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Seasonal changes in fibre and follicle characteristics related to wool bulk in Perendale ewes

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ABSTRACT

Wool bulk is one of six key characteristics that describe processing performance and the final potential of wool products and is largely influenced by fibre crimp and fibre diameter. Measurements of seasonal variation in wool growth, and fibre and follicle characteristics associated with wool bulk were made over 19 months in Perendale ewes within lines selected for or against wool bulk to assess their potential impact on processing performance.

Wool growth rate, mean fibre diameter, mean follicle depth and follicle activity displayed a minimum value in July and a maximum in December-January. Mean fibre curvature and follicle curvature grade had an opposing seasonal trend with a maximum in winter and a minimum in summer. The opposing seasonal cycles for fibre curvature and fibre diameter, compensated each other across seasons with no change in the expression of wool bulk throughout the year.

Keywords: wool bulk; seasonality; fibre dimensions; follicle characteristics; Perendale.

INTRODUCTION

Wool bulk is one of six key characteristics that describe desirable processing attributes of wool and the potential quality of the end product. As a measure of the filling capacity of wool, bulk is a reflection of how individual fibres interact with each other in the loose form, in yarn and in an end product. Wool bulk is largely related to fibre diameter and fibre crimp (Dick and Sumner, 1995; Edmunds and Sumner, 1996), which in turn is dependent on other fibre and follicle characteristics particularly staple crimp and follicle curvature (Sumner *et al.*, 1993; Dick and Sumner, 1995, 1996).

Sheep bred for high bulk wool tend to have a lighter fleece weight than sheep selected against bulk (Sumner *et al.*, 1995). Wool growth rate and fibre diameter, two components of fleece weight, both display a photoperiodic seasonal rhythm in non Merino New Zealand sheep with a summer maximum in December-January and a winter minimum around July (Bigham *et al.*, 1978). The effect of this seasonal variation in wool growth rate and fibre diameter on fibre crimp, and in turn its possible effect on wool bulk, is unknown.

This study investigated seasonal changes in fibre and follicle characteristics related to wool bulk, fibre diameter, and wool growth, in two age groups of Perendale ewes over 19 months. To check whether the seasonal variation in these characteristics differed between high and low bulk wool of similar mean fibre diameter, sheep from lines selected for or against wool bulk were used.

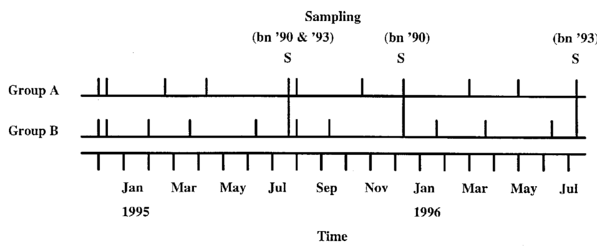
METHOD AND MATERIALS

Sampling

Perendale ewes born in 1990 (5 year old) and 1993 (2 year old) from lines selected for or against wool bulk and maintained within a single larger flock established at Whatawhata Research Centre since 1989 (Sumner *et al.*, 1995), were studied. Two sampling groups (A and B) were balanced for age and bulk selection line (Table 1). On 30 November 1994 the 1990 born ewes were live weighed, and had a snip skin biospy (Parry *et al.*, 1992) and a 12mm trephine skin biospy (Scobie, 1993) taken from the left midside. A midside patch of about 10cm x 10cm was clipped with small animal clippers from the right midside. Equivalent samples were taken from the 1993 born ewes on December 1994. All sheep were again liveweighed, skin sampled and patch clipped on 19 July 1995 and 5 December 1995. An additional patch clip was taken on 31 July 1995 to reestablish the patch area after shearing.

