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Relationship of mean fibre diameter and time of shearing with wool yellowing in Merino sheep farmed under North Island conditions

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ABSTRACT

Approximately 200 adult Merino ewes at each of four sites in New Zealand, near Hamilton (Whatawhata), near Rotorua, near Havelock North (Poukawa) and near Wanganui were shorn once-yearly at five different times over two years. Groups of approximately 40 ewes in each flock were shorn pre mating (March), post mating (May), pre lambing (July) with lambs-at-foot (October) or at weaning (December/January). Midside fleece samples were collected before shearing for measurement of fibre diameter. At shearing each fleece was weighed and skirted. The skirted fleece and skirtings were weighed and core bored for measurement of wool yellowness. The between flock and between shearing time ranking for increasing wool yellowness was Wanganui, Poukawa, Rotorua, Whatawhata and lambs-at-foot, pre lambing, weaning and post mating, pre mating respectively for both the unskirted and skirted fleeces. There was a significant positive relationship between mean fibre diameter and wool yellowing with no difference in the slope of the relationship between flocks or between shearing time treatments. These trends align with finer-woolled Merino sheep having more sebaceous glands, the secretion from which appeared to protect growing wool fibres from the action of components in sweat secreted in response to warm moist atmospheric conditions. The optimal shearing time to produce the whitest wool was spring.

Keywords: Merino; wool yellowing; fibre diameter; shearing time.

INTRODUCTION

Merino sheep are farmed in a diverse range of environments throughout the world most of which tend to be hot and relatively dry. Merinos are traditionally shorn once-yearly to produce fine wool for the manufacture of apparels. Finer wools are softer handling than coarser wools and can be spun into a greater length of yarn. As a result fine wools have a higher commercial value (Meat and Wool NZ, 2004). However, there is a positive phenotypic correlation (r = 0.4 – 0.8, Mortimer, 1987) between fleece weight and fibre diameter. Thus sheep growing finer more valuable wool tend to have lighter fleece weights.

The presence of unscourable yellow discolourations, which can be induced through warmth and moisture (Hoare & Stewart, 1971), limit the range of shades to which the wool can be dyed lowering its commercial value. While Reid and Botica (1995) showed coarse Merino wool to be more prone to discolour than fine Merino wool, a similar correlation was not evident within Romcross type wools. However shearing sheep growing Romcross type wool in the summer/autumn period is known to induce increased discolouration compared with shearing sheep in the winter/spring period (Sumner & Armstrong, 1987; Reid, 1993). The relationship between shearing time and wool yellowing has not been quantified for Merinos grazing in New Zealand.

Since about 1900 Merino sheep farming in New Zealand has been restricted to the South Island. In the late 1980s, during a period of relatively low prices for meat and high prices for fine wool, many Merino flocks were established in different regions throughout the North Island. Temperature range, rainfall and humidity in the North Island are markedly different to those prevailing in the South Island. It was therefore appropriate to quantify the effect of North Island climatic conditions and associated management systems on the production of high value Merino wool.

The study reported here was initiated in 1990 to quantify the relationship between fibre diameter and wool yellowing in flocks of Merino sheep farmed in different areas of the North Island and the influence of shearing Merino sheep once-yearly at different times of the year on this relationship.

