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Inheritance of wear rate in the teeth of sheep

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ABSTRACT

Teeth wear over a 12-month period was measured in young ewes of 9 Romney and crossbred genotypes. Animals of Border Leicester breeding had higher-than-average wear rates and Merino-derived animals showed lowest wear. Genetic variation among genotypes and sires within genotypes accounted for the majority of explainable variation in wear rate. The pooled heritability estimate for teeth wear was 0.46 ± 0.13. After genetic effects, reproductive performance was the next largest factor affecting wear rate. Timing of tooth eruption and incisor occlusion each accounted for very little of the variation in teeth wear observed.

Keywords Sheep's teeth; teeth wear; malocclusion; teeth eruption; sheep breeds

INTRODUCTION

Wear rate is the major culling criterion influencing ewe longevity. It is now well accepted that large geographic and seasonal effects can occur. These are often attributed to mineral availability or grazing management practices, but little has been achieved in the documentation or quantification of the effects. Differences in wear rates between breeds are also often cited by farmers but no trials have been reported comparing breeds in the same environment.

The extent of genetic variation in teeth wear within flocks has likewise received little attention, either in quantification or in assessment of likely cause. Variation in wear rate might be attributable to differential feed intake of animals differing in requirements for maintenance and/or production or could be due to genetic aspects independent of performance measures. If the latter is the case, within-flock selection for reduced teeth wear could result in increased longevity.

EXPERIMENTAL DESIGN

The ewes studied were part of the Strain and Booroola trials at Rotomahana Research Station. They were the daughters of Romney and Perendale ewes and comprised 9 of the genotypes previously observed for age at tooth eruption and reported by Aitken and Meyer (1982). The daughters of Romney ewes were sired by Border Leicester and Booroola rams and rams from 4 Romney and 1 Coopworth strain, while the Perendale-derived ewes were sired by Booroola and Perendale rams. A total of 68 sires were represented in the trial with a range of 4 to 24 daughters per sire. A minimum of 5 sires produced each genotype of ewe.

A dental drill was used to mark the anterior surface of 1 centre incisor in each of about 800 ewes at 21 months of age. The distance from the mark to the tooth wear surface was recorded at the time of marking and measured again 12 months later to assess the amount of tooth wear.

Teeth marking and subsequent measurement of wear occurred during the first and second gestations, respectively. Previous teeth observations on these animals included scoring of teeth angle and measurement of occlusion. Other data routinely recorded in the trials included periodic body weights, wool production and reproductive performance.

The data were analysed by mixed model least squares procedures treating genotypes as fixed and sire/genotype as random. All discrete scores and lambing classes were treated as fixed effects with continuous variables such as body and fleece weights entering the models as covariates. Heritability was estimated on a pooled within-genotype basis.

RESULTS

Both overall and least squares means for teeth wear are shown in Table 1 for the 9 genotypes. The least squares means were derived from the model shown in Table 2 which simultaneously fitted the variables listed, hence the breed values are adjusted for variation in body weight, reproductive performance, etc. Teeth wear averaged 3.7 mm, an unexpectedly high amount of wear for a locality where excessive wear is not reported to be a problem.

Results of the least squares analysis are given in Table 2 showing the statistical significance of variates included in the model. Preliminary analyses examining the independent effects of number of lambs born and number weaned indicated that reproductive performance affected teeth wear rate only through number of lambs weaned. Other variates analysed and subsequently dropped from the model as having minimal influence on permanent incisor wear included fleece weight, scores and measurements taken on deciduous teeth and time of eruption of the second and third incisor pairs.

TABLE 1 Mean teeth wear (mm) over a 12-month period.

Sire breed	No.	Overall	L.S.[1]
Romney A	73	3.4	3.6
Romney B	72	3.4	3.5
Romney C	72	3.8	3.9
Romney D	108	3.5	3.5
Coopworth	70	4.4	4.2
Border Leicester	72	4.1	4.1
Booroola (× R)	87	3.7	3.5
Perendale	104	3.9	3.9
Booroola (× P)	83	3.3	3.2

[1] Least squares means.

TABLE 2 Least squares analysis of teeth wear.

	d.f.	Sig.	% variance increase[1]
Main effects			
Breed	8	***	–)) 21
Sire/breed	59	***	12)
Teeth angle	1	***	3
No. lambs weaned	2	***	4
Two-tooth eruption	1	**	1
Covariates			
Occlusion	1	*	< 1
Two-tooth weight	1	*	< 1

[1] % increase in residual mean square if term deleted from model.

The model accounted for 23% of the total phenotypic variation present, i.e., $\sigma_E^2/\sigma_P^2 = 0.77$. An approximate measure of the relative importance of each term in the model was calculated as the % increase in the residual mean square due to deletion of that term from the model. The range of effects (Table 2) was from less than 1% for measures of teeth occlusion and body weight to 12% for sire/breed and 21% for the combined genetic variables, sires and breeds.