At other times throughout the year both skin biospys and wool patch samples were taken intermittently from Groups A and B (Figure 1) to provide samples at four to six weekly intervals fitted in around grazing and husbandry constraints. Patch clipping was continued on the 2-year-old sheep for a further six months until shearing on 10 July 1996. Midside samples of full length wool were taken from all sheep at shearing and individual fleece weights recorded. The number of lambs born to and reared by each ewe was recorded as a possible factor which may impact on wool growth.

FIGURE 1: Midside wool patch clip and skin biospy sampling schedule for Groups A and B. S = shearing time.



Wool measurements

Core bulk (Standards Association of New Zealand, 1994), fibre diameter, fibre diameter standard deviation and radius of fibre curvature (Edmunds, 1995) were measured from midside fleece samples. Staple length was measured and total number of crimps along the staple counted for each fleece sample. Clipped midside patch samples were washed, clean wool growth estimated (Sumner *et al.*, 1994) and fibre diameter, fibre diameter standard deviation and radius of fibre curvature measured (Edmunds, 1995).

Skin measurements

Skin biopsys were fixed in buffered 10% formalin. Longitudinal sections (1mm) were cut from the snip biospy samples, stained with 0.25% nile blue sulphate then graded for follicle curvature (Dick and Sumner, 1995). Curved length of a follicle and vertical depth from the skin surface to the dermal papilla were measured by image anaysis for all whole follicles in one field (between 12-24 follicles). Each trephine biopsy sample was processed through an ethanol gradient, embedded in wax and cut into transverse sections (7µm). These were stained by the SACPIC method and 300 follicles graded for follicle activity (Nixon, 1993). Follicle density and ratio of secondary to primary follicles (S/P ratio) were calculated from trephine sections taken in December 1994 (Dick and Sumner, 1996).

Statistical analysis

Sheep, wool and follicle characteristics measured once during the trial were analysed by analysis of variance. Variables repeatedly measured through time were analysed for selection line, age and sampling group effects by Bayesian smoothing (Upsdell, 1994). A linear combination of radius of curvature, fibre diameter and fibre diameter standard deviation values from midside fleece samples were used to develop a prediction equation for measured core bulk. This equation was then used with patch measurements to predict bulk at different times of the year.

RESULTS

In 1995 twenty eight ewes gave birth to and reared one lamb, seven ewes had twins and one remained dry. Of the characteristics measured only staple length was significantly affected by the pregnancy and lactational status of the ewe. As the number of lambs reared increased staple length decreased from 142 ± 14mm (no lambs) to 103 ± 6mm (twins). There was a significant age difference in live weight with the five year old ewes being heavier than the two year olds (54.6 ± 1.6kg vs 45.7 ± 1.4kg, $P<0.001$). The 5 year old sheep had heavier fleeces than the 2 year olds, with mean fibre diameters, adjusted for lactation status and bulk flock, of 3.45 ± 0.13kg vs 3.02 ± 0.11kg, $P<0.05$, and a longer staple length of 124.2 ± 3.9mm vs 111.4 ± 3.3mm, $P<0.05$. The bulk line and lactation adjusted mean fibre diameter of the older sheep was coarser (38.8 ± 0.67µm) than the mean fibre diameter of the 2 year old sheep (36.0 ± 0.6µm), ($P<0.01$). Follicle density was lower in the older age group compared with the younger ewes (13.6 ± 0.7 follicles/mm^2 vs 16.9 ± 0.6 follicles/mm^2, $P<0.001$). There was no difference between the two age groups for any other characteristic listed in Table 1. Sheep selected for wool bulk had lighter fleeces, shorter staple length and greater fibre curvature, as measured by radius of curvature, than fleeces from sheep in the low bulk line (Table 1).

TABLE 1: Means, adjusted for age and lambs reared, of live weight and fleece characteristics at July 1995 shearing and follicle population data at December 1994, for each bulk selection line.