MATERIALS AND METHODS

Sheep

Approximately 200 individually identified adult Merino ewes grazing at each of four sites around the North Island were used. The sheep were situated at the Whatawhata Research Centre, near Hamilton; the Wairakei Research Area, near Taupo and later moved to a private property 20 km to the south east of Rotorua; the Poukawa Research Station, near Havelock North and the Wanganui Hill Research Station, near Wanganui and later moved to a private property 10 km to the north west. Each flock had been developed for research purposes with a wide genetic base and was phenotypically more variable than a normal commercial flock. The ewes in each flock were balanced for age, live weight and, where fibre diameter was known, fibre diameter, and divided into five shearing time treatment groups. The shearing time treatment groups were shorn once-yearly pre mating (March), post mating (May), pre lambing (July), with lambs-at-foot (October) or at weaning (December/January). Beginning in February 1990 for the Whatawhata, Poukawa and Wanganui flocks, each of the respective treatment groups were shorn at their allocated time to establish the treatment groups. Establishment of the treatment groups in the Wairakei flock was delayed a year. In this flock the shearing time treatments were established before it was transferred to the private property in the Rotorua area. The shearing time treatments were applied for two years in the Rotorua, Poukawa and Wanganui flocks and three years in the Whatawhata flock so as to provide a common link across the other three flocks. No new sheep entered the flocks during the study.

All the sheep at each site were grazed together throughout the trial and fed adequately according to the normal stock policy on each farm.

Wool sampling and measurement

Before each scheduled shearing the live weight of the ewes due to be shorn was recorded and a fleece sample clipped from the midside region of the body, placed in an identified plastic bag and transferred to the Whatawhata Research Centre wool measurement laboratory. Mean staple length was measured using a ruler and mean fibre diameter and fibre diameter variation measured using an OFDA 100 instrument.

At shearing the weight of each shorn fleece was recorded and each fleece, complete with its belly, individually packed in an identified plastic bag, transferred to the Whatawhata Research Centre wool measurement laboratory and reweighed. Each fleece was then spread on a standard wool table and skirted according to normal wool handling practice for Merino wool. Thereafter the individual weight of the skirted fleece, any heavily stained portions, any cotted portions, edge trimmings ('pieces') and 'belly' wool were recorded. Each portion of the fleece, with the exception of the belly was individually core bored. The core bored samples were hand-carded, washed in water and the tristimulus (Y-Z) values measured by reflectance spectrophotometer using illuminant C and a 2° observer angle. All the bellies from each shearing treatment in each flock were combined, as for normal wool handling procedures, and four core bored samples taken. Each core bored belly sample was hand-carded, washed in water and the tristimulus (Y-Z) value measured to estimate the mean tristmulus (Y-Z) value for all bellies derived from each shearing time treatment group in each flock.

An estimate of the mean tristimulus (Y-Z) value applicable to the full (unskirted) fleece, including the belly wool, was calculated for each sheep according to the method outlined in the international standard, IWTO-31-96. The estimate was derived as the difference between the weighted average radiance factors for the tristimulus Y and Z values of the samples derived from each portion of the fleece, adjusted for Friele's function (Friele, 1952).

Statistical analysis

Differences due to flock and shearing time were estimated by REML, using GenStat 7.1 (Lawes Agricultural Trust, 2003), with the flock by shearing time interaction term as a random effect.

Curvilinearity in relationships between the measured data was tested by Bayesian smoothing techniques (Upsdell, 1994) using the model of tristimulus (Y-Z) = mean fibre diameter x (flock + shear time) + staple length. Each term represented a smooth function of the nominated measurement. As none of the tested relationships were significantly curvilinear simpler linear models were adopted and the relationships analysed by REML using GenStat 7.1 (Lawes Agricultural Trust, 2003) with flock, shearing time and flock by shearing time as random effects.

RESULTS

Least-square means and least significant differences for the measured parameters are given in Table 1. While ewes at the four locations were not significantly different in pre-shear live weight or mean fibre diameter, ewes in the Rotorua flock grew less wool which was shorter and more variable in fibre diameter than the ewes at the other three locations. With removal of the belly wool and stained pieces, the skirted fleeces had lower tristimulus (Y-Z) values (less discoloured) than the complete or 'full' fleece growing on the sheep. Fleece wool grown at Whatawhata had higher tristimulus (Y-Z) values (more discoloured) both as a full fleece and after skirting than fleece wool grown at Rotorua. In its skirted form wool from Rotorua was more discoloured than fleece wool grown at the other two locations.

