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Fibre diameter profiles—potential applications for improving fine-wool quality

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Abstract

Experiments were conducted to examine the potential value of measurement and monitoring of fibre diameter changes throughout the wool-growing year for improving wool quality and wool staple strength of fine Merino wool grown in temperate environments of NSW. This work included an on-farm survey of fibre diameter profile patterns, which indicated the relative magnitude of sources of variation in fibre diameter profiles. This provided the starting point for other, more detailed investigations focused on the effects of reproduction on fibre diameter profile, the potential for using grazing management to improve wool quality and utilization of fibre diameter profile data in Merino breeding for the improvement of fine-wool quality. Despite prolonged drought conditions, there was evidence of regional differences in environmental effects on fibre diameter profile characteristics. It seems that less than 400–500 kg green DM/ha is required to suppress fibre diameter in spring sufficiently to reduce mean fibre diameter. However, this pasture benchmark is at best regarded as preliminary as there appear to be several important interacting environmental factors. Phenotypic evidence supports the existing use of coefficient of variation of fibre diameter over either of the components of fibre diameter variation (along or between fibres) as a selection criterion in Merino breeding programs.

Introduction

Approximately one-third of the volume of the Australian wool clip is now less than 19.5 µm (AWTA, 2005). However, unless these wools meet tight quality specifications, severe discounts are applied at auction. Staple strength (SS) is now the single largest contributing factor to variation in price received for wools in that micron category (Stott, 2004). This has induced wool growers to seek ways of improving wool quality, and in particular, staple strength.

The OFDA2000 instrument (Brims et al., 1999) is one of the methods available for on-farm fibre measurement. In addition to measuring mean fibre diameter and variation in fibre diameter (MFD and CVD respectively), the OFDA2000 can be used to build a fibre diameter profile (FDP), i.e., the change in fibre diameter along the length of a wool staple. Previous studies indicate that certain FDP characteristics may be associated with, and be potential indicators of SS and position of break (Hansford and Kennedy 1988; Peterson et al., 1998; Brown et al., 2002). More importantly, FDP characteristics may be better indicators of potential processing performance than SS (Lamb, 2004). Compared to SS, FDP characteristics cost little to measure using the OFDA2000 instrument.

Although on-farm uptake of technologies such as OFDA2000 is increasing, information on the potential usefulness of measuring and monitoring FDP for improving wool quality in fine and superfine wool flocks in eastern NSW is limited. Work conducted in Mediterranean Western Australia on annual pastures using dry animals demonstrated a consistent response in FDP characteristics to the timing of the break of the season and that it is possible to improve wool quality (decreased MFD and increased SS) by restricting green feed intake after the break of the season (Peterson et al., 2000). Subsequent work in the Goulburn/Yass district (Mata, 2002) highlighted some differences compared to results from the Mediterranean environment of WA. The work described here aims to build on those observations with a view to providing woolgrowers with useful management protocols for improving wool quality.

This paper reports an on-farm survey project that included preliminary assessment of reproductive effects on FDP of breeding ewes and, in the Northern region, the relationship between SS and the components of fibre diameter variation. This work was conducted to identify sources of variation in FDP characteristics in the temperate fine and superfine wool-growing regions of NSW. In conjunction with the survey, studies aimed specifically at determining pasture quality and quantity effects on FDP characteristics and wool quality were conducted. A measurement program for estimation of genetic variation, heritability and phenotypic and genetic correlations among FDP characteristics and economically important wool traits was commenced, but has not yet been completed.

Methods

OFDA2000 measurements of FDP characteristics were carried out on scoured wool samples at CSIRO, Armidale. The FDP characteristics reported here are readily generated by the OFDA2000 instrument and include MFD, CVD, standard deviation of fibre diameter (SDFD), standard deviation of fibre diameter along staple (alongSD), coefficient of variation of fibre diameter along staple (alongCV), standard deviation of fibre diameter across staple (acrossSD), coefficient of variation of fibre diameter across staple (acrossCV), minimum fibre diameter along staple (minFD), maximum fibre diameter along staple (maxFD), difference between minFD and maxFD (diffFD), OFDA2000 staple length (oSL) and finest point from staple tip (FPFT). Dyebands were applied to the midside to link time with wool growth. Additional wool measurements, including staple length (SL), staple strength (SS), percentage tip, mid and base breaks (Tip, Mid, Base) and clean scoured yield (CSY) were carried out on midside samples by AWTA, Sydney; MFD was also measured using Laserscan (CSIRO, Armidale).

