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An evaluation of the New Zealand Wiltshire sheep as a model for studies on the physiology of fibre growth

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ABSTRACT

Wiltshire Horn sheep exhibit an annual moult in spring and potentially provide a model for studies on the seasonality of wool growth. Twelve, 1 year old New Zealand Wiltshire ewes (Wiltshire Horn with some Poll Dorset in ancestry) were kept indoors under natural light and fed concentrates and hay. The sheep were scored for extent of fleece shedding every 2 weeks and skin sampled monthly for histological determination of primary and secondary follicle activity. Follicle activity reached a peak in summer and autumn (January to April) with low activity over winter (May to August) resulting in partial or entire shedding of the fleece in spring and early summer (September to December). There was evidence of a subsidiary shedding cycle in the primary follicles in early summer. Seasonal follicle activity was higher and longer in duration than previously recorded in British Wiltshire Horn ewes maintained on pasture. Four sheep with highly seasonal follicle activity cycles were identified as suitable for further studies on the endocrine control of wool growth. Such sheep can be selected from skin samples collected in June, July and August when follicle activity is at a seasonal minimum.

INTRODUCTION

Most sheep breeds have an annual cycle of wool growth, the growth rate being lowest in winter and highest in summer. This seasonal fluctuation is considered to have an evolutionary link with the shedding cycle which is still exhibited by breeds such as the Wiltshire Horn, Soay and Mouflon (Ryder, 1978). In these breeds, wool follicles undergo more or less synchronised periods of growth and quiescence. The initiation of follicle growth in the spring, following a period of winter inactivity, is temporally associated with fleece shedding.

The fibre growth cycle in mammals, originally described by Dry (1926) consists of 3 main phases - anagen (active proliferation of cells in the follicle bulb and fibre growth), catagen (cessation of fibre growth and formation of the keratinised fibre "brush end") and telogen (resting). The goal of the MAF Technology fibre physiology research programme is to develop a detailed knowledge of the control of fibre growth, with particular focus on the endocrine events surrounding the seasonal initiation of follicle (and fibre) growth (proanagen). A suitable sheep model for such studies would fulfil three criteria (i) exhibit an annual moult;

(ii) have all telogen follicles in winter; and (iii) respond to manipulation to induce a synchronised transition to proanagen. Wiltshire sheep were identified as a potential model because of their spring moult (Slee, 1965; Ryder 1969) and their availability in New Zealand.

The sheep used in this trial came from a commercial flock originating from a small number of Wiltshires imported into New Zealand from Australia in 1974. These were subsequently crossed with Poll Dorsets to improve wool production and reduce the phenotypic expression of horns. The Wiltshire sheep used in this trial comprised approximately 75% Wiltshire (J. Morrison, *pers. comm.*). This paper describes the shedding pattern and follicle activity cycles in 12 New Zealand Wiltshire sheep.

MATERIALS AND METHODS

Twelve, 1 year old New Zealand Wiltshire non pregnant ewes, showing some evidence of fleece shedding, were selected from a commercial farm in September 1989. They were housed indoors at Wallaceville Animal Research Centre (51°S, 142°E). The sheep were maintained in three rooms each exposed to natural light from the east, through a glass window. The sheep were

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fed a diet of lucerne pellets (480g/hd/d) and concentrates (99% peas) at 190g/hd/d and meadow hay *ad libitum*. Liveweights were measured at monthly intervals for the duration of the trial.

Skin samples were taken as snip biopsies on the left midside of all 12 sheep at the start of the experiment then monthly until October 1990. The skin was fixed in 10% phosphate buffered formalin, wax embedded, sectioned and stained by the "Saccip" method (modified from Auber 1952). Ten consecutive follicle groups on each skin sample were examined and assessed for number (expressed as a percentage) of active primary (P) and secondary (S) follicles in transverse section, according to Ryder and Stephenson (1968).

The sheep were assessed for fleece shedding every 2 weeks by drawing the area of fleece actually denuded, on a standard sheep profile. The extent of moulting was then estimated as a percentage of the total body surface area. Scoring began in September 1989 and continued until May 1990.

The follicle activity cycle of P and S follicles is described and differences between sheep in the timing of anagen and telogen are discussed. The nature of the data prevented detailed statistical analysis as there was no "normal" type which could be used as a basis for comparison either between or within sheep. Repeated measures on the same animals from year to year would provide data suitable for analysis and results from further studies with these animals will be published subsequent to this paper.

RESULTS

Follicle Activity

Mean follicle activity of both P and S follicles was high from February to March and low from June to July (Fig. 1). However the rate and timing of follicle activity changes varied considerably between animals (Fig. 2 & 3). A small decline in P follicle activity was seen in 2 sheep (180 and 183) from October to November and in 5 sheep (176, 178, 190, 191 and 199) from November to December (Fig. 2). This represents a subsidiary, or additional, cycle of shedding and regrowth in some P follicles during early summer. Maximum P follicle activity ranged from 75% - 100% between January and April. Over winter (May to August) P follicle activity

declined in 11 of 12 sheep although the magnitude of the decline varied considerably between sheep (Fig. 2).

