restricted Mean Likelihood (REML) model using Genstat 5.0.

Results

Instrument Precision

The MFD results from 99 hoggets were used to assess the precision of tests from the FLEECESCAN and OFDA2000 (Table 1). One fleece test was removed from the dataset due to a misread tag number. The values of precision were based on 3 repeat core measurements on the fleece (FLEECESCAN) or 3 different staples taken from the same 20g sub-sample of the hip-bone (OFDA2000). The precision of the two systems is not directly comparable since one measures the precision of testing a fleece whilst the other is the precision of testing at a site.

A linear mixed model was fitted to measurements of fibre diameter made by both machines. Three replicate samples were measured from each of 100 sheep. The model included a fixed effect for machine and random effects for sheep and replicate within sheep. It allowed the variance between sheep and the variance between replicates to be different for each machine. The model was fitted using the REML command in Genstat for Windows Edition 5. Variance components were compared using likelihood ratio tests and the fixed effect was tested using a Wald test.

There was a significant difference in fibre diameter as measured by the two machines ($p<0.001$, 19.20 for LASERSCAN vs. 19.54 for OFDA2000 (hip)). The variance between sheep was the same for both machines ($p = 0.177$), but the variance between replicates was significantly different ($p<0.001$, 0.200 for LASERSCAN vs. 0.085 for OFDA2000 (hip)).

Measurements from the 99 sheep were split into three micron groups (<19, 19-20, >20) to investigate any changes in the level of precision relative to MFD. There did not appear to be any change in the precision of either measurement system at different ranges of MFD (Table 1 & 2).

Table 1. The precision of testing one staple from the hip-bone using the OFDA2000 in the field. Values in brackets are standard errors.

	<19	19-20	>20	Total
Sheep	31	39	29	99
Mean	18.25	19.47	21.00	19.54
Variance between sheep	0.404 (0.113)	0.057 (0.019)	0.836 (0.231	1.535 (0.223)
Variance between reps	0.104 (0.018)	0.073 (0.012)	0.081 (0.015)	0.085 (0.008)
95% CL (between reps)	±0.63	±0.53	±0.56	±0.57

Table 2. The precision of testing a fleece using the FLEECESCAN in the field. Values in brackets are standard errors.

	<19	19-20	>20	Total
Sheep	46	30	23	99
Mean	18.23	19.43	20.95	19.54
Variance between sheep	0.437 (0.105)	0	0.572 (0.198)	1.463 (0.219)
Variance between reps	0.178 (0.026)	0.218 (0.032)	0.201 (0.043)	0.200 (0.020)
95% CL (between cores)	±0.83	±0.91	±0.88	±0.88

Comparing FLEECESCAN, OFDA2000 and AFT measurements

The different measurement systems were compared on the first set of 99 hoggets. The MFD between animals ranged from 16.4 to 23.2 µm (measured by AFT). The average MFD of the first 60 sheep as measured by the different systems is shown in Table 3. The averaged MFD of the 99 sheep did not change (P>0.05) between sample replicates (i.e. core 1, 2 and 3) for either the hipbone (OFDA2000) or fleece (FLEECESCAN).

There was good agreement between OFDA2000 and AFT measurements of MFD on the mid-side (Table 4). The OFDA2000 measured significantly finer (0.2 µm, P<0.05) than AFT measurements of the hipbone.

Table 3. Summary statistics for various sampling/measurement systems for the same 60 sheep.

	OFDA2000 (hip)	OFDA2000 (mid)	FLEECESCAN	AFT (8 sites)
Sheep	60	60	60	60
Tests / Sheep	3	1	3	8
Mean (µm)	19.72	19.24	19.37	19.32
Standard Deviation (µm)	1.18	1.13	1.26	1.10
Standard Error (µm)	0.15	0.15	0.16	0.13

Table 4. Summary statistics for various sampling/measurement systems for the same 99 sheep.

