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SELECTION INDICES FOR PERENDALE SHEEP

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SUMMARY

Improvement in fleece production and the addition of further wool traits to a selection index, containing a fertility trait, hogget body weight and fleece weight, for Perendale sheep was studied. It was concluded that staple length and fibre diameter should be included to arrest unfavourable changes in wool fineness.

INTRODUCTION

A SHEEP'S BREEDING MERIT is determined on the basis of several traits. Each influences the animal's productive value to a varying degree. The problem for sheep breeders is to estimate the total breeding value for each animal so that selection will give the most rapid improvement in total economic value. This is best achieved by using a selection index, constructed so that an appropriate weight is given to each trait according to its relative economic value, heritability and variation, and the genetic and phenotypic correlations between the different traits (Hazel, 1943).

Since 1967, sheep breeders in New Zealand have had available for use a selection index operated by the National Flock Recording Scheme (Clarke, 1967). Possible modifications to this index are presently being investigated by a Technical Committee of Sheepplan (Dalton and Callow, 1975).

Genetic parameters recently estimated for Perendales (Elliott *et al.*, 1976a) indicated the need for consideration of a selection index designed specifically for this breed. There were indications that continued direct selection for fleece weight might lead to economically undesirable correlated changes in quality number and fibre diameter. A study of the effects of incorporating additional wool traits in a selection index designed to control these changes was therefore indicated for it is only by actually deriving selection indices that the relative efficiency of either including or excluding a trait(s) can be estimated (Gjerdrem, 1967a, b, 1968).

METHOD

A series of selection indices appropriate for Perendale sheep were computed using a modified version of the selection index computer programme SELIND described by Cunningham (1969; 1970).

Traits included in the study were the number of lambs weaned by the animal's dam (NLW), and the animal's own hogget body weight (HBW), greasy fleece weight (FW), staple length (SL), fibre diameter (FD), and quality number (QN) records measured at 14 to 15 months of age. The indices were constructed under the assumption that three annual lambing records were available for NLW with a repeatability of 0.3.

TABLE 1: PARAMETERS USED FOR THE CONSTRUCTION OF THE SELECTION INDICES

Traits	R.E.V.	Phenotypic		Parameters ¹					
		S.D.		NLW	FW	HBW	SL	QN	FD
NLW	700.0	0.60	(lamb)	0.12	0.00	0.20	0.00	0.00	0.00
FW	150.0	0.50	(kg)	0.04	0.32	-0.07	0.76	-0.48	0.43
HBW	0.0	3.96	(kg)	0.08	0.39	0.27	-0.06	0.37	-0.02
SL	25.0	1.54	(cm)	0.00	0.44	0.15	0.49	-0.63	0.53
QN	12.5	1.90	(grade) ²	0.02	-0.16	-0.03	-0.45	0.26	-0.46
FD	-20.0	2.30	(μ)	0.02	0.50	0.15	0.34	-0.26	0.54

¹ Heritabilities on the diagonal, genetic correlations above and phenotypic correlations below the diagonal.

² Quality number grade (Agar, 1973).

The statistics used are shown in Table 1. The phenotypic and genetic parameter estimates were calculated by Elliott *et al.* (1976a) apart from those for NLW which were extracted from a wide range of published and unpublished data mainly for New Zealand Romney sheep. When compared with previous estimates from Romney data (Elliott *et al.*, 1967a), the important differences in the Perendale estimates were:

- (1) Lower heritability for HBW and negligible genetic correlations between this trait and the wool traits.
- (2) Higher heritability for FD and medium to high genetic correlations for the associations between FW, SL and FD, indicating a lack of independent inheritance for these traits.

Relative economic values (R.E.V.s) were based on information from Elliott *et al.* (1976b) and the current wool prices as quoted in the minimum floor prices for August 1975 to June

1976 (N.Z. Wool Marketing Corporation, 1975). A premium for finer wool was indicated, with fleece values based on a 3.0 kg fleece of 52's quality number and 30.8 micron fibre diameter.

