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Comparison of seasonal wool growth pattern and colour variation in fleece weight selected and control Romney flocks

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ABSTRACT

Seasonal wool growth pattern, colour variation and associated wool characteristics were measured in a fleece weight selected (HFW) and its control (RC) flocks. Both flocks had a significant ($p<0.01$) decline in wool growth rate in winter compared with summer. The HFW advantage over RC averaged 19% and 33% for ewes, 24% and 36% for hoggets, in summer and winter respectively. Yield and fibre diameter patterns were closely associated with wool growth. There were no flock differences in either brightness or yellowness, however both Y and Z tristimulus values were lower in spring and summer while yellowness was higher in summer than other seasons. The results suggest that selection for HFW reduces the relative winter wool growth decline compared with RC.

Keywords: wool, seasonal growth, selection, characteristics, brightness, yellowness.

INTRODUCTION

Romney and other long-woolled sheep breeds exhibit a pronounced seasonal wool growth rhythm, with up to a four fold higher summer than winter growth (Story and Ross, 1960; Bigham *et al.*, 1978). This pattern appears to be an evolutionary feature of the seasonal shedding in primitive breeds, however in the modern sheep this greatly disadvantages wool production and processing qualities. Consequently impaired wool characteristics, namely low tensile strength, cottedness and reduced length after carding, together with yellow discolouration of wool clips, are a serious concern for the wool industry. Selection for high fleece weight in Romney sheep has demonstrated a considerable improvement in both fleece weight and liveweight (Hawker and Littlejohn, 1986; McClelland *et al.*, 1987; Wuliji *et al.*, 1991). However, whether this has had any effect on the seasonal wool growth pattern, wool colour and other associated wool characteristics is unknown.

An experiment was conducted at the Woodlands Research Station to investigate seasonal wool growth patterns and colour variation in a fleece weight selected flock and its random control flock.

MATERIALS AND METHODS

The trial was designed to monitor the wool growth pattern and colour variation of ewes during each of the defined production seasons. Mixed age ewes of the high fleece weight selected (HFW) and its random control flock (RC) were midside patch clipped at three monthly intervals after the 1989 fleece shearing (middle of December). Ewe progeny of HFW and RC born in 1989 were also included in the trial and midside patch clipped after lamb shearing (end of December) until shearing as hoggets in late September, 1990. A second shearing was also carried out for these progeny pre 2-th in late January, 1991. The 10x10 cm^2 patch was clipped on the right midside of each animal using small animal clippers (fitted with size No. 30 blade). Flocks were grazed together on white clover-ryegrass pasture all year round, except during the mating and lambing seasons when they were grazed separately. The patch growth period was varied according to the animal management routine. Ewes in summer and spring clipping had an extra two weeks growth respectively but the winter period was four weeks less so that clipping occurred before lambing while hoggets in spring had six weeks more growth which extended into the following summer. The daily wool growth rate (g/day) was estimated from the midside patch growth and total number of days in each season. The yield, mean fibre diameter (FD) and tristimulus colours (X:red, Y:green and Z:blue areas of the colour spectrum) and yellowness (Y-Z) of patch samples were determined for each season to allow comparison between flocks and between seasons.

The data were analysed by residual maximum likelihood using the REML package (Robinson, 1984). The models for mixed age ewes included the ewe as a random effect, with season, flock, ewe age and flock by season interaction as fixed effects. The following interactions with age (2 tooth vs older component) were also necessary (because of the different initial shearing date for 2 tooths): season by age for fleece growth; flock by age for colour; and both of these interactions for FD and yield.

The models for hoggets included the sire and hogget as random effects, with the covariate birth date and birth/rearing rank, flock, dam age, season and flock by season interaction as fixed effects. The models for fleece growth and FD had birth date nested within season.

