Seasonal Variations in Skin and Wool Follicle Morphology of Grazing Merino Sheep with Low or High Staple Strength

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ABSTRACT: Differences in skin and wool follicle morphology between 6 low and 6 high staple strength (SS) Merino sheep were examined over a 12-month period at pasture. Low SS sheep had a higher skin weight and lower percentage of normal wool follicles than high SS sheep. Low SS sheep also had a significantly higher seasonal change in the percentage of normal wool follicles than high SS sheep. There was a significant relationship between SS and minimum percentage of normal follicles, coefficient of variation in follicle bulb diameter, and the seasonal change of the incidence in normal follicles. There were significant seasonal changes in wool follicle bulb diameter, dermal papilla diameter and length but these were not related to SS grouping. The differences in skin weights and percentage of normal follicles between SS groups warrants further study as these changes may influence the selection process of sheep for improved SS.

Key Words: Seasonal Production, Wool, Follicle Cysts, Skin Weight

INTRODUCTION

Schlink et al. (1999) examined a Merino flock in the Mediterranean climate zone of southern Australia, in which wool growth sheep were shown to have a seasonal amplitude of 28.7%. This was reflected in fluctuations in fibre diameter (FD) and fibre length, effecting reductions in staple strength (SS), processing performance and price at auction.

Sheep can be selected for improved SS to reduce the problems associated with the seasonality of wool growth (Lewer and Li, 1994). However, limited information is available on the wool follicles changes associated with different SS outcomes. Schlink and Dollin (1995) showed that fibre shedding is involved in SS reductions with follicles failing to produce a continuous fibre in the staple. Hynd et al. (1997) found that stocking rate significantly affected the incidence of inactive follicles but there was little difference between fine and strong wool Merino sheep. A maximum number of inactive follicles occurred approximately one month after the break of season in May. The proportion of inactive follicles accounted for 27.5% of the variation in staple strength. However, Thompson et al. (1998) found a poor relationship between the incidence of inactive follicles and fibre shedding. We examined grazing Merino sheep with low or high SS to determine if they had the same pattern of follicle activity and whether a relationship existed between SS and wool follicle morphology.

MATERIALS AND METHODS

The animals for this study were a flock of 10 low and 10 high SS sheep grazing at Bakers Hill, Western Australia (33°42’ 117°36”). Their selection and wool growth characteristics have been described (Schlink et al., 1999). Skin samples were collected from all 20 sheep at fortnightly intervals from November 1992 until 13 October 1993 on the mid-side area, using a 10mm trephine, after the area was anaesthetised using lignocaine with 2% adrenaline. The skin was fixed in buffered formalin for a minimum of 8 days, transferred to 70% ethanol for 24 h, trimmed of any projecting wool and sub-dermal tissue, blotted dry, weighed, and then embedded in histological wax.

SS measurements were made on fleeces shorn on November 28, 1999. Six sheep with the minimum (low) SS and six sheep with the maximum (high) SS were selected from the flock. Monthly skin samples were taken from November to February, fortnightly for April and May, and monthly for June to October. These were sectioned longitudinally to the wool follicle at 8 μm thickness for 30 serial sections, then stained with haematoxylin and eosin. Every fifth section was examined and follicles were classified as normal or abnormal. Abnormal follicles were similar to those in category three of Hynd et al., (1997) with irregular outer root sheaths, thickened and irregular connective tissue sheaths, and reduced mitotic activity. The number of cysts in the outer root sheath per follicle, follicle bulb diameter, dermal papilla diameter and length were also recorded for follicles transected along their central axis. A minimum of 35 follicles per sheep was measured.

Data were analysed using ANOVA and linear regression analysis (Minitab Inc., USA). Table curve (Jandel Scientific, USA) was used to fit non-linear regression to the data. Seasonal changes were calculated by expressing the difference between the highest and lowest values for the season as a percentage of the lowest value (Schlink et al., 1999). Effects were statistically significant at P<0.05 unless otherwise stated. There were no significant interactions between SS group and time in any of the parameters reported. S.E.M. is used as the error term unless otherwise stated.

RESULTS

The low and high SS groups had SS of 20.2 and 39.3 N/ktex, respectively (P<0.001). Similarly, clean fleece weights averaged 4.84 and 4.33 kg (P=0.18),

fibre diameters 21.4 and 22.1 μm (P=0.58), FD coefficients of variation (CV) 25.2 and 20.6% (P=0.003) and staple lengths 95 and 97 mm (P=0.78).

Skin weights were significantly different between the SS groups, averaging 1.14±0.02 and 1.07±0.02 mg/mm² for the low and high SS groups, respectively. Seasonal change in skin weight was 92% with no significant differences between the SS groups (Figure 1). Using the FD and fibre length growth data from Schlink et al. (1999), there was a significant relationship between skin weight and volume of wool growth in the weeks preceding skin sampling (r²=0.29, P=0.071) pooled across all the skin sampling times.