Characteristic	High Line	Low Line	SED[1]	Significance
Number of born 1990 sheep	6	10	-	-
Number of born 1993 sheep	10	10	-	-
Fleece free live weight (kg)	49.1	50.2	1.9	NS
Greasy fleece weight (kg)	2.90	3.47	0.15	***
Staple length (mm)	97.0	131.7	4.6	***
Total number of staple crimps	16.2	15.4	1.8	NS
Core bulk (cm^3/g)	31.83	25.94	0.71	***
Radius of fibre curvature (mean) (µm)	1046.5	1451.8	78.4	***
Fibre diameter (mean) (µm)	37.30	37.12	0.79	NS
Fibre diameter (SD) (µm)	8.46	7.74	0.43	NS
Follicle density (follicles/mm^2)	15.36	15.65	0.83	NS
Follicle S/P ratio	5.06	5.16	0.17	NS

[1] Standard error of the difference

At the five common sampling time points, Groups A and B were not different for any of the measured characteristics and were therefore analysed together across time. Unless stated otherwise, there was no difference between age groups in the characteristics measured across seasons. Throughout the year ewes from the high bulk line grew significantly less wool per day than low bulk sheep ($P<0.05$), (Figure 2a). Both bulk lines followed similar seasonal changes in wool growth, with a winter minimum in June-July and a maximum in December-January. Fibre diameter displayed a distinct seasonal cycle synchronous with wool growth (Figure 2b). However, except for mid winter there was no fibre diameter difference between bulk lines. Fibre diameter standard deviation did not differ between bulk groups and showed no seasonal variation.

The low bulk line had straighter fibres than the high bulk line, with annual mean radius of curvature values of 1579 ± 302µm vs 1120 ± 204µm ($P<0.001$). Both bulk lines showed a decrease in radius of curvature (fibres more curved) over the winter ($P<0.01$) (Figure 2c). Follicle depth displayed a similar seasonal pattern to fibre curvature. The high bulk line had shallower follicles than the low line ($P<0.01$), and both groups had a significantly lower follicle depth in the winter compared to summer ($P<0.01$), (Figure 3a). Conversely, follicle curvature was greater in the high bulk sheep ($P<0.001$) and both bulk

FIGURE 2: Mean values for fibre characteristics; a) wool growth, b) fibre diameter, c) radius of curvature, over time. Open symbols are the low bulk selection line and solid symbols are high wool bulk selection line. Plotted lines are significantly different at the 5% level where confidence bands do not overlap.

