

The estimation and utilisation of variation in fibre diameter profile characteristics between sheep

By

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Declaration

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree or qualification.

I certify that to the best of my knowledge, any help received in preparing this thesis and all sources used have been acknowledged in this thesis.



Daniel John Brown

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Table of Contents

Declaration	ii
Acknowledgments	iii
Table of Contents	v
List of Tables	ix
List of Figures	xii
List of Appendices	xiv
List of Abbreviations	xvi
Abstract	xviii
CHAPTER 1: General Introduction	1
CHAPTER 2: Review of Literature - Fibre diameter responses of sheep to environmental conditions and its relationship with staple strength	
2.1 Introduction	3
2.2 Definitions	4
2.3 Staple Strength	6
2.3.1 <i>The importance of staple strength</i>	6
2.3.2 <i>Measurement of staple strength</i>	7
2.3.3 <i>Variation in staple strength</i>	9
2.4 Constituent fibre properties in relation to staple strength	9
2.4.1 <i>Components of fibre diameter variation</i>	10
2.4.1.1 Fibre diameter distribution.....	15
2.4.1.2 Variation along-fibres	15
2.4.1.2.1 Fibre diameter profiles	16
2.4.1.2.2 Minimum fibre diameter.....	17
2.4.1.2.3 Rate of fibre diameter change.....	19
2.4.1.2.4 Overall along-staple fibre diameter variation.....	20
2.4.1.3 Between-fibre variation in fibre diameter	20
2.4.2 <i>The Intrinsic Strength of Wool Fibres</i>	21
2.4.3 <i>Fibre Shedding</i>	23
2.4.4 <i>Fibre Length variation</i>	25
2.4.5 <i>Fibre Crimp and Curvature</i>	26
2.5 Factors that influence staple strength and FDP characteristics	28
2.5.1 <i>Environmental Influences</i>	28
2.5.1.1 Susceptibility to environment	28
2.5.1.2 Nutrition.....	29
2.5.1.2.1 Voluntary feed intake	31
2.5.1.2.2 Metabolism and nutrient partitioning	33
2.5.1.2.2.1 Follicle nutrition.....	35
2.5.2.3 Physiological state.....	37
2.5.2.4 Weather conditions	38
2.5.2 <i>Wool type</i>	38
2.5.3 <i>L/D ratio</i>	39
2.5.3.1 The response of L/D ratio to nutritional change	40
2.5.3.2 L/D ratio and other environmental influences	41
2.5.4 <i>Skin and follicle characteristics</i>	41
2.5.4.1 Follicle density	42

2.5.4.2 S/P ratio.....	43
2.5.4.3 Skin thickness	44
2.5.5 Genetic differences	44
2.5.6 Sheep management	48
2.5.7 Other factors.....	49
2.5.7.1 Sheep behaviour.....	49
2.5.7.2 Sheep health	50
2.5.7.3 Disease	50
2.5.7.4 Internal and external parasites.....	50
2.5.7.5 Mineral and vitamin balance.....	51
2.5.7.6 Age	52
2.5.7.7 Sex	53
2.5.7.8 Hormones	53
2.6 Conclusion	54

CHAPTER 3: The estimation of fibre diameter profile characteristics using reduced profiling techniques

3.1 Introduction	56
3.2 Materials and Methods.....	58
3.2.1 Wool samples.....	58
3.2.2 Fibre diameter profiling.....	59
3.2.3 Simple profile reduction	60
3.2.4 FDP characteristics.....	60
3.2.5 Profile Prediction	61
3.2.6 Customised profiles	62
3.2.7 Statistical analysis	63
3.3 Results	65
3.3.1 Simple profile reduction	65
3.3.2 Prediction profiles and customised profiles	69
3.3.3 FDP characteristics between environments, bloodlines and sires.....	74
3.4 Discussion	74
3.5 Conclusions	79

CHAPTER 4: Bloodline and sire differences in FDP characteristics over a number of environments

4.1 Introduction.....	81
4.2 Materials and Methods.....	82
4.2.1 Experiment 1	82
4.2.2 Experiment 2	83
4.2.2.1 Wool Samples	83
4.2.2.2 FDPs and FDP characteristics.....	84
4.2.2.3 Statistical Analysis.....	84
4.2.3 Description of environments	85
4.3 Results	87
4.3.1 Experiment 1	87
4.3.2 Experiment 2	90
4.4 Discussion	94
4.5 Conclusions.....	97