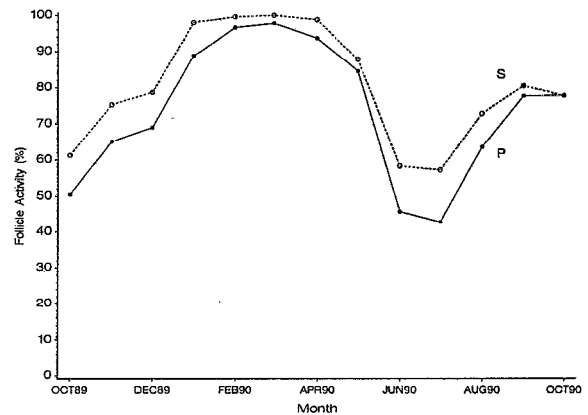


FIG 1 Mean percentage of active follicles in New Zealand Wiltshire sheep (n=12) as estimated from skin biopsies taken at monthly intervals over a 12 month period.

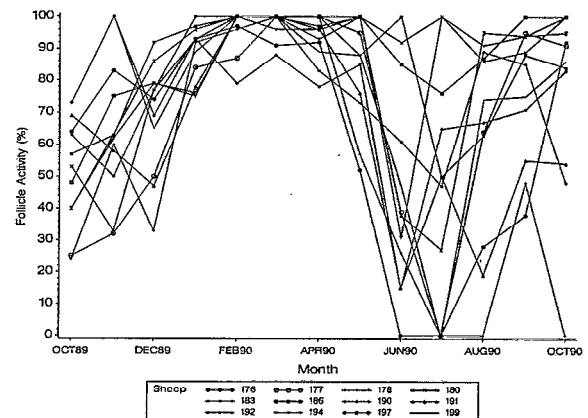


FIG 2 Percentage of active primary follicles in 12 New Zealand Wiltshire sheep, as estimated from skin biopsies taken at monthly intervals for 12 months.

Follicle activity in S follicles followed a similar pattern in most sheep with a slow increase from October to January (Fig. 3). A subsidiary cycle in S follicles was noted in 2 sheep (177 and 190) in December. All follicles were active (*viz.* 100%) in all 12 sheep in March (Fig. 3). Over the period from June to August, S follicle activity stayed high in some sheep and declined

in others and based on this there were 3 apparent groups of sheep. These groups, named as types "A", "B" and "C" (for ease of identification but not as statistical categories), had the following characteristics: A - very low follicle activity between June and August; B - maintained high follicle activity between June and August; and C - showed a decline to about 50% follicle activity between June and August (Fig 3). Four sheep had very low S follicle activities ($14\% \pm 10\%$) with the majority of follicles in telogen; 6 sheep maintained very high S follicle activity ($93\% \pm 7\%$) and 2 sheep showed an approximate 50% decline in S follicle activity ($56\% \pm 11\%$), over the period from June to August.

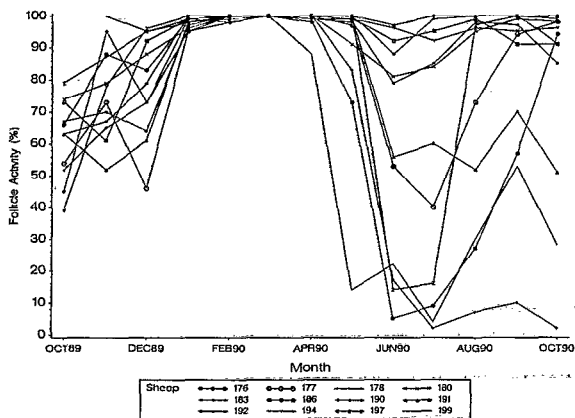


FIG 3 Percentage of active secondary follicles in 12 New Zealand Wiltshire sheep, as estimated from skin biopsies taken at monthly intervals for 12 months.

Shedding Scores

Shedding progressed in the same bilateral pattern on all sheep and began at the neck, tail area and belly and moved towards the middle and back of the sheep so that the last part to shed was the dorsum. Partial shedding was characterised by the retention of a patch of dorsal fleece for the duration of the trial.

Sheep shed at different rates and the final extent of shedding as at February 1990 (when shedding appeared to have stopped) ranged between 45% and 100%, with 10 of the 12 sheep having lost 78% or more

of their fleece (Fig. 4). The final extent of shedding in February was highly correlated with the shedding score in early October ($P < 0.005$, Fig. 5).