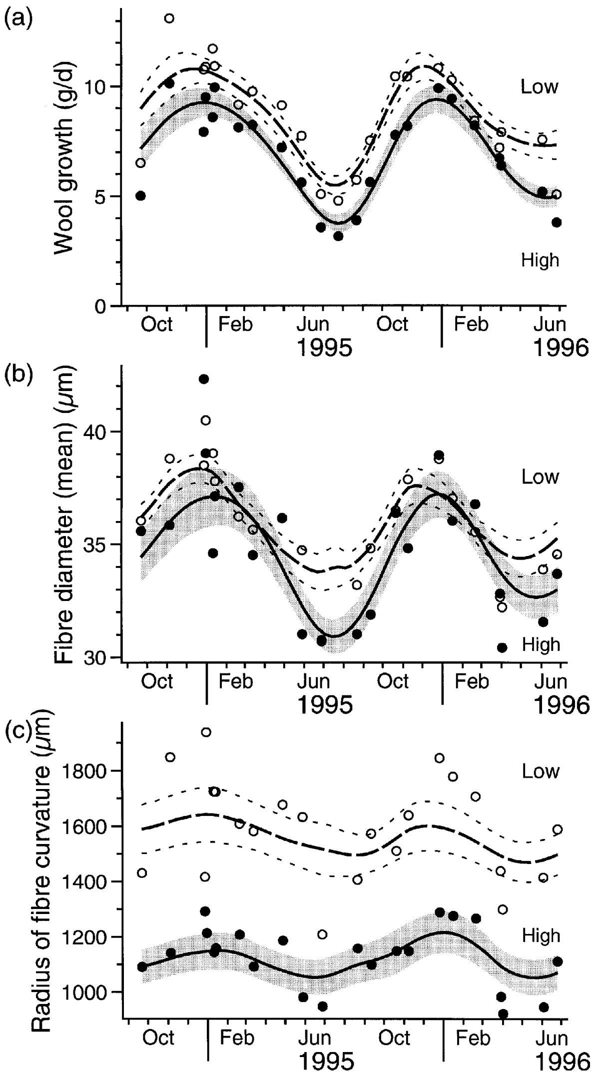


FIGURE 3: Mean values for follicle characteristics; a) follicle depth, b) follicle curvature, over time. Open symbols are the low bulk selection line and solid symbols are high wool bulk selection line. Plotted lines are significantly different at the 5% level where confidence bands do not overlap.

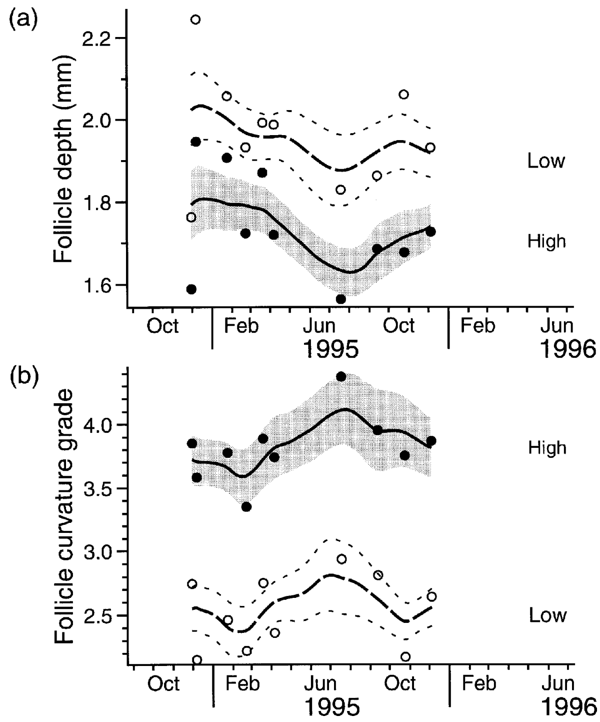
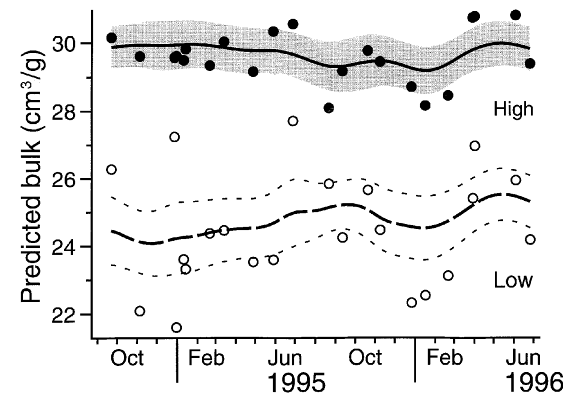


FIGURE 4: Mean predicted values of wool bulk over time. Open symbols are low bulk selection line and solid symbols are high bulk selection line. Where shaded areas do not overlap the plotted lines are significantly different at the 5% level.



groups had an increase in follicle curvature between Feburary and winter (P<0.01) (Figure 3b). Although high bulk sheep had shorter follicles than the low bulk sheep (1.94 ± 0.31mm vs 2.15 ± 0.33mm, P<0.001) there was no seasonal shift in total follicle length in either selection line. Therefore, in winter follicles lay at a shallower depth, became more curved and the fibres produced were more curved.