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The percentage of normal wool follicles was significantly lower for the low SS group than the high SS group, averaging 88.2±0.9 and 91.3±0.9% for the year, respectively (P=0.013). Seasonal changes in the percentage of normal wool follicles are shown in Figure 2. The seasonal change in the percentage of normal follicles was significantly different for the low and high SS groups, averaging 64.4±13 and 27.1±2%, respectively (P=0.016).

Wool follicle bulb diameter, dermal papilla diameter and dermal papilla length all changed significantly with time of year (Figure 3). SS group had no effect on the bulb or papilla parameters. Seasonal change was 34.2±2.9% for bulb diameter, 45.1±2.3% for papilla diameter and 45.1±3.6% for papilla length. There were no statistically significant SS group differences in the seasonal changes in bulb diameter, dermal papilla diameter and dermal papilla length. However, the seasonal change in skin weight was significantly greater than for any of the wool follicle dimensions measured.

The incidence of outer root sheath cysts in the follicle was independent of SS group but did vary significantly with time of the year, from zero in December 1992 to a peak 0.23 cysts/follicle in August to October 1993.

The incidence of shed fibres in the fleece was low and not significantly different between SS groups, averaging 3.6 and 2.2% for the low and high SS groups, respectively. There was no significant linear relationship between SS and shed fibres in the fleece (r²=0.29, P=0.071) and the relationship was not improved by use of non-linear models to fit the data. SS was significantly related to minimal percentage of normal follicles (r²=0.41, P=0.026) and r² increased using an exponential fit where:

SS = 17.7 + 0.027 * exp (x/12.2) r²=0.50 P=0.043 and x is the annual minimum in the incidence of normal follicles. This relationship was not significantly improved by the addition of other follicle morphology measurements. SS was also significantly negatively related to FDCV (r²=0.54), seasonal change in the incidence of normal wool follicles (r²=0.33), and average follicle bulb CV (r²=0.39).
DISCUSSION

Low staple strength sheep had a higher skin weight than high staple strength sheep, and tended to have a higher clean fleece weight, although not significantly so. There was a significant relationship between skin weight and volume of wool produced, in agreement with results of Gregory (1982), Williams and Thornberry (1992) and Hynd (1995). This relationship is further supported by the work of Liu et al. (1998) where production of wool protein was strongly related to skin protein synthesis rate.

Although skin weight was higher in the low SS group, this group had a lower average percentage of normal wool follicles than high SS sheep. This poorer normal follicle status did not, however, lead to a significant increase in fibre shedding. In agreement with previously published work (Thompson et al., 1998) there was no significant relationship between abnormal wool follicles and the incidence of shed fibres in the fleece. However, recent studies of Schlink et al. (1998) found that not all shed fibres are replaced by re-growth fibres in the fleece. This failure to re-grow fibres suggests that wool follicles may be lost from the follicle population. The loss of follicles may impact upon ratio-dependent estimations of follicle from the follicle population. The difference in percentage of follicles regressed in grazing sheep at the break of season in May. Ansari-Renani and Hynd (1996) found induction of follicle degeneration with cortisol administration also induced follicles to shutdown with similar morphology to those observed in the field. Although they suggested that cortisol acted through altering the production of EGF, work in our laboratory has shown that EGF concentration in the skin is not altered by cortisol administration (Schlink et al., unpublished). Schlink et al. (1998) showed that cortisol needed to be raised for 12 days to produce a significant increase in shed fibres, and only in sheep on a declining plane of nutrition. Sheep respond to acute stress with raised cortisol concentrations for less than 24 hours (Purchas 1973), considerably less than that required to induce fibre shedding and reduce staple strength. This suggested that cortisol did not play a major part in the decline in numbers of normal follicles. However, most of the of the interactions between cortisol and nutrition have been of a short-term nature and would not mimic the long-term stress associated with sheep surviving in a situation of declining body weight. The reductions in normal follicle numbers are likely to account for some reductions in wool growth in late summer and autumn.

The relationship of SS to FDCV is consistent with previous reports (Lewer and Li 1995; Peterson et al., 1998; Schlink et al., 1999). Peterson et al. (1998) found FDCV along the wool fibre to have the highest correlation with SS, but this was not the case in Schlink et al. (1999), nor was the correlation between SS and CV of follicle diameter found to be significant through the seasons. Adams and Briegel (1998) showed that the relative importance of the various factors that contribute to SS differed between various groups of sheep. This would suggest that that the components of SS vary in their relative importance in influencing SS and that single parameters should not be used to predict SS outcomes in flocks of sheep.

Overall skin and follicle parameters mirrored those of the previously reported fibre changes in grazing Merino sheep. The differences in skin weights and incidence of normal follicles between SS groups warrants further study as these changes may influence the selection of sheep for improved SS.

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