	OFDA2000 (hip)	OFDA2000 (mid)	AFT (hip)	AFT (mid)
Sheep	99	99	99	99
Tests / Sheep	3	1	1	1
Mean (µm)	19.54	19.08	19.74	19.04
Standard Deviation (µm)	1.23	1.17	1.24	1.14
Standard Error (µm)	0.13	0.12	0.13	0.11

There was no significant (P>0.01) difference in the abilities of the FLEECESCAN or OFDA2000 to predict the MFD of the whole un-skirted fleece (AFT 8 sites MFD). The regression statistics for these relationships are shown in Table 5. The relationships between OFDA2000 and AFT measurements on the hipbone and mid-side are shown in Table 6.

Table 5. Statistical data for linear regressions and difference vs. average plots when comparing various systems of MFD measurement. Values in brackets are standard errors.

X vs. Y	Linear Regression	Diff. vs. AFT
OFDA2000 (1 staple hip) vs. AFT (8 sites), n=60		
r^2	0.80 (0.54)	NS
Slope	1.03 (0.04)	NS
Intercept	-0.23 (0.75)	NS
FLEECESCAN (1 core) vs. AFT (8 sites), n=60		
r^2	0.83 (0.54)	0.08
Slope	1.16* (0.04)	0.16^{+}(0.04)
Intercept	-3.05 (0.75)	
		Diff. vs. Ave
OFDA2000 (1 staple hip) vs. FLEECESCAN, n=99		
r^2	0.75 (0.62)	NS
Slope	0.88* (0.05)	NS
Intercept	2.61 (0.98)	NS

*slope significantly different to 1 (P>0.05); $^{+}$slope significantly different to 0 (P>0.05); NS = not significant.

Table 6. Statistical data for linear regressions and difference vs. average plots when comparing various systems of MFD measurement. Values in brackets are standard errors.

X vs. Y	Linear Regression	Diff (Y-X). vs. Ave
OFDA2000 (hip, 1 staple) vs. AFT (hip), n=99		
r^2	0.77 (0.60)	NS
Slope	0.89* (0.05)	NS
Intercept	2.02 (0.96)	NS
OFDA2000 (mid, 1 staple) vs. AFT (mid), n=99		
r^2	0.77 (0.56)	NS
Slope	0.91 (0.05)	NS
Intercept	-1.80 (0.95)	NS

*slope significantly different to 1 (P>0.05); $^{+}$slope significantly different to 0 (P>0.05); NS = not significant.

Sheep can be ranked on their MFD measurements and rankings can be compared between different methods of MFD determination. For example, sheep were ranked from 1 to 60 based on their MFD measurement. The linear regression and correlation coefficient was then calculated between this ranking and the ranking based on the MFD of 8 sample sites. The standard error of the regression could then be used to estimate the error in ranking. A 95% CL of ±17 would therefore mean that a sheep ranked as 40 out of 60 (based on the single MFD measurement) would have a 5% chance that the true rank of the animal (based on the MFD of the 8 sites) would be less than 23 or greater than 57.

The rankings based on FLEECESCAN measurements best matched the rankings based on the average MFD of the 8 sample sites (Table 7).. This included being slightly better than the AFT test of a mid-side. The 95% CL's shown in Table 7 show that 95 out of 100 sheep will be ranked within ± *x* sheep of the true ranking (based on the AFT 8 sites value).

Table 7. Correlation coefficients (with standard errors) between the rankings of sheep based on the MFD of 8 sites (AFT), versus the ranking of sheep based on the MFD measurements of other systems, for 60 sheep.

Comparative Measurement	r^2 (s.e.)	95% CL
AFT (mid-side)	0.75 (8.70)	±17
FLEECESCAN (1 core test)	0.79 (8.07)	±15.8
FLEECESCAN (mean of 3 core tests)	0.88 (6.10)	±12.0
OFDA2000 (hip-side, 1 staple)	0.72 (9.29)	±18.2
OFDA2000 (hip-side, mean of 3 staples)	0.74 (8.80)	±17.2
OFDA2000 (mid-side, 1 staple)	0.74 (8.97)	±17.6
OFDA2000 (mean of mid and hip, 1 staple each)	0.79(8.09)	±15.9

Variation at sites across fleece

The average difference between mid-side and hipbone sample sites was 0.45 µm for OFDA2000 measurements of greasy staples, and 0.5 - 0.7 µm for AFT measured samples. The shoulder was the finest sample site and also had the highest yield (Table 8). There was only a 1.09 µm difference between the finest and broadest (rump) sample site. Of all the sites, the mid-side had the strongest correlation with the average MFD of the 8 sites.

