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WOOL SHEDDING AS A TRAIT FOR GENETIC IMPROVEMENT USING MARKER ASSISTED SELECTION?

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SUMMARY

Data were available on the shedding ability of a New Zealand Wiltshire flock. 4123 shedding records collected annually in August/September, December and January from 844 different individuals were available. The repeatability of August/September shedding scores was low (0.20 ± 0.110), whereas the repeatability of December and January scores was moderate (0.47 ± 0.032 and 0.66 ± 0.025 respectively) and increased with the exclusion of lamb scores (to 0.55 ± 0.038 and 0.81 ± 0.019 respectively). These results indicate that scores recorded on lambs do not fully reflect their adult shedding potential and ultimate shedding within a season is not achieved until at least January. The heritability of January shedding score was 0.60 ± 0.089 when lamb scores were excluded. Given full expression does not occur until after selection of replacements would normally be carried out, and there is strong evidence for genetic control, shedding is an ideal trait for QTL studies and ultimately marker assisted selection.

INTRODUCTION

Marginal returns for mid to high micron fleeces are diminishing as wool prices decline and shearing costs rise. This combined with increased ethical considerations around "daggy" sheep, has led to increased interest in sheep that can shed their wool. Literature from England indicates that adult Wiltshire Horn (WH) sheep are capable of fully shedding their fleece on an annual basis (Slee, 1959), although there is variation in the lambs (Slee, 1963). Slee (1959) also demonstrated, using various crosses between WH and Blackfaces (first cross, second cross, backcross etc), that genetic variability in shedding related to the proportion of Wiltshire Horned genes.

The majority of New Zealand Wiltshires (NZW) are polled resulting from the crossing of WH to the Poll Dorset to remove the horns (Parry *et al.* 1991). This has resulted in variation in the shedding ability of NZW. A flock of research NZW which have been divergently selected for fleece weight since 2003, as a predictor of shedding, exhibit variation in shedding ability. Sufficient data were available from this flock to provide estimates of the repeatability and heritability for shedding.

MATERIALS AND METHODS

The flock of NZW were run on a research property near Ashburton, New Zealand (latitude 43.53° S and longitude 171.48° E). The flock consisted of 5 family lines. Within each family divergent selection for fleece weight, as a predictor of shedding, has been carried out since 2003. Lambing commences mid-September, with weaning mid-January. All ewes 1 year and older are run together except during mating in April, with ewes and rams under 1 year of age kept in separate mobs. Shedding scores are made in December and January for lambs, September, December and January for hoggets and in August, December and January for ewes. A shedding score of 0-5 was developed by

Denis O'Connell and Murray Ashby (AgResearch) using the distinct pattern with which the fleece is shed, details of which are in Table 1.

Table 1. Scoring system for assessing fleece shedding in New Zealand Wiltshire sheep

Shedding Score	Description
0	No shedding from any part of the body
1	Wool shed fully from belly only (and in some instances neck)
2	Wool shed fully below midline (may exclude the rump region)
3	Some shedding above midline in addition to 2 (may exclude rump region)
4	Wool shed fully from all body (including the rump region) except for a strip along the spine approximately 10 to 15cm wide
5	Wool shed fully from all of the body

Data were available from 844 different individuals with a total of 4123 records. The number of observations per shedding score and age are in Figure 1. The current flock was established in 1989 and shedding records began in 2003 for all ages present.

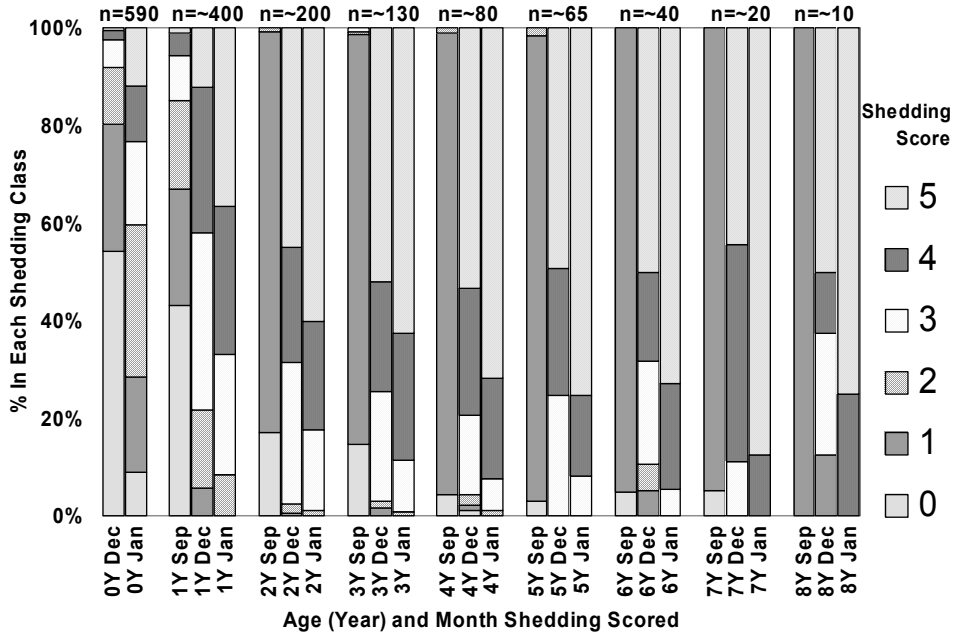

Figure 1. Distribution of raw shedding scores for a flock of New Zealand Wiltshire sheep. 0=no shedding – 5=full shedding, n=number of measurements per age/month

