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A review of the importance of wool traits as genetic improvement objectives and selection criteria for New Zealand Romney sheep

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ABSTRACT

Selection objectives for wool characteristics are usually set by analysing past prices, considering the results of processing trials and trying to predict future changes. Deficiencies in the information for setting selection objectives were, until recently, the main problem in calculating selection weightings. The situation has largely been rectified and the major problem now is in translating the objective into index weightings. Variation in the genetic parameters causes great variation in the indices and there are doubts about the accuracy of the estimates of genetic and environmental correlations available.

Recently calculated objectives place more emphasis on fleece weight than earlier formulations. Bulk, colour, length, resistance to cotting and soundness (staple strength) seem sufficiently important to include in the objective but indexes calculated using present genetic parameters usually place little weight on them. The result is that the extra gains from including colour, cotting and soundness in the index will probably not compensate for the work involved. However inclusion of resistance to cotting and soundness in the objective leads to more attention to fleece weight in the index.

Forseeable changes in market conditions seem unlikely to change these conclusions but a different set of correlations or cost/benefit calculations might lead to modifications.

Keywords Romney; sheep; wool; selection objectives; selection criteria.

INTRODUCTION

The New Zealand Romney is regarded as a dual purpose sheep with wool and meat both being important products. Past breeders of these sheep have used selection of replacement rams and ewes to change many traits associated with the qualities of these products and their rates of production. If the selection potential available is to be used for optimum benefits, alternative plans need to be carefully evaluated. This evaluation is far from simple when many traits contribute to the overall value of the benefits from the sheep. The task is made less complex if it is assumed that aesthetic factors are unimportant and that optimum benefits equate with optimum monetary profitability.

The present review will concentrate on wool traits but will not ignore the ways in which other aspects of sheep profitability affect selection for wool.

METHODS OF DETERMINING SELECTION TRAITS AND WEIGHTINGS

When a number of traits contribute to overall profitability it is necessary to decide which traits should be improved and how important each is in

comparison to other traits. The potential contribution of a trait and the attention it should receive in selection is determined by a combination of its economic value, its ability to respond to selection and also by the extent to which it is correlated with other important traits.

Hazel and Lush (1942) defined the 3 major ways in which breeders can improve several traits in the same flock. The modern Romney breeder usually uses 2 of these:

- (1) independent culling levels in which animals not reaching an acceptable level in any one trait (e.g. freedom from pigmentation, foot shape) are culled,
- (2) the selection index (e.g. the Sheeplan index).

The index method is inherently the more accurate (Young, 1961; Turner and Young, 1969), although more difficult to apply. As recording and computing aids develop, however, the difficulties are fading and greater use of indices in making selection decisions can be expected.

Selection Objectives v Selection Criteria

A frequent problem in defining improvement plans has been confusion between objectives and criteria

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(James, 1982a; Morris *et al.*, 1982). The objective is what the breeder seeks to improve. Initially this was a description of the ideal animal, then a list of traits; the recent tendency has been to write the objective in the form on an equation. Many complex questions have yet to be solved in defining selection objectives (see McPherson, 1982; James, 1982b). However, in simple terms, when monetary profitability determines the overall objective, the weight given to each trait is determined by a measure of its economic value.

The selection criteria are the traits which are considered at the time of selection. A particular level of the trait may be necessary before the animal is acceptable or a record of the trait may be multiplied by a weighting factor in calculating the selection index. At times traits which are in the objective are not considered as selection criteria, usually because the response to selection will not match the costs involved. Other traits may be used as criteria although they do not appear in the objective. These traits should be genetically related to the objective, show good response to selection and be easy to assess accurately at an early age. For example, hogget live weight is an important selection criterion in Sheepplan even though it has zero value in the objective. This is due to the genetic and phenotypic parameters used in deriving the index and, in particular the favourable genetic correlations assumed with lambs born, fleece weight and weaning weight.

Sources of Economic Weightings

There are many methods by which economic weights for the objective can be derived. (James, 1982a; McPherson, 1982). Few have been applied to the problem of defining selection objectives in sheep. Those used for assessing the relative importance of different wool characteristics have been reviewed by McPherson (1982) and summarised by Ross *et al.*, (1982). They include:

- (1) analysis of historical prices;
- (2) wool users, comments on effects of traits;
- (3) processing trials.

Ideally all 3 sources of information should be used in defining selection objectives.

