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Selection for lean and against fat in sheep

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ABSTRACT

Two N.Z. sets of phenotypic and genetic parameters were used to compare expected genetic responses from index selection for an economic breeding objective favouring the lean and penalising the fat content of lamb carcasses. The effect of different economic values for lean relative to fat were examined over the range corresponding to the 'biological' objectives, weight-adjusted fat and lean growth rate. Particular attention was given to the magnitude and direction of responses in lean and fat. Increasing the economic emphasis on lean relative to fat progressively increased the lean response but was associated with an increasing fat response in an undesirable direction. Different measures of carcass fatness varied in their ability to discriminate among genes affecting fat and lean differentially when included in a selection index along with growth rate, and were superior to eye muscle depth. Good estimates of the relative economic values are required for derivation of optimum selection strategies, especially if indexes of low discriminating power are to be used for selection.

Keywords Selection, growth, carcass composition.

INTRODUCTION

Processors and consumers want meat with high lean and low fat content. However, as lambs grow they put on fat and lean together giving rise to an antagonism between the weights of lean and fat in the carcasses of lambs of the same age. This antagonism extends to genetic differences among animals.

Genetic parameters of lamb carcass traits have been reviewed by Bennett and Clarke (1984), Rae (1984) and Bennett (1990). They indicate that selection of animals on the basis of body weight would be expected to increase carcass weight, lean weight and some indicators of carcass lean such as eye muscle area. They also predict that selection for body weight would increase fat weight, fat tissue depths and the percentage of fat in carcasses of animals killed at the same age (Rae, 1984; Bennett and Clarke, 1984). In view of these associated responses, several workers have proposed either selection against fat using an index which attempts to adjust for associated variation in body weight or carcass weight, or selection for lean tissue weight which, for animals of the same age, is equivalent to selection for lean tissue growth rate.

Bennett and Clarke (1984) contrasted the

expected rates of genetic change in growth and carcass fatness, for selection goals which aimed at either increasing lean growth rate (LGR) or decreasing weight-adjusted percentage fat (APF). Responses were examined on both a constant age and a constant weight basis for a number of selection schemes which combined growth and carcass fat predictors taken on the animal and its relatives. The results indicated a need to examine the financial implications of different selection strategies both in terms of the costs of collecting additional data for selection decisions and in terms of the relative economic value of increasing carcass lean and decreasing carcass fat.

More recent studies by Simm *et al.* (1987) have considered an economic index giving a positive economic weighting for lean relative to a negative economic weighting for fat. In this situation, liveweight, ultrasonic fat depth and ultrasonic muscle depth all made important contributions to expected genetic progress. Parratt and Simm (1987) and Simm and Dingwall (1989) also showed that an economic index can be expected to give different selection outcomes in terms of the responses in lean relative to those in fat, compared to selection for lean growth rate.

This study examines the expected responses in

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lean and fat weights for N.Z. lambs within the range of relative economic values corresponding to the 'biological' selection objectives, weight-adjusted fat and lean growth rate. It complements a parallel study of relative economic values for lean and fat weights in New Zealand lambs (Waldron *et al.*, 1991).

MATERIALS AND METHODS

Expected genetic responses from index selection for the lean and fat components of carcass weight were predicted using estimates of phenotypic and genetic parameters from the two New Zealand data sets. One was based on an early preliminary analysis of data representing whitefaced dual-purpose breeds in the Wiremu lean lamb trial (Parratt *et al.*, 1987) and the other on data coming from a more thorough analysis of Southdown x Romney lambs in the Ruakura progeny trial (Bennett *et al.*, 1991). A range of breeding goals was considered, each having the aim of decreasing fat weight while increasing lean weight (Wiremu), or fat-free carcass weight (Ruakura), and spanning a wide range of economic values for lean weight (or fat-free weight) relative to fat weight, which was set at -1.0. Although each selection goal was aggregate economic merit based on both traits, particular emphasis was given to examining the relative responses in the lean and fat components of carcass weight for animals of the same age. The method of presenting of the results of these predictions used by Simm *et al.* (1987) and Simm and Dingwall (1989), was followed. Different breeding goals were described in terms of the ratio of the relative economic values of fat and lean, the relative economic values reflecting the independent effects of lean weight and fat weight on meat value (Waldron *et al.*, 1991).