CHAPTER 5: The relationship between the FDP characteristics and staple strength across bloodlines and environments

5.1 Introduction	98
5.2 Materials and Methods	100
5.3 Results	101
5.3.1 <i>Experiment 1</i>	101
5.3.2 <i>Experiment 2</i>	104
5.4 Discussion	108
5.5 Conclusion	114

CHAPTER 6: Determinants of environmental responsiveness of fibre diameter in grazing fine wool Merino sheep

6.1 Introduction	116
6.2 Materials and Methods	119
6.2.1 <i>Animals</i>	119
6.2.2 <i>Environment</i>	120
6.2.2.1 <i>Temperature and Rainfall</i>	120
6.2.2.2 <i>Pasture</i>	121
6.2.3 <i>Sheep Management</i>	122
6.2.4 <i>Sampling regime</i>	122
6.2.5 <i>Wool Measurements</i>	123
6.2.5.1 <i>Dyebands</i>	123
6.2.5.2 <i>L/D ratios</i>	124
6.2.5.3 <i>FDPs and FDP characteristics</i>	125
6.2.5.4 <i>Staple strength and staple length</i>	125
6.2.5.5 <i>Fibre diameter and Yield</i>	125
6.2.6 <i>Fat depth</i>	126
6.2.7 <i>Skin thickness</i>	126
6.2.7.1 <i>Calliper method</i>	126
6.2.7.2 <i>Ultrasound method</i>	126
6.2.8 <i>Statistical Analysis</i>	127
6.3 Results	127
6.3.1 <i>Pasture Analysis</i>	127
6.3.2 <i>Summary of traits measured throughout the experiment</i>	128
6.3.3 <i>Relationship between the FDP characteristics and the fibre based measurements</i>	132
6.3.4 <i>Relationship between FDP characteristics and mid-side wool quality characteristics</i>	134
6.3.5 <i>Relationship between FDP characteristics and body traits</i>	136
6.3.6 <i>Relationships between the fibre based and mid-side measurements</i>	138
6.3.7 <i>Relationships between the fibre based measurements and body traits</i>	138
6.3.8 <i>Canonical correlation analysis</i>	138
6.3.9 <i>Relationship between FDP and mid-side measurements with staple strength</i>	140
6.3.10 <i>Relationship between the fibre based measurements with staple strength</i>	142
6.3.11 <i>Relationship between the body traits with staple strength</i>	143
6.3.12 <i>Comparison between skin thickness measurements</i>	143
6.4 Discussion	145
6.5 Conclusions	154

CHAPTER 7: Methods for estimating fibre length and diameter in wool staples

7.1 Introduction	156
7.2 Materials and Methods	158
7.2.1 <i>Fibre length measurement techniques</i>	158
7.2.1.1 Autoradiographic (³⁵ S) technique.....	158
7.2.1.2 Dyeband based techniques	158
7.2.1.2.1 Snippet technique.....	159
7.2.1.2.2 Dyeband technique.....	159
7.2.2 <i>Fibre length prediction</i>	160
7.2.2.1 Prediction method 1	160
7.2.2.2 Prediction method 2	161
7.2.2.3 Prediction method 3	162
7.2.3 <i>Statistical analysis</i>	162
7.3 Results	162
7.3.1 <i>Fibre length prediction</i>	164
7.4 Discussion	165
7.5 Conclusion	169
CHAPTER 8: General Discussion	170
References	176
Appendices	198