Regional variation in fibre diameter profiles

The survey project aimed to measure FDP characteristics of fine-wool Merinos on the New England, Southern Tablelands, South West Slopes and Central slopes. However, severe drought conditions prevailed across most of NSW for much of the survey period with extended periods of supplementary feeding, uncharacteristic pasture conditions and atypical flock management practices. Thus, the degree to which the FDPs generated are generally representative of the flocks, properties and regions from which they were drawn was compromised.

For purposes of initial analysis, properties were classified according to environment as Northern (summer dominant rainfall) and South/Central (winter/spring dominant or aseasonal rainfall). Production characteristics and FDP data were collected from subsets of breeding ewe and weaner or hogget flocks on 8–9 properties in both the North and South/Central regions during the 2002–2003 and 2003–2004 wool-growing seasons (Fig. 1). The sheep were dyebanded, weighed and condition scored at approximately quarterly intervals throughout the wool growing year.

In the absence of detailed pasture quality and quantity data (due in part to the ongoing drought), the relationship between rainfall and FDP characteristics was assessed. While it is recognized that rainfall alone is not a good indicator of environmental conditions, there is evidence that there are regional differences in those relationships (Table 1)

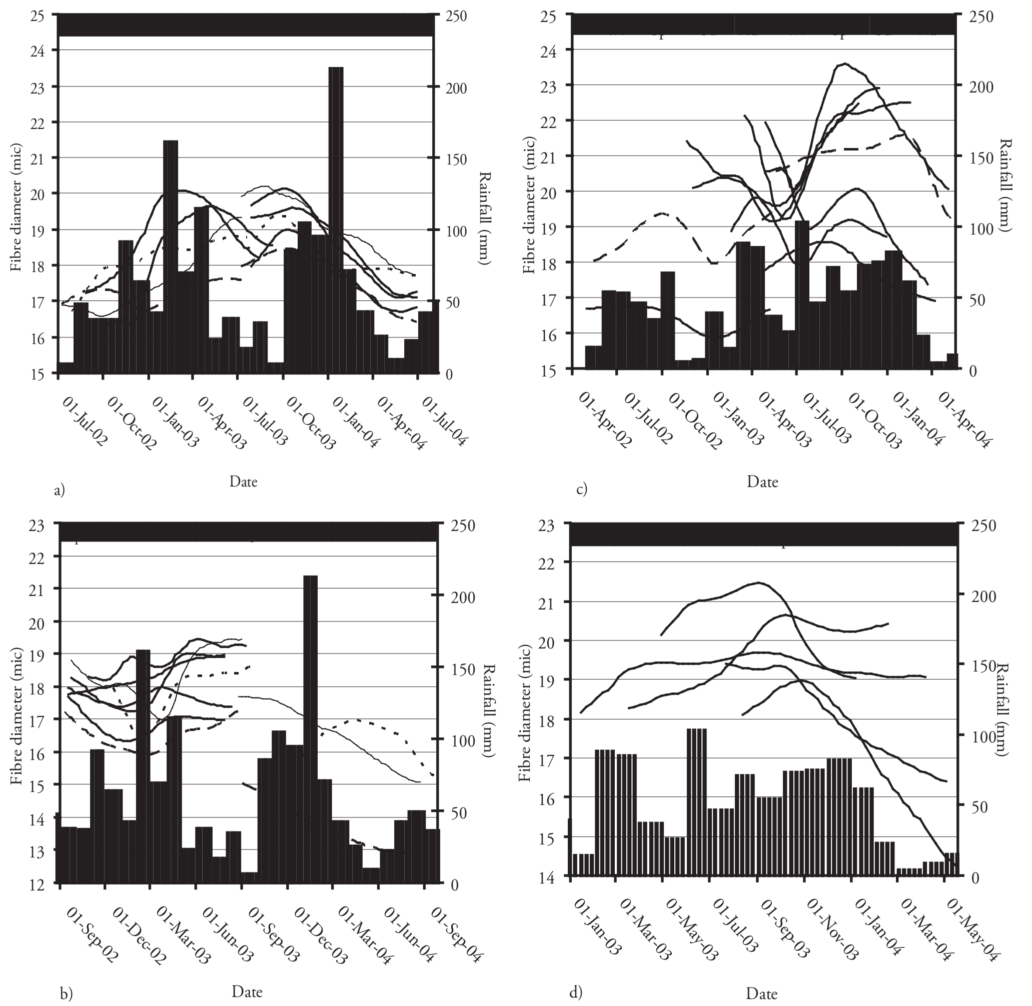

Fig. 1. Fibre diameter profiles of surveyed flocks: a) breeding ewes, New England; b) weaners, New England; c) breeding ewes, South/Central; d) hoggets, South/Central. Northern region rainfall data are for Armidale and South/Central region rainfall data are for Yass. Dotted lines indicate the same flock in the 2 consecutive years.

Table 1. Simple correlation (± s.e.) between fibre diameter changes and seasonal rainfall.

	Northern	South/Central
Season of minFD vs. season of minRainfall	0.03 (0.23)	0.69 (0.15)
Season of maxFD vs. season of maxRainfall	0.01 (0.32)	0.76 (0.18)