The relative economic value for HBW was an assessment of the amount by which profitability is increased per unit increase in HBW. Data of a Perendale flock run under hill country conditions (Elliott *et al.*, 1976b) indicated that over the ewe's lifetime a poor relationship existed between hogget body weight and the two most important ewe productive traits, number of lambs weaned and fleece weight. Increases in mean hogget body weight by 1 kg, independent of changes in other traits, was shown to have improved lifetime productivity by 10 to 20 cents. This added production, when combined with an expected increased carcass value due to higher ewe liveweight, was considered to be offset by an expected higher maintenance cost of 5 to 6 cents per annum per additional kg ewe liveweight on hill country (Hight and Dalton, 1974).

Selection indices were first constructed with the object of simultaneously improving FW, SL, ON and FD. Later a study was made of the addition of further wool traits to an index containing NLW, HBW and FW.

To determine the losses from not recording a trait, a series of reduced selection indices were also computed (Cunningham, 1969). In addition restricted selection indices (Cunningham *et al.*, 1970) were calculated to determine the relative economic value which would result in zero genetic change in a trait under index selection.

For each index, the following were derived:

- (1) The weighting factor for each trait measured and included in the construction of the index.
- (2) The "value of each variate" in terms of its contribution to economic response. This is defined as the percentage reduction in overall rate of genetic progress which would result if that variate is omitted.
- (3) The genetic gain for each trait in terms of its response per generation and per standard deviation of index selection for each trait.
- (4) The correlation of the index with the aggregate genotype. The aggregate genotype or breeding value is the sum of the additive genetic values of only those traits included in the construction of the index, multiplied by their relative economic values. The genetic response in aggregate economic merit is proportional to the value of this correlation.

(5) The standard deviation of the index. This is the value in economic units of the genetic gain in aggregate genotype achieved by one standard deviation of selection on the index.

The efficiency of a reduced index relative to the original index can be estimated from the ratio of the standard deviations of the two indices (Cunningham, 1969).

RESULTS

The results are presented in two sections:

(1) *The study of improvement in fleece production* (Table 2).

In selection index I1 the genetic gain for FW, SL and FD are in the desired direction, but unlike FD, the change in QN is toward coarser wool — an unfavourable economic direction.

TABLE 2: SELECTION FOR IMPROVED FLEECE PRODUCTION

Variates	I1	I2	Index		I5	I6
	Variates in the		Aggregate	Genotype		
FW	FW	FW	FW	FW	FW	FW
SL	SL	SL	SL	SL	SL	SL
FD	FD ¹	FD ¹	FD ¹	FD	FD ¹	FD
QN	QN ¹	QN ¹	QN	QN	QN	QN ¹
Value of Variates						
FW	22.0	15.7	13.9	67.2	85.1	23.1
SL	11.5	14.7	17.3	—	—	12.0
FD	26.4	—	—	31.4	—	28.6
QN	0.3	—	3.2	1.0	0.0	—
Genetic Gains ²						
FW	0.106	0.146	0.141	0.086	0.128	0.106
SL	0.423	0.715	0.689	0.197	0.460	0.424
FD	—0.553	0.610	0.557	—0.559	0.407	—0.358
QN	—0.144	—0.405	—0.307	—0.080	—0.258	—0.167
Correlation of Index and Aggregate Genotype						
	0.68	0.48	0.50	0.60	0.41	0.68
Standard Deviation of Index						
	31.7	22.6	23.5	28.1	19.3	31.6
Index Weighting Factors						
FW	61.1	33.8	33.0	76.7	48.3	61.9
SL	11.7	8.5	10.5	—	—	11.0
FD	—11.0	—	—	—10.5	—	—11.2
QN	1.4	—	3.4	—2.2	0.1	—

¹ Variate omitted in forming the reduced index.

² Unit change per generation per standard deviation of selection on the index.

Despite the favourable change in fleece weight by index selection with an aggregate genotype as for index I1, the expected genetic gain of 0.106 kg was 17% lower than the 0.128 kg expected to be achieved by direct selection for FW alone.

The value of variate indicates that QN is of little value in index I1.

It is of interest to note that an index constructed with an aggregate genotype of FW, SL, FD and QN but where only FW and SL are recorded (I2) the genetic gain in FW (0.146) is 0.018 kg (14%) above that for direct selection on fleece weight. However, in this case the genetic gains for FD (+ 0.6 microns) and QN (-0.4 of a grade) are in an unfavourable economic direction. The efficiency of index I2 is also 29% lower than the original index I1.