List of Tables

Table 2.1 Summary of the published phenotypic and genetic correlations between the FDP characteristics, mid-side mean fibre diameter, mid-side fibre diameter variation and staple length with staple strength.....	11
Table 2.2 Summary of heritability estimates for skin traits from Crook (1997)	42
Table 3.1 The error terms used in the overall analysis to test the environment (Envt), bloodline (Bld), environment by bloodline interaction (Envt * Bld), Envt * Sire (Sire) and sire by environment interaction effects in the model.....	64
Table 3.2 Differences between the mean values for the FDP characteristics estimated from the simple reduced profiles and the mean values as calculated from the full original profile	66
Table 3.3 Residual correlation coefficients for the relationship between the FDP characteristics calculated from the full original FDP and those estimated from the reduced FDPs using simple profile reduction	67
Table 3.4 The intra-class correlations between inclusion scenarios within each level of inclusion for the Armidale samples	68
Table 3.5 The least square means, standard errors (s.e.) and residual correlations between staples for each FDP characteristics from the Armidale samples.....	68
Table 3.6 The percentage of variation within each component of the model used from the Armidale samples.....	69
Table 3.7 The residual correlations between the original full FDPs and the predicted FDPs at 10 levels of inclusion from the FDP prediction technique.....	70
Table 3.8 The average level of final snippet inclusion as a percentage for each initial inclusion scenario from the FDP prediction and intensive re-sampling techniques	71
Table 3.9 The differences between the mean values of AstVAR and AstCV estimated from the predicted profiles (0 snippets re-sampled) and the customised FDPs to the means calculated from the original full FDPs. Ten initial levels of inclusion and 6 levels of intensive re-sampling are presented	72
Table 4.1 The number of animals sampled in each environment, bloodlines and year group from experiment 2	83
Table 4.2 The error terms used to test the effects in the model fitted in the analysis of variance from experiment 2	84
Table 5.1 The residual correlations between the FDP and wool quality characteristics with staple strength over all the data (n= 40), within each environment (n= 20) and within each bloodline (n= 20) in experiment 1	101

Table 5.2	The proportion of variation in staple strength (SS) explained by the wool quality, FDP and both wool quality and FDP characteristics in the stepwise multiple regression analysis over all data in experiment 1	102
Table 5.3	The residual correlations between the FDP and wool quality characteristics with staple strength over all the data (n= 380), environment (n= 110 and 270) and within each bloodline (n= 83, 62, 116 and 119) in experiment 2	105
Table 5.4	The proportion of variation in staple strength (SS) explained by the wool quality, FDP and both wool quality and FDP characteristics in the stepwise multiple regression analysis over all data in experiment 2	105
Table 5.5	The proportion of variation in staple strength (SS) explained by the wool quality, FDP and both wool quality and FDP characteristics in the stepwise multiple regression analysis within each environment in experiment 2	106
Table 5.6	The proportion of variation in staple strength (SS) explained by the wool quality, FDP and both wool quality and FDP characteristics in the stepwise multiple regression analysis within each bloodline in experiment 2	107
Table 6.1	The sampling regime and ³⁵ S-cysteine Injections for the duration of the experiment.....	123
Table 6.2	Summary of the mean values and variation between animals for each of the wool and body characteristics measured during the experiment	129
Table 6.3	The mean fibre diameter at dyeband and staple length growth in-between dyebands throughout the experiment.....	130
Table 6.4	The least squares means for each L/D ratio measurements throughout the experiment.....	132
Table 6.5	The least squares means for the mean fibre diameter and fibre diameter measurement made at the beginning (initial) and at the end of the experiment (mid-side).....	132
Table 6.6	Correlation coefficients for the relationships between the wool fibre characteristics and the FDP characteristics.....	133
Table 6.7	Correlation coefficients for the relationships between the wool quality characteristics and the FDP characteristics.....	134
Table 6.8	Correlation coefficients for the relationships between the body characteristics and the FDP characteristics.....	136
Table 6.9	Correlations and standardised canonical coefficients for the canonical variables for IMFD and the L/D ratio measurement and FDP characteristics.....	139
Table 6.10	Correlations and standardised canonical coefficients for the canonical variables for the body traits and FDP characteristics.....	140

Table 6.11 Correlation coefficients for the relationships between the FDP and wool quality characteristics and staple strength.....	141
Table 6.12 The proportion of variation of staple strength (SS) explained by wool quality, FDP and both wool quality and FDP characteristics in stepwise multiple regression analysis.....	142
Table 6.13 Correlation coefficients for the relationships between the wool fibre characteristics and staple strength.....	142
Table 6.14 Correlation coefficients for the relationships between the body traits and staple strength	142
Table 6.15 The mean values, standard errors (s.e.) and correlation coefficients for the relationship between the skin thickness measurement made using skin calliper and those made using real time ultrasound equipment throughout the experiment.....	144
Table 7.1. Least squares means (\pm s.e.) for measurement of fibre length and diameter from the 3 techniques evaluated.....	163
Table 7.2. Correlation coefficients (r) for the relationships between the fibre properties estimated using the radioisotope technique and those obtained using dyeband and snippet techniques.....	164
Table 7.3. Least squares means (\pm s.e.) for the fibre length and L/D ratio measurements from the ³⁵ S, dyeband, snippet and three prediction techniques	164