Fleeces shorn with either lambs-at-foot or at weaning were lighter than fleeces shorn at the other times of the year with a progressive increase in fibre diameter variation for fleeces shorn in the spring/summer period compared with fleeces shorn in late autumn/winter. Fleeces shorn with lambs-at-foot had the least discolouration and fleeces shorn in late summer pre-mating the most discolouration.

There was a significant positive relationship between wool yellowing and mean fibre diameter in both full and skirted fleeces and between wool yellowing and staple length in full fleeces (Table 2). The relationship between wool yellowing and staple length in skirted fleeces was not significant. Relationships between wool yellowing and fleece weight, and between wool yellowing and fibre diameter variation, in both full and skirted fleeces, were all not significant. Staple length was, however, retained in the model as a covariate to adjust for the known positive phenotypic correlation between mean fibre diameter and staple length (Mortimer, 1987), as both characteristics are likely to affect the rate of drying of a fleece after rain.

TABLE 1: Least square mean values and least significant difference for measures of pre-shear live weight, fleece weight and wool characteristics.

Treatment	Pre-shear live weight (kg)	Fleece weight (kg)	Staple length (mm)	Mean fibre diameter (μm)	SD fibre diameter (μm)	Tristimulus (Y-Z)	
						Full fleece	Skirted fleece
Flock							
Whatawhata	43.4	4.07	94	20.6	4.5	4.5	2.6
Rotorua	43.4	3.62	81	20.8	4.8	2.9	1.7
Poukawa	44.6	4.24	95	20.4	4.2	2.7	1.1
Wanganui	43.4	4.27	97	20.3	4.1	2.7	1.0
LSD[1]	1.6	0.25	4	0.7	0.2	0.7	0.8
Shearing time							
Pre mating	43.9	4.21	90	20.7	4.7	3.7	2.1
Post mating	43.4	4.12	92	20.5	4.2	3.4	1.7
Pre lambing	44.5	4.20	95	20.3	4.3	2.8	1.5
Lambs-at-foot	42.0	3.80	91	20.6	4.4	2.6	1.2
Weaning	44.7	3.91	89	20.5	4.5	3.4	1.7
LSD[1]	1.8	0.27	4	0.8	0.2	0.8	0.9
Flock effect	NS	***	***	NS	***	***	***
Shearing time effect	*	**	†	NS	***	*	NS

[1] Least significant difference. Effect significant at 5% level of significance where the difference between the means exceeds the quoted value.

TABLE 2: Estimates of the overall mean slope and standard error of the estimate of the linear relationships between tristimulus (Y-Z) for both mean fibre diameter and mean staple length for full fleeces and skirted fleeces, adjusted for flock and shearing.

Characteristic	Full fleece			Skirted fleece		
	Mean slope	SE	Significance	Mean slope	SE	Significance
Mean fibre diameter (μm)	0.16	0.02	***	0.18	0.02	***
Mean staple length (mm)	0.10	0.03	***	0.03	0.02	NS

Estimates of the slope and mean tristimulus (Y-Z) value at the mean fibre diameter adjusted for mean staple length are given in Table 3 with the relationships plotted in Figure 1. Slopes of the relationships within each flock and within each shearing time group were not significantly different for either the full fleece or the skirted fleece data. The mean tristimulus (Y-Z) value at the intercept with the mean adjusted fibre diameter was greater for the Whatawhata flock than for the Poukawa and Wanganui flocks with the Rotorua flock being intermediate for both the full fleece and skirted fleece data. Similarly the intercept value for full and skirted fleece data of ewes shorn pre mating was greater than the intercept values for ewes shorn pre lambing or with lambs-at-foot. Values for the mean tristimulus (Y-Z) values post mating and at weaning were intermediate between these extreme values.