While there was considerable variation in FDP characteristics attributable to region, property, year and physiological state of the animal, some trends were evident, indicating the general pattern of FDP is repeatable across years on some properties and within a region. For example, on several of the New England properties, fibre diameter tended to increase in the spring with new pasture growth, followed by a decline in summer as the pasture dried off. Similarly, there was evidence for the South/Central region of a consistent increase in fibre diameter between winter and spring, followed by a decline in summer. However, fluctuations in fibre diameter appear to be more frequent and more rapid in the South/Central regions despite a more consistent rainfall pattern. Fibre diameter changes tended to be greater for the breeding ewe than young flocks in both regions. These observations demonstrate that FDP information collected by wool growers over several consecutive years may be useful retrospective data for management of fibre diameter changes throughout the year. There may also be opportunity for wool quality management using the flock monitoring facility of OFDA2000 but as demonstrated in Fig. 1, fibre diameter changes can be rapid (especially in some of the South/Central flocks), suggesting that FDP monitoring would need to be very frequent in order to be effective.

Effects of pregnancy status on breeding ewes

Within regions, some FDP characteristics varied with reproduction status and management of breeding ewes (Fig. 2). In the Northern region, ewes that were pregnant and reared a lamb exhibited more variation in fibre diameter than other classes. In the South/Central region, pregnancy class had a significant effect on MFD, alongCV and diffFD ($P < 0.05$ for all three traits); dry ewes had the lowest MFD. In both regions, the pregnancy class effect on minFD approached significance ($P < 0.10$), but in the Northern region dry ewes had relatively higher minFD than other classes and in the South/Central dry ewes had a lower minFD (Table 2). These limited data on pregnancy class effects suggest that the FDP characteristics of ewes, particularly those of dry ewes, vary across regions.

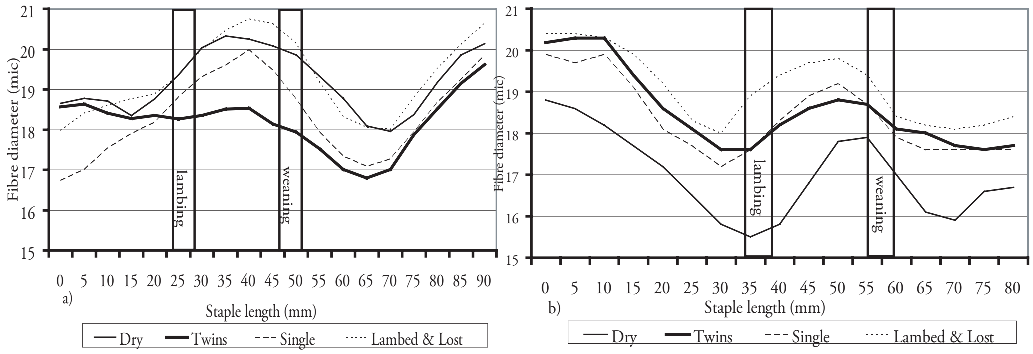

Fig. 2. Example of fibre diameter profiles of classes of breeding ewes for two properties where a) ewes scanned and lambed together and b) ewes scanned and lambed separately (Graham and Lee, unpublished)

Table 2. Effects on FDP traits of pregnancy class in the North and South/Central regions expressed as deviations from ewes that reared a lamb.