Table 8. The average MFD and yield of 100 animals tested at each sample site by the Laserscan under laboratory conditions (Australian Fibre Testing). Correlations are shown between the MFD at a site, and the combined average MFD of the 8 sample sites for 60 hoggets.

Site	No. sheep sampled	MFD (um), variance in brackets	Yield (%), variance in brackets	Correlation (r^2) with MFD of 8 Sites (n=60), se in brackets
Shoulder	60	18.85 (1.36)	71 (27.6)	0.75(0.58)
Shoulder (2nd)	60	18.91 (1.37)	71 (32.4)	0.75(0.58)
Mid	99	19.04 (1.29)	61 (25.7)	0.83 (0.49)
Mid (2nd)	60	19.17 (1.48)	62 (18.4)	0.83 (0.43)
Wither	60	19.27 (1.40)	68 (65.5)	0.80 (0.53)
Middle Back	60	19.56 (1.28)	60 (40.9)	0.79 (0.52)
Hip	99	19.74 (1.54)	62 (30.5)	0.83 (0.51)
Rump	60	19.94 (1.42)	63 (64.5)	0.79 (0.54)
Mean		**19.32**	**64**	

Correlation's between FLEECESCAN and OFDA2000 MFD (whole 600 hoggets)

As mentioned earlier, an attempt was made to correct for the difference between hip-bone measurements and the expected MFD of the whole-skirted fleece. As a result, hipbone measurements were corrected by -0.3 µm and then fleeces were classed into lines based on this value.

The overall mean of the 8 sample sites (19.32µm) for the first 60 sheep compared well with the average MFD of the first 300 fleeces measured by FLEECESCAN (19.17µm) and OFDA2000 hipbone (19.41µm), (Table 9). This difference changed however in the second set of 300 fleeces where the FLEECESCAN measured 0.2 µm broader than the OFDA2000 hipbone measurements. The FLEECESCAN result was based on 1 core per fleece and the OFDA2000 was based on 1 staple per hipbone from each sheep. There was a poor relationship between individual FLEECESCAN and OFDA2000 measurements for all 579 sheep (Table 10 and Figures 3 & 4).

On closer examination, it was found that there were far greater differences between the two instruments on the second set of 300 hoggets. The relationship between FLEECESCAN and OFDA2000 for each set of animals is shown in Table 10.

Table 9. Summary statistics of MFD measurements from OFDA2000 and FLEECESCAN, for different groups of sheep

	OFDA2000 (hip)	FLEECESCAN
All Fleeces, n=579		
Mean (µm)	19.31	19.29
Standard Deviation (µm)	1.16	1.32
Standard Error (µm)	0.05	0.05
First set of fleeces, n=291		
Mean (µm)	19.41	19.17
Standard Deviation (µm)	1.26	1.26
Standard Error (µm)	0.07	0.07
Second set of fleeces, n=288		
Mean (µm)	19.22	19.42
Standard Deviation (µm)	1.05	1.38
Standard Error (µm)	0.06	0.08

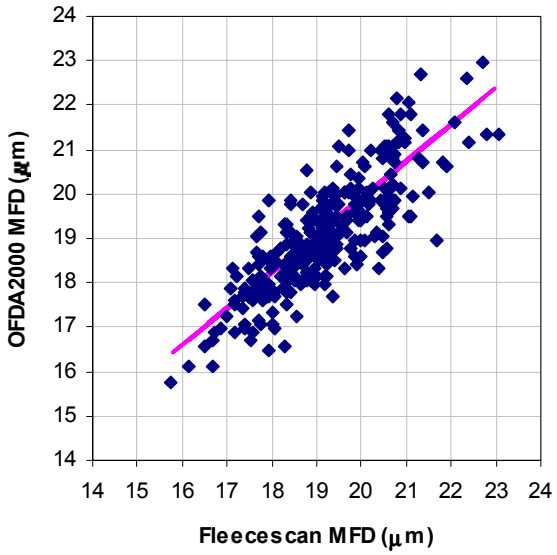
Table 10. Statistical data for linear regressions and difference vs. average plots when comparing OFDA2000 and FLEECESCAN measurements of MFD for different groups of sheep. Values in brackets are standard errors.