List of Figures

Figure 2.1 The extension of wool fibres during staple strength measurement (Source Peterson 1997b)	26
Figure 3.1 Illustration of snippet selection to generate the reduced FDPs	60
Figure 3.2 An example of an original full FDP from the temperate environment at Armidale, showing the additional traits calculated for the predicted and customised profiles	62
Figure 3.3 Illustration of the snippet selection process used to generate the customised FDPs with selection of the snippets at the point of minimum fibre diameter with 2 snippets re-sampled as an example	63
Figure 3.4 An example of the fit between the predicted FDPs (at the 1 in 5 and 1 in 10 levels of inclusion) and original full FDP for a sheep maintained in the Armidale environment	70
Figure 3.5 The relationship between the level of final inclusion and the correlation between the original and estimated values for Regroc1 and Regroc2 from the predicted profiles. Correlations are from the predicted and customised profiles at 10 levels of initial snippet inclusion and 6 levels of intensive re-sampling	74
Figure 3.6 Generalised shape of possible FDPs.....	76
Figure 4.1 Long-term average monthly rainfall for the Armidale, Yallanbee and Condobolin environments (Australian Bureau of Meteorology)	85
Figure 4.2 Long-term monthly average daily maximum and minimum temperature for the Armidale, Yallanbee and Condobolin environments (Australian Bureau of Meteorology)	86
Figure 4.3 Average monthly rainfall for the years in which samples were grown in the Armidale environment (University of New England Weather Station).....	87
Figure 4.4 Least squares means for Mindiam and MFD for the fine and medium bloodlines at Armidale and Yallanbee (experiment 1)	88
Figure 4.5 Least squares means for AstCV, AvSnipCV and MFDCV for the fine and medium wool bloodlines at Armidale and Yallanbee (experiment 1)	88
Figure 4.6 Least squares means for Roc1 and Roc2 for the fine and medium wool bloodlines at Armidale and Yallanbee (experiment 1)	89
Figure 4.7 Least squares means for SL and SS for the fine and medium wool bloodlines at Armidale and Yallanbee (experiment 1)	89
Figure 4.8 Least squares means for Mindiam and MFD for the two fine (F1 and F2) and two medium (M1 and M2) at Armidale and Condobolin (experiment 2)	91

Figure 4.9 Least squares means for AstCV, AvSnipCV and MFDCV for the two fine (F1 and F2) and two medium (M1 and M2) at Armidale and Condobolin (experiment 2).....	92
Figure 4.10 Least squares means Roc1 and Roc2 for the two fine (F1 and F2) and two medium (M1 and M2) at Armidale and Condobolin (experiment 2).....	92
Figure 4.11 Least squares means for SL and SS for the two fine (F1 and F2) and two medium (M1 and M2) at Armidale and Condobolin (experiment 2).....	93
Figure 5.1 Representation of how rates of fibre diameter changes may influence staple strength.....	110
Figure 6.1 The rainfall received during the experimental period and the long-term average for Armidale (Australian Bureau of Meteorology).....	120
Figure 6.2 The mean maximum and mean minimum temperature for Armidale (90 year average) for the months of the experiment (Australian Bureau of Meteorology).....	121
Figure 6.3 The changes in food on offer (FOO) and crude protein g/kg (CP) of the feed on offer throughout the duration of the experiment.....	128
Figure 6.4 The percentage of dead and green feed on offer throughout the duration of the experiment.....	128
Figure 6.5 Example of the FDPs from three of the experimental animals of similar FDP length and IMFD	131
Figure 6.6 The changes in body weight (Bwt), fat depth (Fat) and skin thickness (Skin) throughout the experimental period	131
Figure 6.7 The relationship between L/D ratio and AstCV	133
Figure 6.8 The relationship between IMFD and Roc1	135
Figure 6.9 The relationship between IMFD and AstCV	135
Figure 6.10 The relationship between BwtCV and AstCV.....	137
Figure 6.11 The relationship between SkinCV and AstCV	137
Figure 6.12 The relationship between staple strength (SS) and AvSnipCV.....	141
Figure 6.13 The relationship between mean skin thickness measured using callipers (Skin) and mean skin thickness measured using real time ultrasound (Skin ^{Ultra}).....	145
Figure 7.1. Parameters used in prediction method 1 to estimate fibre length.....	161
Figure 7.2. Components used by prediction method 2 to estimate curve length.....	162