Unfortunately, for Romney wools, the data available have not allowed the analysis of the effects of many traits and wool users seldom have a good understanding of the effects of each trait in the components of their blends. Hence economic weights for wool traits other than fleece weight are unreliable. An additional problem is that past values are only of interest through their use in predicting future values when the returns from genetic improvement accrue.

Several authors have shown that small changes in relative economic values usually have little effect on selection weightings and the estimate for a trait

must be very inaccurate before it leads to a major distortion in the selection emphasis (McPherson, 1982; Ponzoni, 1982).

There is some argument about the extent to which objectives should reflect values to the individual farmer as compared to the industry or the nation as a whole. Some argue that, while selection for certain wool quality traits will have little effect on returns to individual farmers, improvements in these traits makes wool competitive with other fibres.

It is sometimes possible to use knowledge of textile procedures and potential requirements to produce wool for an expanding sector of the industry. The best example of this so far has been the development of the Drysdale as an offshoot of the Romney breed (Wickham, 1978). Unfortunately few sheep breeders have the single-mindedness to ignore present realities and select for future possibilities. Such breeders can greatly increase the flexibility of the sheep industry.

Calculation of Selection Weightings

The original method of deriving a selection index used a set of simultaneous equations, which combined the economic weightings, phenotypic standard deviations, heritabilities, genetic and environmental correlations into index weightings (Hazel, 1943). Sheepplan uses a less direct procedure which first derives estimates of the genetic value of each index trait (breeding values), multiplies these by their economic weights to convert them to monetary units with these monetary breeding values being added to give the overall index value. The 2 procedures produce similar answers but the Sheepplan system has the advantage of allowing breeders to vary their economic weightings more readily.

A problem in the calculation of index weightings is that, when several traits are correlated, the solutions become very unstable. Small changes in genetic and/or environmental correlations can lead to large changes in index weightings. This is a major problem when wool traits are being combined into an index. To make the problem worse, estimates of genetic correlations exhibit a high degree of variability which is not readily explainable in terms of the published standard errors. The theoretical basis of these standard errors has always been in doubt and the variability of the correlation estimates intensifies the doubt.

There are even greater doubts about the reliability of genetic and environmental correlations when one of the traits is recorded at 2 or 3 discrete levels (Olausson and Ronningen, 1975; Mao, 1976). Thus correlated changes in number of lambs born or correlated changes in other traits from selection for lambs born cannot be predicted reliably.

These problems with the use of genetic correlations have been recognised by James (1982b)

who stated that direct pathways of genetic improvement should be preferred and that, while index calculations might imply that correlated traits of no economic value should receive considerable attention, to rely too heavily on these was risky.

THE DEVELOPMENT OF ROMNEY SELECTION OBJECTIVES

Early attempts at defining selection objectives for the New Zealand Romney concentrated on visual traits and would not have lead to rapid improvements in productivity (e.g. Morton, 1932).

Rae (1954) first defined a monetary set of objectives for the New Zealand Romney. His relative economic values, based on gross sale prices, highlighted the importance of number of lambs born. Fleece weight and style grade were of equal importance while wool fineness was of slightly lower importance.

Wickham (1966) and Rae (1968) examined wool traits more closely and reached the conclusion that fleece weight was the most important trait. The faults of tenderness, coting and discolouration appeared sufficiently important for some consideration.

In the early 1970's a study group of this society (NZSAP, 1974) gave wool selection objectives and criteria further consideration and related these to other selection traits. The Romney breed was classified into a group producing "general purpose wool". This wool is used mainly for carpets but some is processed into furnishing fabrics and clothing. For this group it was recommended that higher fertility of ewes (including fecundity) and higher fleece weights should be the major selection objectives and selection criteria. Fleece whiteness and improved body growth rate ranked next as objectives and criteria. It was stated that resistance to coting, resistance to tenderness (soundness) plus improved bulk and resilience were important enough to be part of the selection objectives but doubts about genetic parameters meant that no recommendations were made as to the selection criteria which might lead to improvements. It was also suggested that a little attention might be paid to increasing fibre crimp and maintaining medullation and lustre at low levels. It was recommended that, in normal flocks, the few sheep that appear with melanin pigmentation (black spots) and high levels of kemp be culled. Bigham (1975) and Wickham and Bigham (1976) reinforced these recommendations.

Hight *et al.* (1975) presented a selection objective which was used to calculate the index used in the Waihora nucleus flock of the Lands and Survey Department's Romney group-breeding scheme. The relative economic values of this and other objectives may be seen in Table 1.

