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Wool shedding and lamb fleece weights: first-cross and backcross Wiltshire–Romney sheep scored at lamb, hogget and two-tooth ages

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ABSTRACT

With decreasing wool values, interest is increasing regarding shedding sheep. To investigate this, two long-term studies introducing Wiltshire genes into Romney flocks were initiated. Data from these two studies provide phenotypic relationships between a range of shedding scores at different ages. The data included shedding scores (on a 0–5 scale) repeated on lambs (~5 months), hoggets (~14–18 months) and two-tooths (~27 months), and lamb fleece weights. Positive relationships between shedding scores on the same animals were observed. Lamb fleece weight was negatively correlated with all shedding scores. Lamb shedding score in February had a correlation of 0.54 ($P < 0.001$) with the February score as a hogget at Riverside farm. Scoring wool shedding is a laborious activity requiring individual animals to be scored in the shearing position. Therefore, lamb fleece weight was investigated for its relationship with shedding scores, as a potentially easier alternative. Lamb fleece weight had a greater correlation with February hogget shedding score than with the lamb shedding score (−0.76 vs −0.52, $P < 0.001$). This study indicated that February scores are an accurate predictor of future shedding phenotypes, and when used in conjunction with fleece weight, are a good predictor of phenotypes expressed at later ages.

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Introduction

Market prices in New Zealand for strong and medium (mean fibre diameter >30 μm) wool have been steadily declining since 1990, to the extent that the value of the harvested fleece is now below the cost of shearing for many farmers (Beef + Lamb NZ 2022). Wool now represents less than 10% of income for many sheep and beef farmers (Beef and Lamb NZ 2022). During the long-term decline in wool value, the selective focus of sheep breeding has shifted to lamb production (Johnson et al. 2021; Moloney et al. 2023). The majority of the New Zealand sheep industry presently comprises Romney-based

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breeds (Romney, Romney composites and crossbreds), producing wool between 33 and 37 μm mean fibre diameter (Beef + Lamb 2022). Therefore, low wool returns can be a significant factor for a large portion of the industry.

Farmers are increasingly interested in selection policies that decrease fibre diameter or that replace existing breeds with self-shedding or hair breeds (Farrell et al. 2020a; Farrell et al. 2020b; Farrell et al. 2021). The Wiltshire breed has been promoted as an option to rapidly introduce shedding into a flock. It should be noted that the New Zealand Wiltshire is not a pure Wiltshire, due to the usage of other breeds in the grading up process of this breed type (Parry et al. 1991). Shedding is reported to have a high heritability (h^2 ~0.50; Johnson et al. 2007; Vargas Jurado et al. 2016; Vargas Jurado et al. 2020). There is, however, a question of at what age selection should occur (O'Connell et al. 2012). The choice will depend on the correlation between the shedding trait when measured at different ages, at different seasons of the year and in relation to the proportion of Wiltshire genes present. For an effective and rapid transition from a Romney-based non-shedding flock to a fully shedding type, the identification of shedding should occur at as young as possible. It was hypothesised that fleece shedding of lambs would be indicative of their lifetime shedding scores. This study quantified lamb fleece weights and the shedding score of first-cross and backcross Wiltshire sheep as weaned lambs, hoggets and two-tooth ewes, either in November–December or January–February.

Materials and methods

The first experiment was carried out at Riverside Farm, Massey University (40°50'31"S 175°37'04"E), 11 km north of Masterton, New Zealand (Corner-Thomas et al. 2021; 2022), and the second at Limestone Downs Farm, C. Alma Baker Trust (37°28'35"S 174°45'13"E) 14 km south of Port Waikato, New Zealand. All animal procedures were carried out with the approval of the Massey University Animal Ethics Committee (20/44, 22/15, 23/33).

The Riverside study started in 2020 with the mating of Romney ewes with Wiltshire rams to generate progeny. Each subsequent ewe generation was then backcrossed to different pure-bred Wiltshire rams to generate successive cohorts representing ½ Romney ½ Wiltshire (born 2020) ¼ Romney ¾ Wiltshire (born 2021) and $^{1}/_{8}$ Romney $^{7}/_{8}$ Wiltshire sheep (born 2022) (Corner-Thomas et al. 2021; 2022).