List of Appendices

Appendix 3.1	The differences between the mean values of AstVAR and AstCV estimated from the predicted profiles (0 snippets re-sampled) and the customised FDPs to the means calculated from the original full FDPs. Ten initial levels of inclusion and 5 levels of intensive re-sampling are presented	198
Appendix 3.2	The correlations between the FDP characteristics calculated from the original full FDPs to those estimated from the predicted FDPs from the FDP prediction technique (0 snippets re-sampled) and the customised FDPs. Ten initial levels of inclusion and 6 levels of intensive re-sampling are presented	200
Appendix 3.3	The Spearman rank correlation coefficients for each FDP characteristics at each level of FDP inclusion using the profile prediction technique (without intensive re-sampling)	202
Appendix 4.1	The level of significance of each effect included in each analysis for each FDP and wool quality characteristics from experiment 1	203
Appendix 4.2	The least squares means and standard error (s.e.) of the FDP characteristics for the Fine and Medium bloodlines within each environment from experiment 1	204
Appendix 4.3	The level of significance of each effect included in each analysis for each FDP and wool quality characteristics form experiment 2	205
Appendix 4.4	Least squares means for FDP and wool quality characteristics for the four bloodlines in each environment from experiment 2	206
Appendix 5.1	The residual correlations between the FDP and wool quality characteristics with staple strength over all the data (n= 40), within each environment (n= 20) and within each bloodline (n= 20)	207
Appendix 5.2	The residual correlations between the FDP and wool quality characteristics with staple strength over all the data (n= 380), environment (n= 110 and 270) and within each bloodline (n= 83, 62, 116 and 119)	208
Appendix 6.1	The results of the faecal egg counts conducted throughout the experiment.....	209
Appendix 6.2	Correlation coefficients for the relationships between the wool fibre characteristics and the FDP characteristics	210
Appendix 6.3	Correlation coefficients for the relationships between the wool quality characteristics and the FDP characteristics	211
Appendix 6.4	Correlation coefficients for the relationships between the body characteristics and the FDP characteristics	212

Appendix 6.5 Correlation coefficients for the relationships between the FDP and wool quality characteristics and staple strength (SS).....	213
Appendix 6.6 Correlation coefficients for the relationships within the body characteristics.....	214
Appendix 6.7 Correlation coefficients for the relationships between the wool fibre characteristics and mid-side measurements	215
Appendix 6.8 Correlation coefficients for the relationships within the wool fibre measurements.....	216
Appendix 9.1 Conference paper presented at the 13th meeting of the Association for the Advancement of Animal Breeding and Genetics, page 274-277 (90% work of D.J. Brown)	217
Appendix 9.2 Paper published in Wool Technology and Sheep Breeding, volume 47(3), page 170-183, (80% work of D.J. Brown)	220
Appendix 9.3 Paper published in Wool Technology and Sheep Breeding, volume 48(1), page 1-14, (90% work of D.J. Brown)	232
Appendix 9.4 Paper published in Wool Technology and Sheep Breeding, volume 48(2), pages 86-93 (90% work of D.J. Brown).....	245