	MFD (µm)	CVD (%)	alongCV (%)	diffFD (µm)	minFD (µm)
			Northern region		
Dry		-1.33 (0.66)			+1.15 (0.48)
Lambed & lost		-0.79 (0.63)			+0.32 (0.46)
			South/Central region		
Dry	-1.32 (0.60)		-0.60 (0.71)	-0.38 (0.50)	-1.25 (0.61)
Scanned twins	+0.26 (0.53)		-0.52 (0.61)	-0.31 (0.43)	+0.59 (0.78)
Lambed & lost	+0.85 (0.77)		+1.14 (0.94)	1.13 (0.66)	-0.49 (0.51)

Association between FDP characteristics and staple strength

Given the high heritability of MFD, it may be expected that components of MFD such as minFD and maxFD are also highly heritable. As shown by the genetic variation in Table 3, analysis of repeat measures of FDP data from the CSIRO Toward 13 Micron flock indicated this to be the case. Combined with high phenotypic variability, these are characteristics that lend themselves to genetic change through selection.

Table 3. Summary of variance components (genetic (V_a), environmental between-animal (V_{Eg}), environmental within-animal (V_{Es}) and total phenotypic variance (V_p)) for fibre diameter profile characteristics measured on scoured samples.

		% of V_p		
Trait	Actual V_p	V_a	V_{Eg}	V_{Es}
MFD (µm)	1.89	73	20	7
SDFD (µm)	0.10	66	23	12
CVD (%)	1.80	44	41	15
minFD (µm)	1.68	65	24	11
maxFD (µm)	2.32	74	17	9
diffFD (µm)	0.53	34	33	33
oSL (mm)	115.6	54	17	30
FPFT (mm)	473	16	33	52

Studies by Greeff (1995) and Swan et al. (2000) show that CVD can be used as an indirect selection criterion to improve SS in Merino breeding programs. The FDP survey project was not designed to answer genetic questions about fibre diameter profile characteristics and Merino breeding, but phenotypic data from that project (Table 4) support the findings of Greeff (2002) that although the components of CVD are heritable and correlated with SS, there was no advantage in using either alongCV or across CV as alternative selection criteria to CVD itself.

Table 4. Phenotypic correlation between SS and FDP characteristics from New England region properties (se = 0.04).

	SDFD	CVD	alongSD	alongCV	acrossSD	acrossCV	minFD	maxFD	diffFD
SS x	–0.35	–0.47	–0.32	–0.35	–0.29	–0.39	0.26	0.02	–0.28

Grazing management for wool quality

Although management guidelines for maintenance, growth and reproduction are already available (e.g., Prograze), little attention has been paid to management for fine-wool production. Previous research has shown that restricting the availability of annual pasture in spring assists in limiting increases in fibre diameter when pasture growth is high (e.g., Hyder et al., 2002). However, the fibre diameter response varied widely between years.

A study conducted at Orange, NSW aimed to determine benchmarks for perennial pasture availability in spring to manage the increase in fibre diameter typical of wool growth of fine-wool sheep over this period. The effects of the legume component and its interaction with herbage mass on wool quality were included in the study. Sixteen plots were established for a replicated split-plot design with pasture availability targets of 400, 800 and 1200 kg/ha DM. The level of legume in the pasture was manipulated by spraying and sowing. The plots were grazed in the spring of 2003 and 2004.

In both years, reducing fibre diameter during spring by restricting pasture availability led to significantly reduced MFD of the annual fleece by 0.5–0.85 μm at the lowest pasture availability target. However, manipulating either pasture availability or the botanical composition had no significant impact on staple strength of the annual fleece, which was greater than 40 N/ktex in both years. In 2004, the clean fleece weight of the fleeces from the lowest pasture availability group was about 0.25 kg less than fleeces from other treatments. Clearly, assessment of the benefits of reducing annual fibre diameter through management in spring will need to consider both price premiums for finer wool and likely reductions in total clean fleece weight.