X vs. Y	Linear Regression	Diff (Y-X). vs. Ave
OFDA2000 (1 staple hip) vs. FLEECESCAN (1 core), n=579		
r^2	0.49 (0.83)	NS
Slope	0.61* (0.03)	NS
Geometric Mean Slope	0.88* (0.03)	
Intercept	7.18 (0.50)	
OFDA2000 (1 staple hip) vs. FLEECESCAN (1 core); first set of fleeces, n=291		
r^2	0.68 (0.71)	NS
Slope	0.82* (0.03)	NS
Geometric Mean Slope	0.99 (0.04)	
Intercept	3.31 (0.64)	
OFDA2000 (1 staple hip) vs. FLEECESCAN (1 core); second set of fleeces, n=288		*See fig. 4b*
r^2	0.36 (1.10)	0.11 (1.06)
Slope	0.79* (0.06)	0.34^{+} (0.06)
Geometric Mean Slope	0.76* (0.04)	
Intercept	4.41 (1.17)	

*slope significantly different to 1 (P>0.05); $^{+}$slope significantly different to 0 (P>0.05); NS = not significant.

Clearly there was a problem with at least one instrument when measuring the last 300 fleeces (the fleeces classed by OFDA2000). To try and identify which instrument was in error, the difference between both instruments was plotted against the time sequence that each fleece was measured during the day (Figures 5 and 6). The reason for the poor relationship above was identified from a distinct set of data in the last 300 fleeces. There appears to be a section of time where the FLEECESCAN's measurement of MFD was considerably higher than that of the OFDA2000 for the same fleeces. This body of data seems to explain the poor relationship between OFDA2000 and FLEECESCAN in the second set of 300 fleeces. It appears that while there was no trend in the relationship between the difference in micron of the two machines and the time of measurement by the OFDA 2000 there was a trend in the relationship when plotted against time of measurement by the FLEECESCAN. The difference between the two machines when plotted against time of measurement by the FLEECESCAN tended to trend above the zero difference line after 11:52 AM to around 12:50 PM before trending down. At this stage, there is no explanation for this difference between instruments.

Figure 3a and 3b. The average of FLEECESCAN and OFDA2000 (hipbone measurements - 0.3 µm) measurements plotted against the differences of the same two measurements for the first set of 300 individual fleece tests. Fleeces were classed into lines based on the FLEECESCAN measurement. Dotted lines on Fig 3b denote mean and standard deviation.



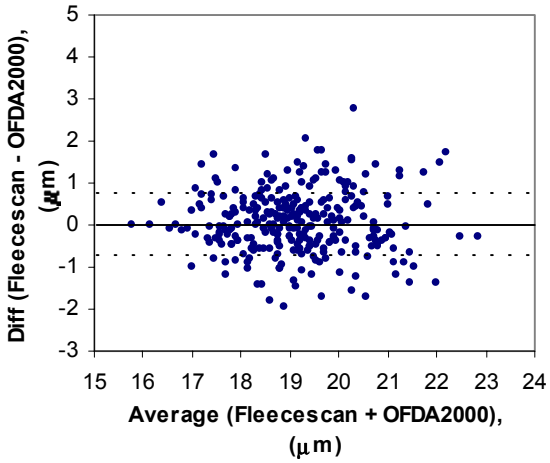
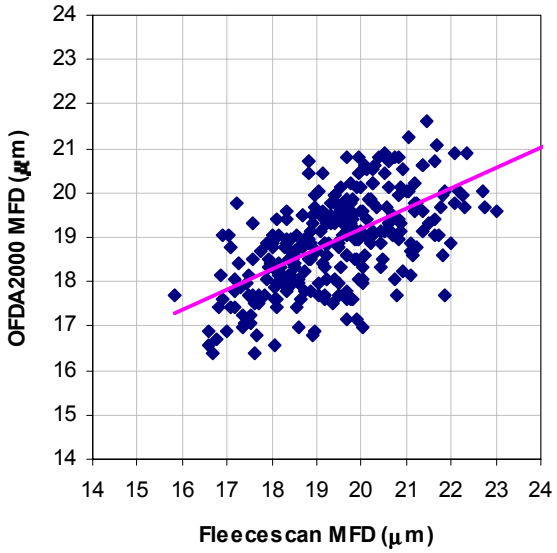


Figure 4a and 4b. The average of FLEECESCAN and OFDA2000 (hipbone measurements - 0.3 µm) measurements plotted against the differences of the same two measurements for the second set of 300 individual fleece tests. Fleeces were classed into lines based on the OFDA2000 measurement. Dotted lines on Fig 1b denote mean and standard deviation.