The Limestone Downs study began in 2021 with Wiltshire rams being bred to Romney-based ewes to generate first cross ½ Romney, ½ Wiltshire rams and ewes (born 2021). Animals at Riverside were scored for shedding at 5–6 months of age (lamb shedding score), 14–15 months of age (hogget shedding score (early), 17–18 months of age (hogget shedding score late) and 27–28 months of age (two-tooth shedding score). Animals at Limestone Downs were scored at 5–6 months of age and 14–15 months of age.

Scoring of the degree of fleece shedding was undertaken by trained personnel (1–2 per event, recorded as scorer contemporary group) using the shedding score (0–5 with increments of 0.5; no shedding to full shedding) method of Johnson et al. (2007) and O'Connell et al. (2012). This shedding scoring was undertaken each November and January/February at Riverside, and in February and December 2022 at Limestone Downs (Table 1). At Riverside, lamb fleece weight was recorded at the animals first shearing

Table 1. Scoring timing for each location and each cohort.

Location	Riverside			Limestone Downs
Proportion of Wiltshire genes	½ Wiltshire	¾ Wiltshire	$^{7}/_{8}$ Wiltshire	½ Wiltshire
Year of birth	2020	2021	2022	2021
Lamb fleece weight (kg)	February 2021	February 2022	February 2023	–
Lamb shedding score	January 2021	January 2022	February 2023	February 2022
Hogget shedding score	November 2021	–	–	December 2022
Hogget shedding score	February 2022	March 2023	–	–
Two-tooth shedding score	November 2022	–	–	–

½ Wiltshire = ½ Wiltshire ½ Romney, ¾ Wiltshire = ¼ Romney ¾ Wiltshire, 7/8 Wiltshire = 1/8 Romney 7/8 Wiltshire. Lambs are approximately 5 months of age, Hoggets are approximately 14 months (November/December) or 19 months (February/March) of age, Two-tooths are approximately 27 months of age.

(approximately 5 months of age) by weighing the entire harvested fleece after the shedding score had been assessed.

Statistical analysis

All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, USA). Correlations between lamb shedding score (January/February), lamb fleece weight, hogget shedding early (November, December), hogget shedding late (February, March), and two-tooth shedding score (November) were conducted within farm using the Corr procedure.

For the analysis of post-lamb shedding score from Riverside farm data, the GLM procedure with the fixed class effects of lamb shedding score, proportion of Wiltshire genes and scorer contemporary group and the covariate of lamb fleece weight was used. Lamb fleece weight of ewe lambs was analysed in a model that included fixed class effects of lamb shedding score and scorer contemporary group. Birth rank was reported as a potential factor in O'Connell et al. (2012); however, this was not significant in this analysis and was removed. Lamb fleece weight was included to test if that alone could be used to predict shedding level.

For the Limestone Downs, the data were analysed using a GLM procedure including the fixed effect of the shedding score February 2022, lamb sex and scorer contemporary group.

Results

Mean shedding score by age, proportion Wiltshire genes and location and lamb fleece weight are presented in Table 2.

Mean fleece weight decreased with increasing proportion of Wiltshire gene in the Riverside flock from ½ Wiltshire to ¾ Wiltshire or $^{7}/_{8}$ Wiltshire; however, there was no significant difference between ¾ and $^{7}/_{8}$ groups. Additionally, there was an increase in the average shedding score in lambs, from 0.36 to 1.55 when moving from ½ Wiltshire to $^{7}/_{8}$ Wiltshire. Riverside and Limestone Downs did not differ ($P > 0.05$) in mean shedding score of ½ Wiltshire animals. February scores were numerically higher than the November scores at Riverside, but they were not significantly different ($p > 0.05$).

Lamb fleece weight and lamb shedding score in February (approximately 5 months) was negatively correlated (−0.52; $p < 0.001$), as was lamb fleece weight and hogget

Table 2. Raw mean and standard deviation (SD) for shedding scores, lamb fleece weight by location, animal age and the proportion of Wiltshire genes.