List of Abbreviations

Δ FL	average absolute change in fibre length growth between the three measurement periods
Δ FD	average absolute change in mean fibre diameter between the three measurement periods
Δ FL/ Δ FD	the ratio of average absolute change in fibre length growth and mean fibre diameter between the three measurement periods
2ptroc ³⁵ S	The rate of fibre diameter change calculated using two absolute points radio-isotope ³⁵ S
AvSnipCV	average coefficient of variation of fibre diameter within snippets
AvSnipSD	average standard deviation of fibre diameter within snippets
AstCV	coefficient of variation of fibre diameter along the fibre diameter profile
AstVAR	variance of fibre diameter along the fibre diameter profile
AvFL	average FL growth over the three measurement periods
AvFLCV	average variation in FL over the three measurement periods
AvL/D	average L/D ratio over the three measurement periods
AvSL ^{Bands}	average staple length growth between dyebands
Bld	Bloodline
Bwt	body weight
BwtCV	coefficient of variation in body weight throughout the experiment
CANCORR	The canonical correlation procedure of SAS
CORR	The correlation procedure of SAS
CP	crude protein
CV	coefficient of variation
CVSL ^{Bands}	coefficient of variation of staple length growth between dyebands
Diff	difference between the maximum and minimum fibre diameter in fibre diameter profile
Envt	Environment
F1,F2	The first and second fine wool bloodlines
Fat	fat depth measured by real time ultrasound
FatCV	coefficient of variation in fat depth throughout the experiment
FGCV	coefficient of variation in fibre diameter length growth rate over the three measurement periods
FD	fibre diameter
FDCV	coefficient of variation in fibre diameter
FDP	fibre diameter profile
FL	fibre length
FOO	food on offer
GLM	The general linear models procedure of SAS
IMFD	mean fibre diameter at the start of the experiment
IMFDCV	coefficient of variation in fibre diameter at the start of the experiment
IWTO	International Wool Testing Organisation
ktex	kilotex
L/D	ratio of fibre length growth to that of fibre diameter
L/DCV	coefficient of variation of L/D ratio between the three measurement periods
M1,M2	The first and second medium wool bloodlines
Max	absolute maximum fibre diameter in fibre diameter profile
Maxdiam1	the Maximum fibre diameter between the minimum fibre diameter point in the middle of the FDP and the tip of the FDP
Maxdiam2	the Maximum fibre diameter between the minimum fibre diameter point in the middle of the FDP and the base of the FDP

Maxpos1	the position of the Maxdiam1 in mm
Maxpos2	the position of the Maxdiam2 in mm
MFD	mid-side mean fibre diameter
MFDCV	variation in fibre diameter within the mid-side mean fibre diameter sample
Min	absolute minimum fibre diameter in fibre diameter profile
Mindiam	the minimum fibre diameter in approximately the middle of the FDP
Minpos	the position of the Mindiam in mm
MS	mean squares
N	Newtons
OFDA	Optical Fibre Diameter Analyser
P	probability
POB	position of break
Profmean	mean fibre diameter in fibre diameter profile
r	correlation coefficient
R ²	R-square value
r _c	canonical correlation coefficient
REG	The regression procedure of SAS
Regroc	The rate of fibre diameter change calculated using linear regression
Roc	rate of fibre diameter change in fibre diameter profile
SD	standard deviation
SDSL ^{Bands}	standard deviation of staple length growth between dyebands
s.e.	standard error
SIFAN	single fibre analyser
Skin	skin thickness measured by callipers
SkinCV	coefficient of variation in calliper skin thickness throughout the experiment
Skin ^{Ultra}	skin thickness measured by real time ultrasound
SkinCV ^{Ultra}	coefficient of variation in real time ultrasound skin thickness throughout the experiment
S/P	ratio of secondary to primary follicles
SL	staple length
SS	staple strength
μCi	micro curies
μm	micron
VARCOMP	The variance component estimation procedure of SAS
w/v	weight per volume
Yld	Clean wool yield

Abstract

Fibre diameter profiles (FDPs) describe the fibre diameter responses of individual sheep to the environmental conditions that they experience throughout the wool growth period. The characteristics of this response pattern vary between sheep and are correlated with staple strength. The unifying hypothesis that differences between sheep in responsiveness of fibre diameter throughout the year may be able to be utilised to improve wool staple strength was accepted.

Three techniques to enable quick estimation of the characteristics of a FDP are described and evaluated using Merino wools from different environments and bloodlines. The results observed from the experiments indicate that using a profile prediction technique that utilised cubic spline functions, the entire staple does not need to be segmented and measured to gain an accurate estimation of all FDP characteristics. The maximum, minimum, average, range and variation along the profile can be accurately estimated using as low as 10% of the original snippets. However a greater proportion of the original snippets need to be measured to gain accurate estimates of the rates of fibre diameter change. Measuring one snippet in every four of the original snippets (approximately 27%) using the profile prediction technique generated FDP characteristics that were not significantly different ($P > 0.05$) and highly correlated ($r > 0.80$) with those of the original profile. The intended use of the data will influence the level of snippet inclusion used. Significant differences in the fibre diameter profile characteristics between environments, bloodlines and sire groups did not significantly influence the estimation procedure. The profile prediction technique allows more extensive research to be conducted using FDPs.