In 1976 the National Flock Recording Scheme was revamped and renamed Sheeplan. Romney

breeders utilising this scheme are left largely to their own devices in deciding levels at which they will cull for wool quality traits but a numerical selection objective was defined for the major traits. This objective was derived as average gross value of a lamb, a kilogram of lamb live weight at weaning and a kilogram of wool over the 1970-71 to 1974-75 period (Clarke and Rae, 1976, 1977; Rae, 1982).

TABLE 1 Estimates of selection objective weights for number of lambs weaned by the dam (NLW) and weaning weight (WWT) relative to greasy fleece weight (1.00)

Source of estimate	Years of data	Traits	
		NLW	WWT
Rae (1954)	1947-53	5.01	0.17
Hight <i>et al.</i> (1975)	?	5.8	0.1
Clarke and Rae (1976, 1977) (Sheeplan)	1970-75	6.02*	0.26
Taylor <i>et al.</i> (1980)	1979-80	5.4	-
Morris <i>et al.</i> (1982)	1975	3.7	0.1
McPherson (1982)	1976-81	3.53	0.08

* number of lambs born

Taylor *et al.*, (1980) compared the prices of lamb and beef in comparison with wool over 2 decades. During this period the overall trend was for wool prices to increase relative to lamb prices. However there were considerable fluctuations. Wool prices were particularly low relative to meat prices from 1965-66 till 1971-72.

Morris *et al.* (1982) made only brief mention of wool quality traits in defining selection objectives for the general-purpose wool group of sheep but carried out a more detailed investigation of the relativities of number of lambs weaned, weaning weight, slaughter dressing percentage, ewe carcass weight and greasy fleece weight.

The most recent study (McPherson, 1982) calculated the marginal return from extra units of production. Thus, the economic weight for a lamb was an estimate of the value of the extra lamb in a set of twins since it was assumed genetic gains would come largely through increased twinning.

Comparison of Objectives

Table 1 allows a ready comparison of the weightings given to number of lambs and weaning weight relative to greasy fleece weight. The more recently derived estimates indicate a fall in the emphasis on number of lambs and weaning weight relative to fleece weight. This arises because:

- (1) wool prices have been sustained better than lamb prices

- (2) one year of sheep life is spent producing wool but not for breeding, and
- (3) the methods used are slightly more sophisticated in their consideration of costs up to the time of sale of the product.

Despite this fall in emphasis on number of lambs, selection indices based on the more recent objectives are highly correlated to those based on earlier objectives.

RECENT EVIDENCE ON WOOL TRAITS

Possibly because of lack of evidence, wool quality traits have not figured largely in recent objectives. However, information is slowly accumulating from processing trials. Hunter (1980) produced a very comprehensive review of these trials and Ross *et al.* 1982 commented on the relevance of some results to breeding coarse-woolled sheep.

McPherson (1982) obtained the New Zealand Wool Board records of wool sales for years 1976-77 to 1980-81. From these he extracted records of all sales of 33 to 40 micron fleece wools and used multiple regression techniques to estimate the effects of the various traits recorded on wool prices. These traits were mean fibre diameter (MFD), style grade (S), length grade (ML) and clean scoured yield (Y). In 1980-81 records were kept of colour grades (CG) and lines that were bad for the faults of mixed quality (QV) mixed length (LV), tenderness (T), coting (Co), [although not in cotted categories], felting (F) and pen stain (P) were noted. Almost 175 000 sale records were analysed.

The interpretation of these analyses is complicated. For instance, the relationship between price and length was not linear and in many analyses the data were separated into short (0 to 100 mm) and long types. The major problem however was that the visual traits were not recorded independently of one another and inter-relationships inherent in the evaluation system must be accounted for. Thus for the 1980-81 data the price effects normally ascribed to style grade were taken over almost completely by CG when S was omitted. Apart from CG the additional traits recorded in 1980-81 controlled little of the variation in style of fleece wools.

McPherson (1982) produced several different objective formulations and then investigated a number of alternative selection indices for the improvement of these objectives. The genetic parameters assumed were the same as those for Sheepplan, when available; otherwise the genetic parameter estimates of Chopra (1978) and Blair (1981) were used as guides.

Efficiency of Wool Production

The efficiency of clean wool production is the true objective and clean or greasy fleece weights are only

criteria of this. However efficiency cannot be measured so it cannot be considered constructively as part of the objective. McPherson's index studies indicate that it makes little difference to genetic gains whether clean or greasy fleece weight is regarded as the objective component. If the genetic parameters used are correct, greasy fleece weight appears a satisfactory criterion for improving clean fleece weight.