Unadjusted mean wear rates for the 9 genotypes ranged from 3.3 to 4.4 mm. Following adjustment for the variables included in the model, the means ranged from 3.2 to 4.2 mm. The major non-genetic factor which affected wear rate was number of lambs weaned. Mean wear rates for ewes weaning 0, 1 and 2 lambs were 3.5, 3.7 and 3.9 mm, respectively.

Three other teeth characteristics were included in the analysis of teeth wear rate. Age at eruption of the first pair of incisors, taken as being younger or older than 460 days, had an effect ($P < 0.01$) on amount of wear. Ewes with early eruption averaged 3.9 mm of wear *v* 3.6 for ewes erupting after 460 days of age. Angle of incisors relative to the plane of the jaw also had a significant ($P < 0.001$) effect. Ewes with teeth deflected inwards relative to the jaw plane showed a mean wear of 3.6 mm compared to 4.0 mm for ewes with teeth normal to the jaw plane. Teeth occlusion, measured as the distance from the anterior edge of the tooth cutting surface to the front of the pad, had a very small but significant ($P < 0.05$) effect. The regression coefficient was negative, i.e., increasingly undershot animals showed marginally increasing wear. The heritability estimate for teeth wear was 0.46 ± 0.13.

DISCUSSION

Genetic factors accounted for most of the explainable variation observed in teeth wear rate. Border Leicester-derived animals were at the high end of the wear rate scale and Merino-derived animals were at the low end with Romneys and Perendales intermediate. These results are in agreement with observations at Tokanui Research Station (W. M. Aitken and J. L. Dobbie, unpublished).

Considerable variation was observed amongst sires within breeds. The coefficient of variation for half-sib group means within genotype ranged from 11 to 14% except for the ewes sired by Ruakura High Fertility rams (Romney 'B') at 7%. The reduced variation among RHF half-sib groups is no doubt a reflection of the long-term closed-flock selection history of the flock.

Previous studies of teeth wear have been primarily concerned with the causative factors of excessive wear. Most have been based on survey data rather than designed trials and have measured teeth length, *per se*, rather than rate of teeth wear. Since teeth erupt from the jaw as wear occurs, the length of the protruding teeth, at least in relatively young sheep, is not a reliable indicator of teeth wear.

Barnicoat (1957), in an extensive review of the likely factors leading to excessive wear in Romneys, concluded that the quality of New Zealand sheep mouths had progressively deteriorated over the previous 30 to 40 years, largely due to the change to ryegrass and increased stocking rates. Sheep with undershot jaws (which he thought to be strongly inherited) exhibited more worn teeth than those not undershot. Healey and Ludwig (1965) on the other hand, attributed variation in wear rate to amount of soil ingested and concluded that neither breed differences nor malocclusion of jaws appeared to be involved.

The observed effects of lamb-rearing status and body weight on teeth wear strongly suggest that increased feed intake necessary for higher levels of performance or maintenance contribute to increased wear rates. Limited data from Barnicoat (1957) indicate that teeth wear rate of ewes is highest in spring, coinciding with greatest lactational demands and feed availability. Different lamb-rearing requirements would be likely to accentuate any such seasonal effect.

Amongst the various teeth characteristics which had been recorded previously, angle of the teeth relative to the lower jaw had the greatest effect on teeth wear. Teeth angled inwards had less wear than teeth normal to the jaw plane, a finding difficult to explain when considered independent of occlusion. The effect of undershot jaws was in the direction reported by Barnicoat (1957) but of a much smaller magnitude. The very small effect of occlusion on wear rate supports the findings of Purser *et al.* (1982) who reported a negligible effect of occlusion on any of several performance measures for Scottish Blackface ewes. We concur with them that culling of ewes or rams on the basis of minor variations from 'normal' tooth placement is unlikely to genetically improve performance.

The effect of age at tooth eruption on wear rates might be explained by the longer period of wear prior to initial tooth marking for earlier erupting ewes. It has been suggested that the hard surface enamel is largely worn away within the first 2 months exposing the somewhat softer (and probably faster-wearing) dentine. Thus, the faster wear observed for early erupting ewes may have been the result of wear differences over the early post-marking period and not characteristic of wear thereafter. Age at four-tooth and six-tooth eruption had a similar effect to two-tooth eruption, possibly due to the same mechanism.

Previous investigations (Barnicoat, 1959) found no differences in chemical composition of high and low wear teeth from different areas, so ascribed the differences to pasture effects. Subsequently Cutress and Healey (1965) compared pasture juices from high and low wear farms but found no differential effects on rate of dissolving exposed tooth dentine.

The results of the present trial do not assist in explaining causative wear factors or wear differences between regions or diets nor do they suggest the nature of possible chemical differences between teeth wearing at different rates. The results do, however, clearly indicate that genetic differences in wear rate do exist, whatever their bases. Moreover, the high heritability observed for teeth wear rate under conditions of moderately high wear indicate that selection could effectively reduce teeth wear rates. Investigations are continuing to relate wear between deciduous and permanent teeth, to examine the seasonal pattern of teeth wear and to relate both wear and malocclusion to peformance and longevity.

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