The importance of SL and FD and the unimportance of QN in index I1 is supported by the results from the reduced indices (I2 to I6).

Index I3 indicates that, by not recording FD, the efficiency of index I1 may be decreased by 26% and that this loss amounts to 8.4 cents per generation per standard deviation of selection on the index. Similarly by not recording SL (index I4) the decrease in efficiency may be 11%, representing a loss of 3.6 cents. By a similar comparison, index I5 indicates that a 39 % decrease in efficiency with a cost of 12.4 cents may occur if both SL and FD are not recorded.

Index I6, which omits to record QN, shows no loss in efficiency when compared with the original index. QN has no value in index I5 where only FW and QN are recorded. A comparison of indices I2 and I3 indicates, however, that the inclusion of QN in an index comprising FW and SL decreases the genetic gains for FD and QN towards coarser wool by 0.05 microns and 0.1 of a grade, respectively; a 3% gain in efficiency occurs which amounts to 0.7 cents.

- (2) *The addition of further wool traits to an index containing a fertility score, hogget body weight and fleece weight (Table 3)*

The value of the variates in index I7 indicates that NLW has a much greater relative importance compared with the wool traits, and that HBW is of minor significance. Both SL and FD are of value in the index which already includes the other three variates.

TABLE 3: SELECTION FOR IMPROVED FERTILITY AND FLEECE PRODUCTION

Variates	Value of Variates		Genetic ² Gains		Index Weighting Factors	
	I7	I8	I7	I8	I7	I8
NLW	29.1	4.8	0.037	0.044	78.5	79.8
HBW	0.3	0.5	0.100	0.158	1.1	1.1
FW	4.7	11.5	0.079	0.063	57.4	52.0
SL ¹	8.0	—	0.351	0.226	14.0	—
FD ¹	8.6	—	—0.118	0.202	—10.0	—
Correlation of index and aggregate genotype					0.32	0.27
Standard deviation of index					48.7	41.9

¹Variate omitted in forming reduced index I8²Unit change per generation per standard deviation of selection on the index.

A comparison of index I7 with its reduced index (I8) indicates that, with an aggregate genotype comprising NLW, HBW, FW, SL and FD, a 14% loss in the efficiency of the index occurs if both SL and FD are not recorded. This amounts to 6.8 cents per generation per standard deviation of index selection.

The low importance of HBW was supported by a reduced index, results of which are not shown. When HBW was omitted a negligible change in the efficiency of the index occurred. This resulted in a decrease in the standard deviation of the index of less than one cent. Similarly, varying the R.E.V. for HBW from +2 to -2 cents made little difference to the conclusions.

It was also shown that for index I7 the R.E.V. needed to stabilize HBW was -3.4 cents. Consequently, the genetic gain for HBW will be positive when R.E.V.s are greater than -3.4 cents. Similarly, the R.E.V. needed to stabilize FD was -16.6 cents indicating that, while the R.E.V. is less than -16.6 cents, the genetic gain in FD will be towards finer wool. For a 3.0 kg fleece this requires a 5.5 cents per micron premium for finer wool.

DISCUSSION

All conclusions about the probable effects of index selection are dependent on the parameters used in constructing the index, and on the relevance of these to the sheep population in question. As an investigation into possible selection indices for Perendales, these studies are of a preliminary nature. They lack precise estimates for the heritability of reproductive performance and the genetic correlations with this trait. Of considerable im-

portance is the need for an accurate estimate of the genetic correlation between fertility and hogget body weight. Clarification on the R.E.V. of hogget body weight to hill country production is also required.

If the assumed relative economic values and parameters used are appropriate, then the following general conclusion appears valid.

For fine-wooled Perendales, a selection index containing NLW, FW, and HBW may be improved by including SL and FD. When both FD and SL are recorded and included in the index it should be possible to hold or even to reduce fibre diameter slightly with little effect on fleece weight.

When additional traits are to be included in a selection index, the extra recording costs need to be considered. The results from this study suggest that staple length and fibre diameter will give sufficient improvement to warrant inclusion in a selection index, particularly for the selection of Perendale rams in élite flocks of Group Breeding Schemes (Hight and Rae, 1970; Rae, 1974), or other key ram breeding flocks.

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