DISCUSSION

A proportion of the ewes in this study were born in the South Island of New Zealand with the others being up to four generations removed from being relocated to the North Island. The lack of significant flock differences between mean live weight at shearing, mean fibre diameter and mean fibre diameter variation indicate the four flocks were equivalent in productive potential. Adaptation to North Island conditions was unlikely to be of importance in the reported results. The Whatawhata and Rotorua flocks were established from a disbanded research flock previously grazed at the Tokanui Research Station, near Te Awamutu. The lower greasy fleece weight of the Rotorua ewes most likely reflects a difference in grazing management between the two flocks although this is not supported by a difference in pre-shear live weight.

TABLE 3: Estimates of the slope for the linear relationship between mean fibre diameter and tristimulus (Y-Z), adjusted for mean staple length, in each flock and shearing time treatment group, for both full fleeces and skirted fleeces. Included is an estimate of the mean tristimulus (Y-Z) value adjusted for mean staple length at the mean fibre diameter for each relationship.

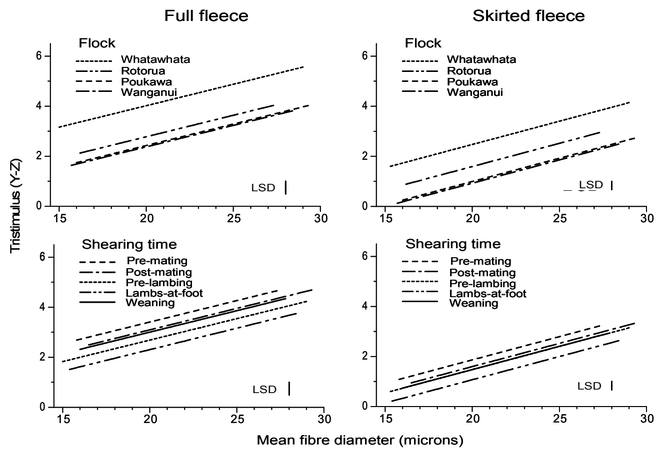
	Full fleece		Skirted fleece	
Treatment	**Slope**	**Mean tristimulus (Y-Z)**	**Slope**	**Mean tristimulus (Y-Z)**
Flock				
Whatawhata	0.17	4.4	0.20	2.6
Rotorua	0.16	3.0	0.15	1.7
Poukawa	0.16	2.7	0.16	1.1
Wanganui	0.16	2.7	0.19	1.0
LSD[1]	0.01	0.2	0.06	0.2
Shearing time				
Pre mating	0.12	3.7	0.15	2.0
Post mating	0.17	3.4	0.17	1.7
Pre lambing	0.20	2.9	0.20	1.6
Lambs-at-foot	0.17	2.6	0.18	1.2
Weaning	0.17	3.4	0.18	1.6
LSD[1]	0.07	0.2	0.05	0.2
Flock effect	NS	***	NS	***
Shearing time effect	NS	***	NS	***

[1] Least significant difference. Effect significant at 5% level of significance where the difference between the means exceeds the quoted value.

Estimates of the tristimulus (Y-Z) values for full fleeces were calculated as a baseline reference point assuming all the wool produced by the sheep had been processed together. In practice this does not happen with the belly wool pieces and stained portions being removed following shearing, before pressing and the subsequent sale of the wool. The skirted fleece component in this study represents that portion of the fleece sold to the wool trade.

These results indicate that while removal of the stained portions of the fleece reduces the overall intensity of discolouration it does not affect the slope of the relationship between discolouration and the mean diameter of the fleece (Table 3). The similarity in slopes of these different responses is suggestive of a 'whole body' response as would be mediated through the greater density of sebaceous gland lobes that have been shown to be present in finer-woolled compared with coarser-woolled Merino sheep (Carter & Clarke, 1957).

FIGURE 1: Plots of the relationships between mean fibre diameter and tristimulus (Y-Z) values for full fleeces and skirted fleeces in four flocks grazed at different locations and when shorn at five different times during the year.