Location	Riverside						Limestone Downs	
Proportion of Wiltshire genes		½ Wiltshire		¾ Wiltshire		$^{7}/_{8}$ Wiltshire		½ Wiltshire
	n	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD
Lamb fleece weight (kg)	236	1.75 ± 0.24	253	1.05 ± 0.45	32	1.17 ± 0.44		–
Lamb shedding score	237	0.36 ± 0.46	266	1.19 ± 1.06	35	1.55 ± 0.94	1654	0.68 ± 0.69
Hogget shedding score	234	0.86 ± 0.68		–		–	1124	0.83 ± 1.02
Hogget shedding score	231	1.27 ± 0.87	100	3.61 ± 1.24		–		–
Two-tooth shedding score	215	1.13 ± 0.89		–		–		–

n = number of animals, ½ Wiltshire = ½ Wiltshire ½ Romney, ¾ Wiltshire = ¼ Romney ¾ Wiltshire, 7/8 Wiltshire = 1/8 Romney 7/8 Wiltshire. Lambs are approximately 5 months of age, Hoggets are approximately 14 months (November/December) or 19 months (February/March) of age, Two-tooths are approximately 27 months of age.

score in March (approximately 18 months) (−0.76; $p < 0.001$). The relationship was weak between lamb fleece weight and November hogget shedding scores (approximately 14 months) (−0.16; $p < 0.015$). The relationship was also weak for two-tooth animals (approximately 27 months) and the lamb fleece weight (−0.25; $p < 0.001$). Hogget score in November had a greater correlation with the March hogget score (0.73; $p < 0.001$) and the score as a two-tooth (0.70; $p < 0.001$), than was observed from the lamb score (0.39; $p < 0.001$), or between the lamb score and February hogget score (0.54; $p < 0.001$) or the lamb score and the two-tooth score (0.47; $p < 0.001$). The Limestone Downs correlation between the lamb and hogget shedding score was similar (0.69; $p < 0.001$) to those seen at Riverside.

The regression of either of the two hogget scores (either November (14 months) or February (18 months)) on lamb score at Riverside was positive. However, at greater scores the variance increased and a lamb score of 2 overlapped in its prediction with a lamb score of 3 (Figure 1). Indicating that lambs scored as a 3 in January (5 months) were scored either 2 or 3 at the March hogget (19 months) scoring event. Differences in the number of lamb scores seen in Figure 1 are due to the hogget scores in November only being conducted on the first cross animals at Riverside, the same applies for the two-tooth scores.

At Limestone Downs, the regression of lamb and hogget shedding scores was also positive, indicating that higher lamb scores were related to higher hogget scores (scores recorded in February (5 months) and December (15 months) of the same year). However, the same trend at greater scores was noted for these animals, with lamb shedding scores over 4 having a significantly greater variance of hogget score than those at 3 or below.

As the proportion of Wiltshire genes increased (Riverside), there was a shift in the proportion of animals in each shedding score towards higher values, this shift in the mid-score point is presented in Figure 2. For hogget scores, there was a shift from 55% for the ½ Wiltshire animals having a score at or below 1–50% of the ¾ animals having a score greater than 4.

Discussion

The results of the current two studies indicate that a high level of lamb shedding is a useful selection tool for farmers looking to identify adult animals which will have a