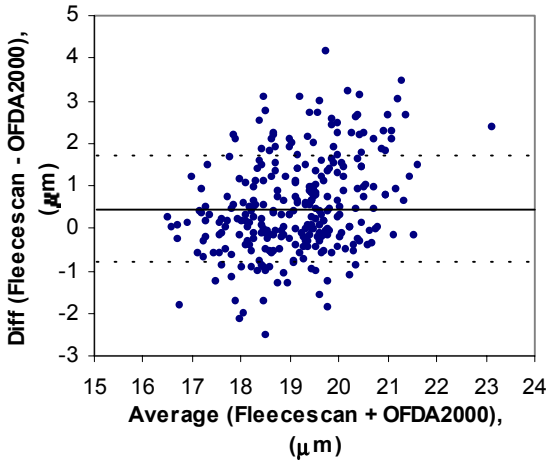


Figure 5. The difference between FLEECESCAN and OFDA2000 (hipbone measurements - 0.3 µm) measurements of MFD for the second set of fleeces (300) plotted against time of measurement by the FLEECESCAN. Line represents a moving average of every 12 measurements.

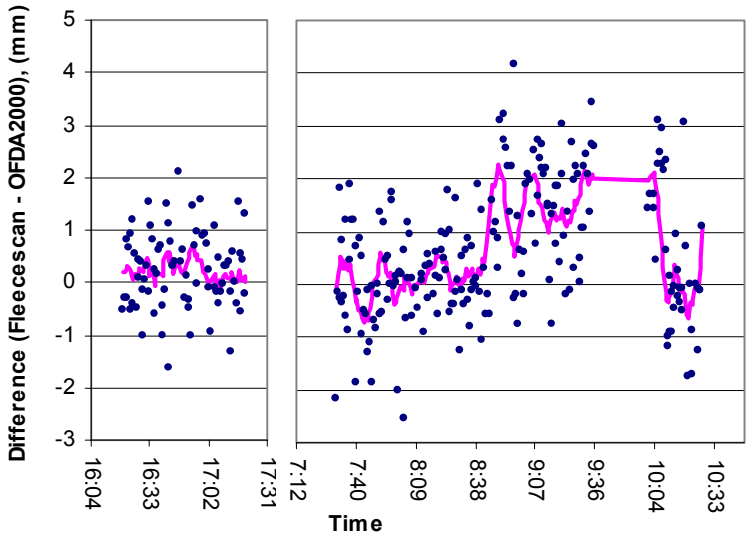
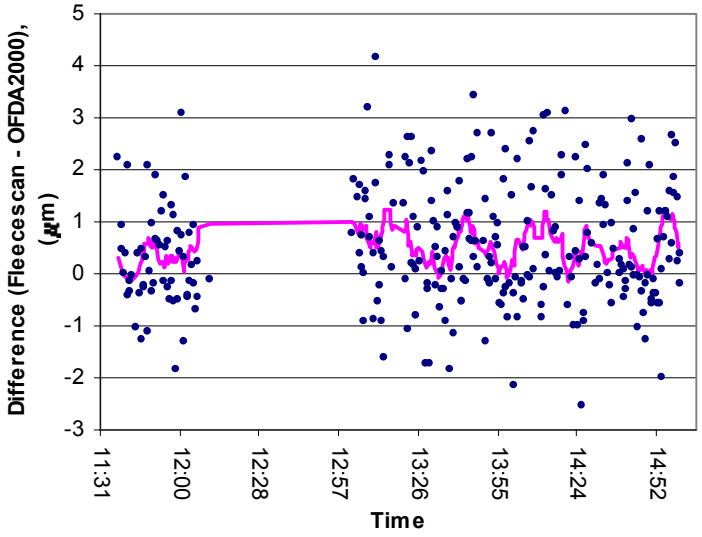


Figure 6. The difference between FLEECESCAN and OFDA2000 measurements of MFD for the second set of fleeces (300) plotted against time of measurement by the OFDA2000. Line represents a moving average of every 12 measurements.