It is also known that the FDP characteristics vary between sheep but it is not known to what extent these difference are genetically controlled. Two experiments were conducted to examine the differences in FDP and wool quality characteristics between environments, bloodlines and sire groups. Environment, bloodline and sire group significantly ($P < 0.05$) influenced many of the fibre diameter profile characteristics. These results suggest that there may be genetic differences in fibre diameter profile characteristics between sheep but that the expression of these differences is dependent on the environment in which the sheep are maintained. Given the nature of FDPs it is not surprising that they are significantly influenced

by the environment in which they are grown. Despite these differences between bloodlines and sires in the FDP characteristics, mid-side mean fibre diameter, fibre diameter variation and staple length, there were no significant differences between bloodlines in staple strength.

The relationships between the FDP and mid-side wool quality characteristics with staple strength were also examined over these bloodlines and environments. Many FDP characteristics were significantly correlated with staple strength. The FDP characteristics also explained additional variation in staple strength above that which could be explained using the standard mid-side characteristics of mean fibre diameter, fibre diameter variation and staple length alone. These relationships were variable between environments and bloodlines. The use of the FDP characteristics also provided for an alternative interpretation as to how absolute fibre diameter and fibre diameter variation combine to explain staple strength. These results can be explained by the fact that the FDPs target key characteristics of the FDP that are biologically related to staple strength. Despite phenotypic variations in the relationship between the FDP characteristics and staple strength the correlations may be more stable at the genetic level, as has been observed with the relationship between mid-side variation in fibre diameter and staple strength. If this was observed for FDP characteristics, different animals and sires might be able to be selected on the basis of these characteristics to improve staple strength. More detailed genetic studies are required before these selection strategies can be recommended.

The relationship between fibre diameter, length and L/D ratio with FDP characteristics and staple strength was examined in 16 fine wool Merino wethers in a 12-month field experiment. Variations in fibre diameter, length and L/D ratio were shown to be associated with FDP characteristics and staple strength. Seasonal variation in fibre diameter appears to be mostly related to mean fibre diameter, fibre length growth rate and seasonal variation in fibre growth rate. One of the most important findings presented in this thesis is the fact that seasonal variation in fibre length growth is equally as related to staple strength as seasonal variation in fibre diameter. Disentangling the relationship of fibre diameter variation from fibre length variation on staple strength is a key area for future research. Between-fibre variations in diameter and length were significantly associated with each other and both significantly negatively correlated with staple strength. These results highlight the need to reduce the variation in fibre growth rate (both fibre length and diameter) between fibres and throughout the year. This objective would be best achieved through genetic selection and management. Changes in fibre diameter throughout the year can also be related to seasonal changes in body

weight, fat depth and skin thickness. While this study defined some of the major reasons why there is large variation between individual sheep in the seasonal variation of wool growth the understanding of these relationship is very limited. These relationships are complex and require more research on a greater number on sheep across environments and genotypes. With further research these variations in fibre diameter, length and L/D ratio might be able to be used in combination with FDPs, wool quality characteristics and body traits to reduce seasonal environmental responsiveness of fibre diameter and thereby improve staple strength and wool quality.

Present techniques to measure average fibre length and fibre length variation are both time consuming and expensive which has effectively restricted the use of fibre length measurements in wool growth studies. A number of techniques to estimate fibre length growth were described and evaluated. Two dyeband-based techniques were used to accurately measure mean fibre length. Fibre diameter variation and fibre length variation from these techniques were not significantly correlated with the measurements made using a standard autoradiographic technique. Mean fibre length and L/D ratio could also be accurately predicted using staple characteristics of staple length, crimp frequency and fibre curvature. These techniques allow fibre length to be estimated more easily and therefore more animals to be measured and studied. While an alternative method to estimate fibre length variation was not able to be identified the research results presented in this thesis suggest that such a technique would be most beneficial.