Variance components were estimated for September, December and January shedding scores using a repeated measures animal model in ASREML (Gilmour *et al.*, 1999). Two models were fitted for

each month, including and excluding lamb scores. Fixed effects fitted for both models included age of the animal when the score was made (0-8), the year the score was made (2003-2007), the fleece weight selection line (high or low), and family (1-5). The repeatability between December and January shedding scores was also estimated. Average weaning weight of lambs within each shedding score was analysed using the GLM Procedure in SAS (SAS Institute, Cary, NC). Fixed effects fitted were year born, shed score and family-line with birthday deviation fitted as a covariate.

RESULTS AND DISCUSSION

Unlike the purebred WH in England, not all adult NZW entirely shed their fleece. The shedding that does occur follows a particular pattern which has enabled a scoring system to be developed. The pattern of shedding appears to correspond with the pattern of follicle development in the fetal sheep (Slee, 1963), such that the belly and neck are the first to shed, with a progressive shedding up the body of the sheep, with the region around the spine the last to be shed. The wool in the region of the rump also seems to be among the final areas to shed wool. The appearance of animals within any given score is fairly uniform because shedding is caused by parts of the fleece peeling off as units in a bilaterally symmetrical pattern, rather than a diffuse loss of fibres (Slee, 1963).

Wiltshires undergo follicle growth cycles (Parry *et al.* 1991; Parry *et al.*, 1995), in contrast to breeds such as the Romney and Merino whose follicles grow continuously (Rogers, 2006). These cycles are controlled by changes in photoperiod, acting through seasonal variations in secretion of the pituitary hormone prolactin (Pearson *et al.*, 1996). The early spring (September) onset of shedding observed in this flock is in line with that observed in English WH in that shedding starts in spring (Slee, 1959) and continues through mid summer. There was between animal variation in the exact timing of the onset of shedding, as illustrated in Figure 1, despite all being subject to the same photoperiod conditions. The proportion of animals shedding increased from September to December to January. Although the genetic correlation between the December and January scores was extremely high (Table 2), the phenotypic correlations between these two months were lower suggesting an environmental influence. This, combined with the higher heritability estimates for the January scores, suggests that the maximal shedding scores for all sheep were not achieved until January (or later) in each year, although some had achieved their maximal score in December.

Another observation is that full expression of an animal's ability to shed does not occur as a lamb, with very few lambs achieve a high shedding score (Figure 1). As the animals aged, there was an increasing proportion fully shedding (despite a high fleece weight selection line being maintained). This observation was further supported in that exclusion of lamb scores from the analysis resulted in a considerable lift in the heritability and repeatability values, particularly for the January measurements. These observations are in agreement with those of Slee (1959) and Rathie et al. (1994) who showed that full expression of shedding did not occur in lambs. Slee (1959) suggests that lambs must reach a certain age and or weight threshold for shedding to commence and that the ultimate extent of shedding depends on when shedding commenced. This hypothesis is supported by an analysis of the current data set which shows that lambs that achieved a shedding score of 4 or 5 at weaning were significantly heavier, independent of age ($P<0.01$), than those in any of the other 4 scores and that those lambs that had a shedding score of 0 were significantly lighter ($P<0.001$).

The heritability values suggest that there is a high genetic component to this trait, with potentially a limited number of genes controlling expression. Although we found no published heritability

estimates, the work of Slee (1959) demonstrated that the ability to shed was significantly linked to the proportion of WH genes the animals were carrying and was therefore heritable.

Table 2 Heritability and repeatability estimates (± std error) within and between year/s for shedding scores in a flock of New Zealand Wiltshires

	Including Lambs	Excluding Lambs[1]
Heritability		
September Scores	0.15 ± 0.058	-
December Scores	0.30 ± 0.056	0.47 ± 0.074
January Scores	0.52 ± 0.063	0.60 ± 0.089
Repeatability Between Years		
September Scores	0.41 ± 0.048	-
December Scores	0.51 ± 0.031	0.62 ± 0.035
January Scores	0.70 ± 0.024	0.84 ± 0.017
Correlation between Dec and Jan Scores		
Phenotypic	0.68 ± 0.020	0.78 ± 0.019
Genetic	0.93 ± 0.300	0.99 ± 0.017

[1]There were no shedding scores recorded on lambs in September

CONCLUSIONS

Within the flock of New Zealand Wiltshires studied there was considerable variation in their shedding ability. Shedding is an event that is controlled by photoperiod. Ultimate shedding does not occur until mid-summer, at which time the shedding scores have their highest heritability and repeatability. As such, any selection based on shedding would be the most effective using the January scores. Lambs do not fully express their genetic potential to shed, likely through mechanisms associated with age and weight. From the age of 1 year, the heritability and repeatability of January shedding scores is high. Shedding appears to be under strong genetic control, specifically related to Wiltshire Horned genes. Full expression does not occur until after selection of replacements would normally be carried out, and there is strong evidence for genetic control. Shedding is therefore an ideal trait for consideration for marker assisted selection.

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