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.

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List of Abbreviations

△FL	average absolute change in fibre length growth between the three measurement periods
△FD	average absolute change in mean fibre diameter between the three measurement periods
△FL/△FD	the ratio of average absolute change in fibre length growth and mean fibre diameter between the three measurement periods
2ptroc	The rate of fibre diameter change calculated using two absolute points
^{35}S	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	coefficent 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	coefficent 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 minium fibre diameter point in the middle of the FDP and the tip of the FDP
Maxdiam2	the Maximum fibre diameter between the minium 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	coefficent of variation in calliper skin thickness throughout the experiment
$Skin^{Ultra}$	skin thickness measured by real time ultrasound
$SkinCV^{Ultra}$	coefficent 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 suprising 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.