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RESULTS

Ewes

Wool growth rate was significantly ($p < 0.01$) higher for HFW in all four seasons compared with RC ewes (Table 1). Both ewe flocks had a significant ($p<0.01$) decline in wool growth rate in winter compared with other seasons. Although the HFW flock had a bigger drop than RC in wool growth rate, it had a smaller percentage of wool growth reduction in winter. The HFW advantage over RC averaged 19% in summer and 33% in winter. Greasy wool growth rate in autumn was similar to that in spring for both flocks, but spring growth was lower ($p< 0.05$) than autumn growth for clean wool growth, which reflected the yield differences in these seasons. The yield was significantly ($p<0.05$) lower in each successive season from summer to spring, whereas no consistent difference was shown between flocks. The FD was 1.1μm, 0.4μm, 1.6μm and 0.8μm coarser for the HFW flock in each season from summer to spring respectively, compared with RC ewes (only autumn FD was not significantly different). There were large fluctuations in FD over the seasons which coincided with the wool growth pattern, with the wool coarsest in summer ($p<0.01$) at an average of 42.6μm and finest in winter at an average of 30.2μm ($p<0.01$). The analyses showed there were no significant differences in either brightness (Y) or yellowness (Y-Z) between flocks, however both Y and Z were lower in spring ($p<0.05$) and lowest in summer ($p<0.05$) in relation to the other two seasons. Yellowness was highest in summer ($p<0.05$) and lowest in autumn.

Hoggets

The wool growth patterns of the ewe hogget flocks closely resembled those of the mixed-age flocks. Significant differences ($p<0.01$) were found between HFW and RC hogget wool growth rates (Table 2), and the HFW advantage over RC increased to 24% and 36% in summer and winter respectively. Although winter growth rate was the lowest ($p<0.05$) within the year for each flock, the percentage reduction from the summer was much less than for their respective mixed age ewe flocks (-51.5% for RC hoggets compared with -80.1% for RC ewes and -46.9% for HFW hoggets compared with -77.7% for HFW ewes). In contrast to the mixed age ewes the spring wool growth was significantly higher ($p<0.05$) than in the autumn. Yield and FD patterns were closely associated with the wool growth pattern and similar to the ewes except that they were the highest ($p<0.05$) in spring (ie rising 2-tooths). There were no overall selection differences for yield, but on the other hand FD was significantly coarser in HFW hoggets for all seasons, with an average increase of 0.9μm, 1.7μm, 2.3μm and 1.0μm for the summer to spring, respectively. There was no overall difference between flocks in Y, Z or yellowness values and these showed a similar seasonal pattern to those described for ewes, with the only exception that yellowness was highest at the 2-tooth age ($p<0.01$). Birth and rearing ranks appeared to have very little impact on the overall average daily clean growth rate which was 10.7 g/d, 10.6 g/d and 10.2 g/d for single/single, twin/single and twin/twin groups respectively, whereas other fixed effects were non significant.

DISCUSSION

The seasonal wool growth pattern in naturally grazed Romneys at Woodlands peaked in the summer months (December-February) and troughed in the winter months (June-August). These results are generally in agreement with a range of previous findings in long-woolled sheep (Story and Ross, 1960; Bigham *et al.* 1978; Hawker *et al.*, 1982).

The seasonal rhythm of fur coat growth in many primitive mammals is set by photoperiod, corresponding to their endogenous hormonal levels, so that the short day-length in the winter season suppresses the activity of wool follicles while the long day-length of summer stimulates wool growth. For sheep such as Soay and Wiltshire, this seasonal rhythm is complete, i.e. wool follicles became virtually quiescent and show moulting in spring (Ryder and Lincoln, 1976). At the other extreme, in modern breeds such as the Merino, such a rhythm is nearly totally lost while most of the long-woolled breeds such as the Romney, lie in between these extremes. The reversing of the wool growth rhythm in Romney sheep by alternating day-length artificially, showed success though it took a long period (Morris, 1961). The important endogenous hormone involved in this process was later shown to be melatonin. Its increased secretion will suppress prolactin and therefore cease wool follicle activity. The constant administration of melatonin during long days resulted in the reversal of the seasonal reproductive cycles and fleece moulting in Soay rams (Lincoln and Ebling, 1985). Hawker and Crosbie (1985) showed that the large difference between high and low winter wool growth in ewes (fed in doors) was in their winter rather than summer differences, with low winter wool growth ewes exhibiting a more pronounced seasonality for wool growth. McClelland *et al.* (1987) found that selection for HFW has led to a 78% improvement in the efficiency of winter wool growth over the control animals. The hormonal profile follow up study on the above ewes did not show any significant differences in their melatonin levels during daylight or darkness, at the winter or summer solstices and at the spring or autumn equinoxes, though there was a considerable variation between ewes in spring and winter (Scott *et al.*, 1992), and a further elucidation of this mechanism is warranted.