Primary follicle activity did not vary between bulk groups and was constant throughout the year (99.3 ± 1.8%), except in July when significantly less follicles (96.1 ± 4.0%) were actively growing fibre (P<0.05). From September to June secondary follicle activity did not vary between bulk groups. The mean secondary follicle activity in high bulk sheep was significantly lower than the low bulk sheep in July (92.1 ± 6.5% vs 96.0 ± 5.5%, P<0.05), and overall the proportion of active secondary follicles was less in July than at other times of the year (94.4 ± 6.3% vs 99.6 ± 0.9%, P<0.001).

Using fleece measurements of core bulk the equation developed to predict bulk was: bulk = -0.12 ± 0.001 (±SE) radius of fibre curvature + 0.28 ± 0.14 fibre diameter - 0.13 ± 0.24 fibre diameter standard deviation + 34.3 ± 4.6. This equation explained 76.2% of the variation in wool bulk. Application of this equation to fibre measurements at different times of the year indicated no significant change in bulk within either selection line across seasons (Figure 4).

DISCUSSION

The differences in fleece weight, staple length and radius of curvature as a result of wool bulk selection (Table 1) concur with previous findings (Dick and Sumner, 1996). Increased staple crimp frequency was previously reported in high bulk sheep (Sumner *et al.,* 1993; Dick and Sumner, 1995, 1996), yet there is no association with bulk line in total number of staple crimps (Table 1). This indicates that sheep from these selection lines are producing the same number of crimp waves and it is only the difference in staple length that causes staple crimp frequency to be greater in high bulk sheep.

Wool growth and fibre diameter displayed synchronous seasonal changes with a minimum in winter and maximum in summer. While seasonal changes in wool growth rate vary with sheep breed, the three fold change from summer to winter (Fig. 2a) is similar to that previously reported in Perendale wethers (Bigham *et al.,* 1978). Mean fibre diameter values of 39µm during periods of high wool growth were 1.3 times greater than the 29µm winter low (Fig. 2b). This degree of seasonal fibre diameter change is comparable to that previously found in Perendales and other New Zealand Romney cross type breeds such as Romney, Coopworth, Corriedale and Cheviot (Bigham *et al.,* 1978). In this the first report of seasonal changes in fibre and follicle characteristics associated with wool bulk, the changes were concomitant with previously reported changes in wool growth and fibre diameter. The seasonal trends in this trial, where summer grown wool is coarser and has less fibre curvature than winter grown wool, is analgous to the effect of increasing age (Sumner and Dick, 1997).

Sheep breeds that display the greatest seasonal variation in wool production shed more wool by releasing brush end fibres after a follicle has been through an inactive telogen phase. Soay sheep, which can shed their whole fleece in spring and early summer, have a 2 to 4 fold increase in fibre diameter and wool growth rate between winter to summer, compared to the Merino breed which exhibits little evidence of fibre shedding and minor seasonal variation in fibre diameter and growth rate (Ryder and Stephenson, 1968). Mean winter follicle activity of 95% in Perendale sheep indicates that the primitive seasonal moulting mechanism may still have a small effect on wool growth for some sheep in this breed. The variation in proportion of follicle activity in winter between sheep in this study was large as has been the case in most studies of breeds which show some shedding.

The analysis and display of seasonal changes in characteristics associated with bulk (Figs. 2 and 3) by Bayesian smoothing (Upsdell, 1994) has fitted a mean band for each bulk line across time smoothing out the more extreme points. Consequently, the graphs presented may tend to underestimate the extent of seasonal flucuation. While it is impractical to measure wool bulk on wool grown during short time periods, the consistently close association of core bulk with radius of curvture, mean fibre diameter and fibre diameter standard deviation shown by Edmunds and Sumner (1996) and Sumner and Dick (1997), enables the calculation of a predicted core bulk using the objectively measured characteristics. Use of a prediction equation calculated from measured wool bulk showed that, as in the case of age effects, changes in fibre curvature and fibre diameter compensated each other such that predicted core bulk was unaffected by seasonality (Figure 4). This suggests sheep may be shorn at any time of the year without differentially affecting wool bulk.

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