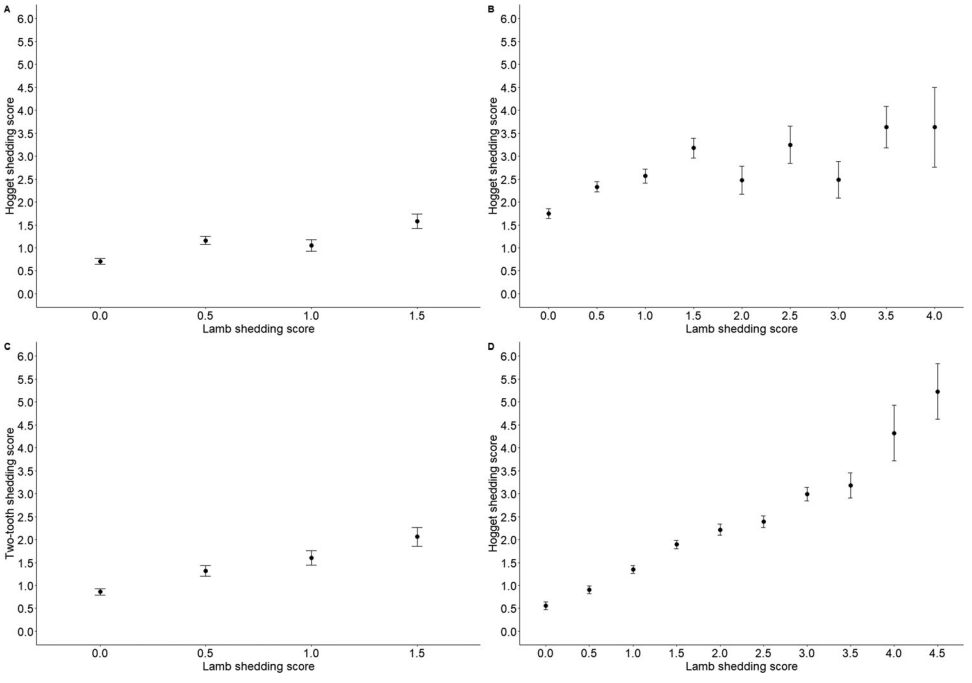

Figure 1. LSMean and SEM for shedding score (a). Lamb score (approximately 5 months) to hogget score in November (approximately 15 months) at Riverside (b). Lamb score to hogget score in March (approximately 19 months) at Riverside (c). Lamb score to two-tooth score in November (approximately 27 months) at Riverside (d). Lamb score in February (approximately 5 months) to hogget score in December (approximately 15 months) at Limestone Downs.

greater fleece shedding. The inclusion of the lamb fleece information within the Riverside trial increased prediction accuracy of scores at older ages. As sheep farmers look to decrease their farming costs, there is now the potential to incorporate the shedding scoring system described here and in previous research (Johnson et al. 2007; O'Connell et al. 2012) to efficiently transition to a shedding flock.

As more animals are scored the trend becomes clearer, similar to the genetic correlations reported by previous studies (O'Connell et al. 2012; Vargas Jurado et al. 2020), in part some of this trend may be due to a reduced influence of scorer errors. This was evident in the larger flock at Limestone Downs flock, where there were almost 1200 more animals being scored in the ½ Wiltshire generation. These numbers would be achievable for many New Zealand sheep farmers. The scores from both the lambs and their subsequent hogget score could be used in the following January/February to generate a high confidence in the selection of shedding sheep. This is similar to the advice given by Johnson et al. (2007).

The scoring system utilised in this study is easy for farmers to implement, either themselves or by observing the flock during shearing and/or dagging. The score can be utilised to very quickly remove the animals which have scores of 0.5 or lower. If the rate of transition is to be maximised, the lambs which demonstrate more pronounced shedding in January/February, when shedding is at its peak (Johnson et al. 2007), can be preferentially