Winter growth in the HFW ewes and hoggets was proportionally higher compared with their RC contemporaries, supporting the results from Massey University where the wool selected flock was +20% in summer and +47% higher in winter wool growth over the control hoggets (McClelland *et al.*, 1987). The HFW flock had a higher liveweight, fleece weight, ovulation and multiple birth rates than the RC flock (Wuliji *et al.*, 1992). However, the extra reproductive load in HFW ewes may constrain their wool growth potential in the autumn/winter seasons, and this may be part of the reason for the relatively large percentage of selection flock difference in autumn wool growth in the hoggets.

FD seasonal changes in ewes were strongly associated with wool growth rate; coarser in summer, finer in winter, while autumn and spring were intermediate. In hoggets FD was coarsest during spring which reflected the fact that the spring period overlapped with part of the following summer due to management regime. It is probably also partly due to the progressive age differences between summer and spring. FD increases for HFW are in a range of 1.1 to 5.3% for ewes and 2.5 to 7.7% for hoggets over seasons, accounting for about 25% to 33% of the wool growth differences of the flocks. This suggests that the fleece weight differences between these flocks are largely contributed by the combination of fibre length growth, total follicle numbers and wool bearing surface area differences. The percentage difference between HFW and RC flocks between seasons suggests that there is a heritable component in Romney sheep that could be exploited to reduce the winter growth decline or to better utilise nutrients for wool growth and higher follicle productivity during winter.

TABLE 1: Seasonal wool growth rate and wool characteristics estimated by midside patch clippings in HFW (n=222) and RC (n=83) ewes

Parameters	Flock	Summer	Seasons Autumn	Winter	Spring	Average SED for seasons
Greasy wool growth	RC	18.1^{c}	11.0^{b}	3.6^{a}	11.0^{b}	0.3
(g/d/head)	HFW	21.5^{c}	13.0^{b}	4.8^{a}	12.7^{b}	0.2
SED for flocks		0.3^{**}	0.3^{**}	0.3^{**}	0.3^{**}	
Clean wool growth	RC	13.5^{d}	8.1^{c}	2.5^{a}	6.9^{b}	0.2
(g/d/head)	HFW	16.0^{d}	9.5^{c}	3.3^{a}	8.0^{b}	0.1
SED for flocks		0.2^{**}	0.2^{**}	0.2^{**}	0.2^{**}	
Patch wool yield	RC	74.8^{d}	73.3^{c}	68.4^{b}	62.3^{a}	0.5
(%)	HFW	74.6^{d}	72.8^{c}	67.4^{b}	62.8^{a}	0.3
SED for flocks		0.5^{ns}	0.5^{ns}	0.5^{*}	0.5^{ns}	
Patch wool fibre diameter	RC	42.0^{d}	39.6^{c}	29.4^{a}	37.2^{b}	0.5
(µm)	HFW	43.1^{d}	40.0^{c}	31.0^{a}	38.0^{b}	0.3
SED for flocks		0.3^{**}	0.3^{ns}	0.3^{**}	0.3^{*}	
Tristimulus colour						
Y	RC	69.8^{a}	72.4^{c}	72.9^{c}	71.1^{b}	0.4
	HFW	69.4^{a}	72.2^{c}	72.4^{c}	70.9^{b}	0.3
SED for flocks		0.4^{ns}	0.4^{ns}	0.4^{ns}	0.4^{ns}	
Z	RC	65.3^{a}	69.9^{c}	69.5^{c}	67.3^{b}	0.3
	HFW	64.8^{a}	69.6^{d}	69.2^{c}	66.9^{b}	0.2
SED for flocks		0.3^{ns}	0.3^{ns}	0.3^{ns}	0.3^{ns}	
Yellowness (Y-Z)	RC	4.5^{c}	2.5^{a}	3.4^{b}	3.9^{b}	0.3
	HFW	4.7^{c}	2.6^{a}	3.6^{b}	3.9^{b}	0.2
SED for flocks		0.2^{ns}	0.2^{ns}	0.2^{ns}	0.2^{ns}	

*:p<0.05;**:p<0.01;ns:non significant;abcd:means bearing different superscripts differ significantly at p<0.05 within rows.