Preparation of lines classed on MFD

Results for the classed lines are shown in Table 11 and 12. The averaged results for FLEECESCAN and OFDA2000 measurements were not weight adjusted (i.e. taking into account skirted fleece weight). Both instruments showed good agreement with the resultant core test results for each line when used to separate fleeces into micron classes. However, the FLEECESCAN was consistently reading broader than the AWTA core test results for the second set of 300 fleeces. This is consistent with the observations illustrated in Figures 4a, 4b and 5.

Table 11. The mean fibre diameter of 267 fleeces classed into 3 lines according to FLEECESCAN. Values from OFDA2000 are hipbone - 0.3 µm

	Line			
	18.6 and less	**18.7 to 19.8**	**19.9 and greater**	**Weighted Average (µm)**
FLEECESCAN (µm)	17.9	19.2	20.8	19.3
OFDA2000 (µm)	18.0	19.2	20.4	19.2
AWTA core (µm)	17.7	18.9	20.3	18.9
No. Fleeces	95	100	72	
Greasy Weight (kg)	384	477	368	
Min of FLEECESCAN	15.8	18.7	19.9	
Max of FLEECESCAN	18.7	19.9	23.1	
Min of OFDA2000	15.8	17.7	18.3	
Max of OFDA2000	19.9	21.4	23.0	
Var. of FLEECESCAN (σ^2)	0.4	0.1	0.5	
Var. of OFDA2000 (σ^2)	0.7	0.5	1.1	

Table 12. The mean fibre diameter of 264 fleeces classed into 3 lines according to OFDA2000. Values from OFDA2000 are hipbone - 0.3 µm

	Line			
	18.6 and less	**18.7 to 19.8**	**19.9 and greater**	**Weighted Average (µm)**
FLEECESCAN (µm)	18.6	19.7	20.7	19.5
OFDA2000 (µm)	17.8	19.3	20.5	19.0
AWTA core (µm)	18.1	19.1	20.5	19.0
No. Fleeces	106	113	45	
Greasy Weight (kg)	454	516	237	
Min of FLEECESCAN	15.8	16.9	18.8	
Max of FLEECESCAN	21.8	23.0	24.3	
Min of OFDA2000	16.4	18.8	20.0	
Max of OFDA2000	18.7	19.9	22.0	
Var. of FLEECESCAN (σ^2)	1.5	1.3	1.3	
Var. of OFDA2000 (σ^2)	0.3	0.1	0.2	

Conclusions

Both OFDA2000 and FLEECESCAN systems were similar in their levels of precision when ranking animals based on MFD measurements although the OFDA2000 measurement based on 1 greasy staple were slightly more precise than the FLEECESCAN measurement of a fleece. The ability of each system to rank animals based on MFD measurements compared well with conventional laboratory testing from a 20g sub-sample taken at the hip-bone. However, it may be difficult to accurately assess the MFD of animals using the OFDA2000 unless a relationship can be established between MFD at the site of sampling and the MFD of the whole fleece. This can be achieved by measuring the difference between the averaged MFD of measurements from a particular sample site, and the MFD of the resultant sale-lot or line after coring and testing by AWTA. The relationship could then be used as a guide to future testing.

There were serious problems with the quality control of FLEECESCAN measurement throughout the testing period. There is strong evidence to suggest that the FLEECESCAN was overestimating MFD during a 1 hour testing period. There was insufficient information available that could explain this discrepancy although discussions with CSIRO have indicated that the fibre snippets may not have been properly scoured. Critically, this discrepancy was not identified by the operator, or by the Laserscan software and so one would not be aware of the error in measurement. The OFDA2000 does have an automatic calibration check using a polyester fibre that should negate any errors associated with the accuracy of the instrument itself. However, it is strongly recommended that both instruments be checked at regular intervals using a wool standard.