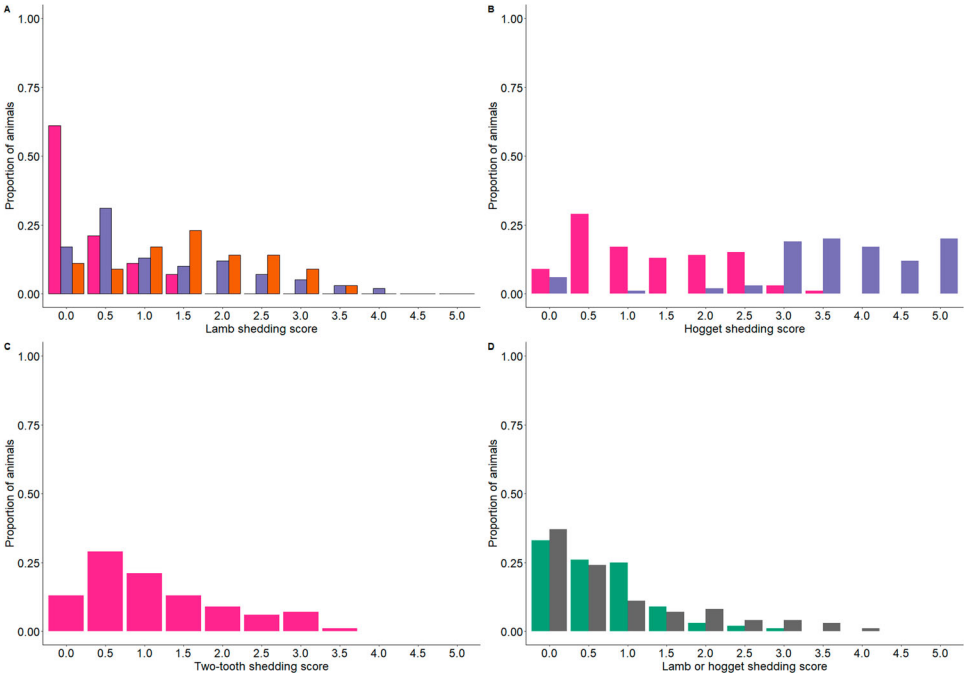

Figure 2. Proportion of animals with each shedding score as (a). Lambs scored in January/February (approximately 15 months) at Riverside farm (b). Hoggets scored in February/March (approximately 19 months) at Riverside farm (c). Two-tooths scored in November (approximately 27 months) at Riverside Farm (Pink columns – 1/2, Purple columns – 3/4, Orange columns – 7/8) (d). Lambs (approximately 5 months) (Green columns) and Hoggets (approximately 15 months) (Grey columns) scored in February and December at Limestone Downs.

fed to increase their growth rates and increase the chance that they can be utilised for mating to lamb as hoggets.

One major driver of the conversion to a shedding flock will be the ability to generate income to offset costs, which is a future focus of this wider study. As fleece weights decrease with increasing Wiltshire introgression, it does not immediately remove the requirement to undertake shearing. This is an important aspect to investigate as the cost offset argument is dependent on the removal of shearing costs, this is a focus of the Riverside study and will be published in due course. The wool returns will be more negatively impacted by the inclusion of the Wiltshire genes than if the farm remained with a non-shedding phenotype, until the majority shedding score is such that routine shearing is no longer required.

The favourable correlations between the scores across breed proportion and ages indicate that the lamb shedding score is a robust measure for determining the animal's ability to shed its fleece at older ages (Johnson et al. 2007; O'Connell et al. 2012; Vargas Jurado et al. 2020). The increase in score with increasing proportion of Wiltshire has been reported previously; however, the phenotypic correlation with fleece weight has not been reported previously within New Zealand Romney–Wiltshire crossbreds. It is an uncommon trait to measure or report for farmers; however, it would be noticeable from a routine shearing perspective that the lambs with greater proportion of Wiltshire

genes have lower fleece yields. Additional measures could be undertaken to, for example, weigh lambs or ewes prior to shearing, then again afterwards to obtain an estimate of the weight change and therefore the difference in fleece weight. Whilst not standard practice, this could be investigated as a measure which farmers in New Zealand could utilise. However, the work of O'Connell et al. (2012) would indicate that at a high level of Wiltshire genes the difference would be minimal with fleece weights under 500 g.

Additional work will be required to determine the impact of the inclusion of Wiltshire genes on lamb growth rates, carcase yields and lambing rates. It is important to include the meat characteristics as shedding is incorporated into the flock so as to maintain farm income, even with potential to decrease farm cost.

Conclusion

As farmers move to a flock of shedding sheep, there is an increasing drive to be able to determine the most efficient method to determine which animals should be retained. This study indicates that the use of lamb scores in conjunction with either a lamb fleece weight or an early hogget score (in November) will give a high probability that animals with favourable shedding scores as two-tooth animals will be selected.

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