TABLE 2: Seasonal wool growth rate and wool characteristics estimated by midside clippings in HFW (n= 107; (2-th, n=78) and RC (n= 48; (2-th, n=36) hoggets.

Parameters	Flock	Summer	Seasons Autumn	Winter	Spring	Average SED for seasons
Greasy wool growth	RC	16.7^{c}	9.4^{b}	8.1^{a}	17.6^{d}	0.3
(g/d/head)	HFW	20.7^{c}	12.9^{c}	11.0^{a}	20.7^{c}	0.2
SED for flocks		0.4^{**}	0.4^{**}	0.4^{**}	0.4^{**}	
Clean wool growth	RC	12.4^{c}	6.9^{b}	4.8^{a}	13.5^{d}	0.2
(g/d/head)	HFW	15.1^{c}	9.1^{b}	6.6^{a}	15.9^{d}	0.1
SED for flocks		0.3^{**}	0.3^{**}	0.3^{**}	0.3^{**}	
Patch wool yield	RC	74.5^{b}	73.6^{b}	60.4^{a}	77.1^{c}	0.6
(%)	HFW	72.9^{c}	70.8^{b}	59.7^{a}	76.6^{d}	0.4
SED for flocks		0.9^{ns}	0.9^{*}	0.9^{ns}	1.0^{ns}	
Patch wool fibre diameter	RC	37.2^{c}	33.2^{b}	29.8^{a}	39.8^{d}	0.2
(µm)	HFW	38.1^{c}	34.9^{b}	32.1^{a}	40.8^{d}	0.2
SED for flocks		0.4^{*}	0.4^{**}	0.4^{**}	0.4^{**}	
Tristimulus colour						
Y	RC	70.8^{b}	73.3^{c}	73.1^{c}	64.7^{a}	0.4
	HFW	70.2^{b}	72.4^{c}	72.5^{c}	64.2^{a}	0.3
SED for flocks		0.4^{ns}	0.4^{*}	0.4^{ns}	0.4^{ns}	
Z	RC	67.3^{b}	71.2^{d}	69.0^{c}	58.4^{a}	0.6
	HFW	66.5^{b}	69.8^{d}	68.2^{c}	57.2^{a}	0.4
SED for flocks		0.6^{ns}	0.6^{*}	0.6^{ns}	0.6^{ns}	
Yellowness (Y-Z)	RC	3.5^{b}	2.0^{a}	4.0^{c}	6.3^{d}	0.2
	HFW	3.7^{b}	2.6^{a}	4.3^{c}	7.0^{d}	0.2
SED for flocks		0.2	0.2^{*}	0.2	0.3^{**}	

*:p<0.05; **:p<0.01;ns: non significant;
abcd: means bearing different superscripts differ significantly at p<0.05 within rows.

Reduced wool brightness was associated with increased yellowness and with lower yield (except in 2-tooths) during the high growth seasons, this being in general agreement with other studies in New Zealand (Bigham *et al.*, 1983a; Sumner, 1983) . Sumner (1983) found that wethers of long-wool breeds in the North Island developed yellow discolouration during the warm autumn and wet spring. Bigham *et al.* (1983a) estimated that h^2 was low (0.13 ± 0.06) for yellowness and found that there were small differences between long-wool breeds and strains. Elucidation of seasonal variation in yellowness and its relationship to other characters may allow better management and breeding strategies.

The relationship of seasonal wool growth pattern with other wool characteristics such as staple strength will be presented in a subsequent publication. Nevertheless, these are expected to be related to wool growth seasonality. Bigham *et al.* (1983b) stated that sheep producing tender fleeces have a lower growth rate in winter than those producing sound fleeces. This lowered growth rate is due to a reduction in both diameter and length growth rate with reduced fibre diameter contributing to the increase in the susceptibility to tenderness.

CONCLUSIONS

A seasonal pattern of wool growth exists in both HFW selected and RC Romney ewes, this pattern being confounded with the reproduction, lactation and nutritional status. Selection for HFW appears to reduce the relative winter growth decline and increase the wool growth efficiency. The results suggest that selection for high fleece weight in crossbred sheep will reduce relative winter wool growth decline and increase staple strength and fibre diameter uniformity and thereby improve wool clip quality as well as farmers income.

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