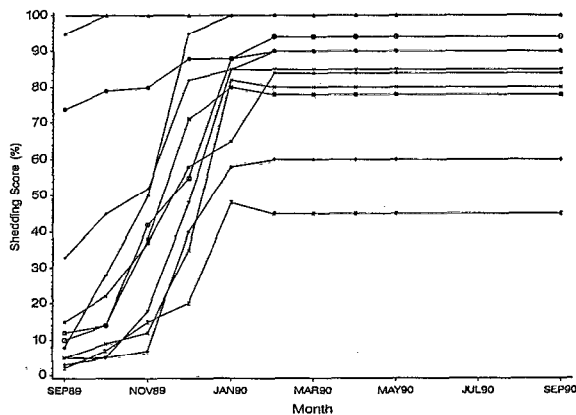


FIG 4 Shedding scores (percentage of body area denuded) in 12 New Zealand Wiltshire sheep as estimated monthly over a 12 month period.

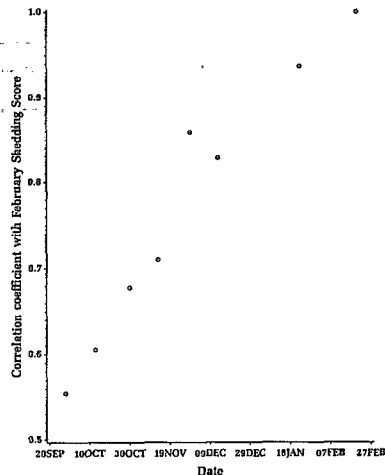


FIG 5 Correlation between spring and summer (Oct - Jan) shedding scores (1989) and shedding score on 27.2.90.

DISCUSSION

The results from the present study concur with those previously reported for Wiltshire Horn sheep in Britain

(Ryder, 1969). Ryder followed the follicle activity cycle over 2 years in 3 Wiltshire Horn ewes maintained on pasture and found that both P and S follicles were highly active from September to March (after converting to the seasonally equivalent Southern Hemisphere months). From March to April both primary and secondary follicles began to enter catagen. By June, almost all follicles were in telogen. The extent and duration of the telogen phase reported by Ryder is longer than that found in the present study, by about 2 months. Four sheep in the present study showed the low levels of S follicle activity reported by Ryder. The decline in primary follicle activity seen in the present study in November and December 1989, was also observed by Ryder (1969). Ryder concluded that these were subsidiary cycles where a proportion of follicles replaced their fibres without a visible moult. In contrast to Ryders comments, the present study showed that a secondary, partial shedding of the fleece was exhibited in sheep showing subsidiary follicle activity cycles.

The bilateral pattern of fleece shedding seen in the present study was similar to that observed in previous British and Australian studies. In the Wiltshire Horn shedding began on the belly in October and continued up the flanks towards the back (Slee 1965, Ryder 1969). By December or January shedding was complete. Similarly Williams and Mullaney (1980) reported that wool shedding in adult Wiltshire-Merino crosses began on the neck, chest and shoulders, then spread across the belly and breech. The last stage of moulting was up the flanks to the back and rump.

Shedding is thought to be caused by the growth of new fibres but the physiological basis of this phenomenon is not known (Slee, 1965; Ryder 1978). Slee (1963) found that in nearly all of 160 Wiltshire Horn lambs studied between 1954 and 1961, the birthcoat was shed in the same chronological order as the embryonic follicle initiation and suggested that the differential response to environmental cues was affected by the degree of maturity of the wool follicles. In the present experiment, increases in the shedding score followed increased follicle activity but shedding was not an accurate indication of the timing or length of the proanagen phase.

In crosses of the Wiltshire Horn with non-shedding breeds, the extent of shedding depends on the proportion of Wiltshire Horn genes present (Slee 1959,

Williams and Mullaney, 1980). The final extent of shedding ($84\% \pm 17\%$) in the present trial is consistent with these sheep being approximately three-quarter Wiltshire Horn (Slee, 1959; Williams and Mullaney, 1980).

The high correlation between shedding score in October and shedding score in February shows that early estimates of shedding are representative of the final extent of shedding.

CONCLUSIONS

A suitable sheep model for studies of the control of seasonal wool growth would have 100% follicle activity in summer and 0% in winter. All the Wiltshires studied had high levels of follicle activity in summer. Four of the 12 sheep had very low follicle activity scores in winter.

Some New Zealand Wiltshire sheep are suited for studies of proanagen but they need to be selected by histological estimation of follicle activity in skin biopsies collected in June, July and August. Follicle activity cycles have been demonstrated to vary considerably between Wiltshire ewes and are also likely to vary with the environment and between years. The current MAF Technology fibre physiology research programme incorporates further studies of the effects age, environment and individual animal, on the variation in follicle activity. The manipulation of follicle activity by photoperiod is the focus of the next stage of research.

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