A number of alternative indices were considered with a view to examining the ability of different selection criteria to provide divergent responses in lean and fat. These included both live animal and carcass criteria, although in all cases it was assumed that these traits could be measured on the live animal. The carcass measurements were used to indicate an upper limit to the responses that might be achieved from individual selection in practice. Expected genetic responses per generation of selection were estimated for a unit standard deviation of selection pressure on the index.

RESULTS AND DISCUSSION

Wiremu Dual-Purpose Lambs

Expected genetic responses in weights of dissected lean and fat in six-month old Wiremu lambs selected on the basis of an index comprising autumn body weight (ALW) and an ultrasonic live animal fat depth (UFD) measured at the same time, are presented in Figure 1. The general pattern of responses with changing relative economic values is broadly similar to that obtained for a 'synthetic' set of phenotypic and genetic parameters taken from the literature and unpublished evidence by Simm *et al.* (1987). Increasing economic emphasis on lean relative to fat progressively increased the lean response but was associated with an increasing fat response in the undesirable direction.

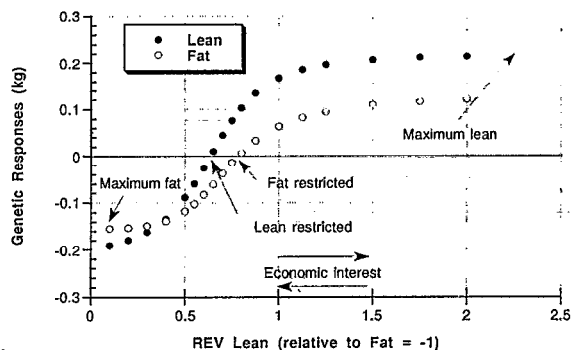


FIG 1 Expected genetic responses in fat and lean weights for dual-purpose lambs selected on an index based on autumn liveweight and ultrasonic fat depth. Relative economic values approximately corresponding to various 'biological' indices are indicated: major emphasis on lean (Maximum lean) or against fat (Maximum fat), increase in lean without change in fat (Fat restricted), decrease in fat without change in lean (Lean restricted) and the region of greatest economic significance (Economic interest) from the results of Waldron *et al.* (1991).

Also shown in Figure 1 are the relative economic values implicit in various 'biological' selection objectives such as lean growth rate (i.e. all selection emphasis is placed on lean), fat-restricted lean selection (i.e. increased lean without change in fat) and lean-restricted fat selection (i.e. decreased fat without change in lean), weight-adjusted fat depth selection falling between the latter two objectives. It is noteworthy that

this weight-adjusted fat objective falls outside the region of economic interest suggested by the relative economic values estimated by Simm *et al.* (1987) and Waldron *et al.* (1991).

Fennessy *et al.* (1987) have presented results from a selection experiment using ultrasonic backfat depth adjusted for body weight. Their responses in backfat depth on a constant age basis have been encouraging, at the time of that report amounting to about 0.9 phenotypic standard deviations in the lean line and 2.0 standard deviations in the fat selection line of Coopworth sheep. As predicted by Rae (1984) and by the selection parameters used in this study, lamb growth rates in the two lines were similar to unselected control lambs.

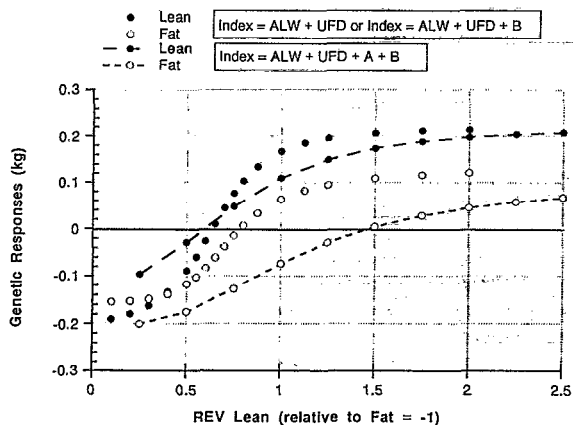


FIG 2 Expected genetic responses in fat and lean weights for dual-purpose lambs selected on indexes based on autumn liveweight (ALW), ultrasonic fat depth (UFD) and eye muscle dimensions (A and B).