The density of sebaceous glands in skin, which by inference is positively related to sebum output, has recently been shown to be negatively related to wool yellowing (Sumner & Craven, 2005). The results presented here are thus in accord with the results of Sumner and Craven (2005), that secreted sebum protects growing wool fibres from the effects of secretions from the sweat (sudoriferous) glands in the skin that appear to induce wool yellowing under appropriate environmental conditions. Similarly Aitken *et al.* (1994) reported the propensity of wool to develop yellow discolourations was negatively related to the wax/suint ratio associated with the fibres in a greasy state.

The difference in the mean tristimulus (Y-Z) values between the four flocks aligns with the expected output of sweat, and hence suint, likely to be produced at each of the four locations induced by local climatic conditions. The average annual rainfall at collection sites near the trial sites at Whatawhata, Rotorua, Poukawa and Wanganui was 1726, 1234, 895 and 1004 mm respectively during the trial (data supplied by NZ Meterological Service). The Whatawhata site generally has more humid summer conditions than the other sites while the Rotorua flock was grazed in a sheltered situation amongst adjacent *Pinus radiata* plantations potentially increasing the relative humidity relative to open grazing conditions (Cleugh, 2002). The Wanganui flock was grazed on an exposed windy site where the fleeces would dry rapidly after rain and show little discolouration. The Poukawa flock was grazed on rolling country surrounded by low ranges of hills. These local climatic effects were clearly reflected in the degrees of discolouration present in these large flocks run under grazing conditions, supporting the findings of Sumner and Craven (2005) for a small group of sheep subjected to controlled environmental conditions (Sumner *et al.,* 2004).

The trends in tristimulus (Y-Z) values associated with shearing Merino ewes at different times during the year mirror the effects previously reported for sales of Romcross-type wool (Reid, 1993) and for individual Romcross-type ewes (Sumner & Willoughby, 1985, 1988; Sumner & Armstrong, 1987; Sumner & Scott, 1990). Wools shorn in winter and early spring are the whitest and wools shorn in summer and early autumn are the most discoloured. The effect for fleece weight was not so clear cut. Sheep shorn with lambs-at-foot or at weaning were carrying relatively long fleeces at lambing. This necessitated an additional crutching. Management constraints for some of the flocks precluded each flock being treated equally and the weights of crutchings removed were not able to be weighed, distorting the total recorded fleece weight.

Climatic conditions prevailing in the last few months before shearing, when the fleece is longest, have a greater impact on wool discolouraton than when the fleece is shorter. Short wool dries quickly after rain and shows little fleece discolouration. When the fleece is longer the localised environment at the base of the fleece appears to be isolated from the effects of rain wetting and yellow discolourations develop throughout the fleece when the sheep itself is exposed to warm moist conditions. This further reinforces the hypothesis that the severity of fleece discolouration in a growing fleece is due to an interaction between skin gland secretions and the atmospheric conditions to which the sheep is exposed.

The significant linear relationship between mean fibre diameter and tristimulus (Y-Z) values for both the full fleece and skirted fleece samples confirm the correlation data of Reid and Botica (1995). While a mean fibre diameter of 21 μm or less has commonly been taken by advisors and consultants as an upper limit for sheep to produce 'average' or better coloured wool under North Island conditions, these results indicate there is no practical threshold value for wool growers to use other than the finer the wool, the less the chance of it discolouring before shearing.

Other management considerations must also be taken into account by wool growers attempting to maximise their net returns, such as feed availability at shearing. Maximising fleece weights of Romcross sheep requires that they be shorn when sheep have access to adequate green herbage to meet their immediate energy requirements. The same is likely also to apply to Merino sheep. In the North Island Merino sheep should be shorn in the spring/early summer. This is a period of good pasture growth and results in minimal fleece discolouration, the two most important criteria for efficient wool production on-farm. Unfortunately this is at the end of the normal Merino wool marketing period in New Zealand when the volume of wool being offered for sale is decreasing and wool prices may be more volatile.

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