A grazing management study was also conducted during spring–summer at Armidale in 2003–2004 and 2004–2005. The aim was to limit the increase in fibre diameter associated with the spring flush of feed and to reduce annual MFD without adversely affecting SS or bodyweight. Replicated groups of approximately 40 young ewes were given either the best available pastures (regular), or half the green herbage mass available to the regular ewes (restricted). Average green herbage mass available to the regular groups was 1500 kg and 1000 kg/ha DM in years 1 and 2 compared to 600 kg and 500 kg/ha DM for the restricted groups. The sheep were moved around a set of one-hectare plots to achieve desired grazing conditions.

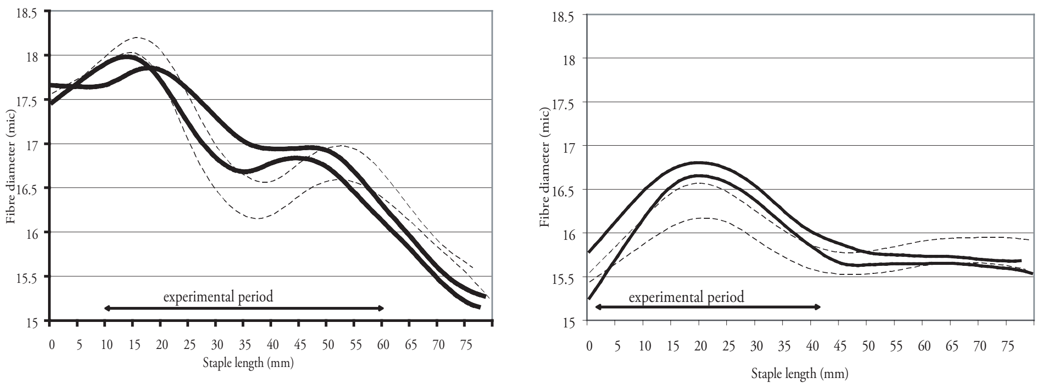

Fig. 3. Fibre diameter profiles of 'regular' (solid lines) and 'restricted' (dotted lines) treatments of young dry ewes in 2003–2004 (year 1) and 2004–2005 (year 2), respectively, in the New England.

In year 1, pastures were assessed weekly and measured monthly using pasture cuts from quadrats and sorting of the green and dry components. As it was clear that this level of monitoring was insufficient during periods of rapid pasture growth, pasture monitoring was increased to weekly measurement by pasture cuts and sorting of green and dry components in year 2. The experiment commenced late in year 1. The summer feed restriction of the restricted groups was severe, which resulted in no difference between treatments in MFD and a significant difference between treatments in SS ($P < 0.001$), alongSD and alongCV ($P < 0.01$), CVD ($P < 0.05$) and mid breaks ($P < 0.001$). In year 2, there were significant differences between groups in percentage mid breaks ($P < 0.05$), along SD and alongCV ($P < 0.001$) but no difference in SS or MFD.

Pasture conditions in this trial were carefully and regularly monitored, especially in year 2 (more intensively than is likely commercially). This suggests that improvement of wool quality of New England wools by monitoring and manipulating grazing conditions to manage fibre diameter profile will be a complicated and delicate task because the response in fibre diameter is associated with interactions between pasture quantity and quality.

Conclusions

Extended periods of drought prevailed across the regions for much of the survey period and this probably compromised the results, leaving some uncertainty over the extent to which the FDPs are representative of the flocks and regions involved. Nevertheless, it is clear that FDP characteristics are associated with local environmental conditions, suggesting that monitoring of FDP at the flock or property level, combined with pasture quality and quantity data, may be a useful tool in the management and improvement of wool quality in fine-wool flocks. Pasture benchmarks for management of FDPs in temperate perennial pasture systems can, at this stage only be described as preliminary as there appear to be several important interactions among environmental factors. In periods of rapid pasture growth, monitoring of both fibre diameter and pasture quality and quantity would need to be very frequent to achieve wool quality benefits. Further work is required if such methods are to be applied on-farm.

In the New England, phenotypic evidence supports the existing use of CVD as an indirect selection criterion for SS in favour of either of the components of fibre diameter variation (alongCV and acrossCV). Whether that is the case in other regions of NSW is yet to be determined. Further genetic parameter estimation and prediction of responses to selection is required to determine the potential application of FDP characteristics in Merino breeding.

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