Length

Modern textile machinery is becoming more demanding of the length of fibres (Ross *et al.*, 1982) and prices fall rapidly as length falls below 75 mm. With sheep that are being second shorn, length is becoming an important characteristic. McPherson's analyses suggested that, in second-shorn sheep, selection for staple length was almost as profitable as selecting for fleece weight (dropping fleece weight as a criterion). Also considering staple length as an objective but not a criterion would put additional emphasis on fleece weight as a selection criterion.

Fibre Fineness

While a proportion of Romney wool is used in clothing, where fibre fineness is important, fibre diameter is of no interest to most users of Romney wool. McPherson (1982) showed only a small effect of diameter on price although there was a tendency for this to increase over the years 1977-81. Fineness estimates were of little value in selection indices.

Evenness

Results of processing trials indicate that there would be little benefit from reducing variation in length and diameter over the body or between the sheep in a normal flock. The absence of price penalties for variable length or variable diameter in McPherson's studies provides further evidence that evenness need not be considered in selection.

Cotting and Unsoundness (Tenderness)

There are technical reasons why the economic importance of these could be increasing. Accurate estimates of price effects have yet to be obtained. McPherson (1982) estimated the lifetime economic value for coting at \$2.11/grade or \$2.32/standard deviation and for soundness as \$1.21/grade or \$0.60/standard deviation (v \$6.03/standard deviation for fleece weight and \$3.09 for WWT). In the index studies the low heritabilities assumed (0.15 and 0.10) resulted in them being unimportant as selection criteria. However including them in the objective resulted in greater emphasis on fleece weight as a selection criterion. This followed from the genetic correlations assumed (GFW-Co = 0.40, GFW-T = 0.60).

Colour

There are technical reasons to believe that whiteness is likely to be increasing in importance as an economic trait. In the various selection objectives derived by McPherson (1982) colour figured quite prominently, yet in the selection index models colour always received a low weighting in the most profitable indices and little response was likely to occur; this despite the assumption that the heritability was 0.3. Bigham *et al.* (1983) have more recently produced a heritability estimate of measured yellowness of 0.13. This is lower than a number of estimates of the heritability of visual yellowness of greasy wool. If this estimate was used in index calculations even less selection would be imposed on colour.

If the economic and selection parameters used are adequate estimates, it appears that the extra gains from including whiteness in a maximum-profit selection index will scarcely pay for the work involved.

Bulk

Processing trials have demonstrated the importance of loose wool bulk in recent years (Carnaby and Elliott, 1980) and a considerable price premium for bulk has been reported for Perendale wools (Elliott, 1984). The future premium for bulk in Romney wools is difficult to predict. Probably if there are a number of lines that are distinguishably more bulky there will be a premium.

Assuming that a price premium will exist, how much progress can be made? Bigham *et al.* (1983) calculated a heritability of 0.41 for measured bulk in mixed Romney and Border Leicester x Romney data. This, plus the likely discovery of a main gene for bulk that is common in Perendales (M.L. Bigham, personal communication), indicates that progress can be made. However selection will probably be based on hand-assessed bulk (Elliott, 1980) and genetic parameters for this have yet to be calculated.

Objective and index weightings for bulk still have to be assigned but it seems that some flocks should attempt to improve it.

In the discussion on length it was stated that length could replace fleece weight in selection fairly effectively. However one consequence of this would be further reductions in bulk.

Fleece Character

Some sheep breeders continue to consider fleece character in their selection. Character almost invariably has received negative weightings (selecting against character) in selection indices.

CONCLUSION

On the basis of existing evidence it seems that for Romney sheep there is no need to add any wool

quality traits to the Sheeplan index. However more emphasis should be placed on fleece weight partly as a result of economic weights and partly because it seems likely to result in favourable changes in wool quality traits.

Ten years ago the major problem in planning selection schemes for sheep was lack of data on economic weights. This deficiency has been largely overcome. The major deficiency now is the lack of sufficient estimates of genetic and environmental correlations for indirect pathways of response to be predicted accurately.

Another deficiency is the lack of cost-benefit comparisons of different selection schemes. No New Zealand studies have gone beyond the stage of deriving selection indices. While, in theory, this allows genetic gains to be maximised, it does not take into account the costs of alternative methods of selection.

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