The outcome of several other selection indexes have also been predicted from these Wiremu parameters. Although ultrasonic eye muscle depth was not measured, its likely benefits were examined by considering an index combining ALW, UFD and carcass eye-muscle depth (B). This index showed almost identical response predictions for lean and fat weights to those shown in Figure 1. This is in contrast to the predictions made for well-fed Suffolk lambs in the U.K. by Simm and Dingwall (1989). An index comprising ALW, UFD and both carcass eye-muscle cross-sectional dimensions

(A and B), did however give a pattern of selection response predictions which were more similar to those presented by Simm and Dingwall (1989). These comparisons are presented in Figures 2 and 3.

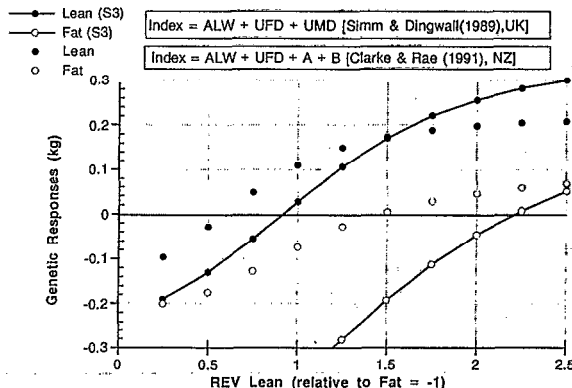


FIG 3 Comparison of expected genetic responses from index selection - Simm and Dingwall (1989) and Clarke and Rae (1991)

An index which included ALW, UFD and kidney fat weight (KFat) gave a pattern of responses which was even more similar to those presented by Simm and Dingwall (1989). It achieved high lean responses without concomitant increases in fat weight at relative economic values for lean relative to fat (ratio) as low as 1.5:-1. These results illustrate that indexes that discriminate between genes affecting lean and fat weights can be based on measures of total body size in combination with either measures of fatness or measures of leanness.

Ruakura Black-Faced Lambs

Predicted responses in the weight of chemically extracted carcass fat and fat-free carcass weight for Southdown x Romney cross lambs using an index comprising ALW and subcutaneous carcass fat depth measurement C are presented in Figure 4. The response surfaces for variations in the relative economic values of fat relative to fat-free weight are broadly similar to those presented above, although in this case the weight-adjusted fat objective seems to lie a little closer to the region of likely economic interest indicated by Waldron *et al.* (1991). In this case also, eye-muscle dimensions A and

B added little to the ability of the index to provide differential responses in fat relative to fat-free weight.

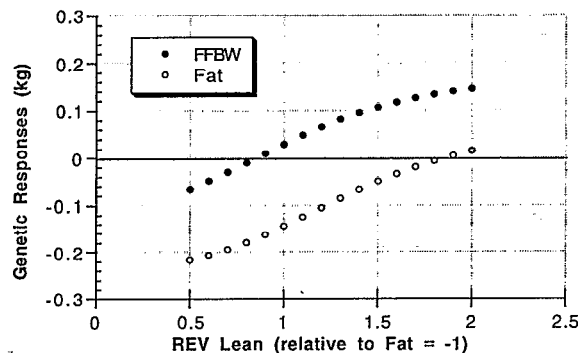


FIG 4 Expected genetic responses in the fat and fat-free (FFBW) components of the carcasses of Southdown x Romney lambs selected on an index comprising autumn live weight and subcutaneous carcass fat depth.

CONCLUSIONS

These early N.Z. results of expected genetic responses to selection for an economic index favouring lean and penalising fat suggest that good estimates of phenotypic and genetic parameters are required for derivation of an optimum selection strategy. In particular, they suggest that selection criteria based on published estimates from overseas breeds and/or management systems may not be very reliable for discriminating among genes affecting fat and lean differentially in New Zealand lambs. This seems true both in terms of the relative rates of genetic progress they predict and in terms of the relative value of alternative selection criteria they suggest. The results nevertheless confirm that 'discriminating' indices are quite robust to variations in the relative economic values of fat relative to lean.

The results also suggest that it is important to have good estimates of the relative economic values of lean relative to fat. For our leaner dual-purpose breeds,

weight adjusted fat does not seem to be a particularly useful commercial selection criterion. The high emphasis placed on lean growth rate in the United Kingdom also seems questionable from market signals for New Zealand lambs and for the competitive future of sheep relative to other meats, especially if selection criteria of low 'discriminating power' among genes affecting lean relative to fat are the basis of a breeder's selection decisions.

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