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# ECONOMIC SELECTION INDICES FOR LEAN MEAT PRODUCTION IN SHEEP

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## SUMMARY

Economic selection indices were derived for terminal sire sheep breeds or strains, using physical and financial results from New Zealand export lamb-producing flocks. The aggregate breeding value comprised carcass lean weight and carcass total fat weight. Index measurements were live weight, ultrasonic fat depth and ultrasonic muscle depth. Economic values of lean weight and fat weight were estimated to be NZ $5.07 and NZ $-3.72 per kg, respectively. The s.d. of the aggregate breeding value was NZ $3.20 and the correlation between the full index and the aggregate breeding value was 0.23. The expected economic response to selection on live weight alone was only 29 % of that expected from selection on the full index.

## INTRODUCTION

Consumer discrimination against animal fats is increasing. Consequently, production of overfat carcasses is a serious problem in many countries. Possible selection criteria to genetically improve carcass composition in terminal sire breeds or strains include (i) growth rate; (ii) estimated carcass lean %; (iii) estimated carcass lean weight; (iv) estimated lean tissue growth rate; or (v) economic

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selection indices. In sheep, where production is usually linked to seasonal grass growth, the main objective is to maximise production in a given time interval. For this reason, and for operational reasons, selection decisions will often be made at a fixed age, rather than a fixed live weight. At a given age there is usually a positive genetic correlation between growth rate and carcass fat weight or %, and a negative correlation between growth rate or live weight (LW) and carcass lean %. Hence, selection on growth rate is likely to increase fatness, and selection on estimated lean % is likely to reduce carcass weight at a given age. Neither outcome is desirable. Even with relatively precise *in vivo* estimation of carcass composition, prediction equations for lean weight tend to be dominated by LW (e.g. Sehested, 1984). Similarly, lean tissue growth rate, estimated as the product of growth rate, killing-out and lean proportions, tends to be highly correlated with growth rate (Simm, 1983). This is a consequence of the part-whole relationship between lean weight and LW, and also the relatively high coefficient of variation of growth rate/LW compared to that of killing-out and lean proportions. Economic selection indices for lean meat production theoretically give optimal weightings to LW and *in vivo* measurements, to maximise the rate of genetic change in profitability. In this study economic selection indices were derived for terminal sire breeds or strains, using physical and financial data for New Zealand (NZ) export lamb-producing flocks. The selection criteria mentioned above are often used in preference to economic selection indices, because of fears that the relative economic values of traits in the aggregate breeding value may not remain stable, and that genetic and phenotypic parameters may vary with the breed or strain, and conditions of testing. A sensitivity analysis was conducted to assess the importance of these factors.

## GENETIC AND PHENOTYPIC PARAMETERS

The aggregate breeding value of the indices derived here comprised carcass lean weight and total carcass fat weight. Index measurements examined were LW, ultrasonic fat depth or area (FD) and ultrasonic muscle depth or area (MD). After reviewing the literature and unpublished data (D.L. Johnson; P.R. Beatson and A.C. Parratt, personal communications) the genetic and pheotypic parameters shown in Table 1 were assumed.

Table 1. Genetic and phenotypic parameters used in index calculations

| | LW | FD | MD | Lean wt. | Fat wt. |
|---|---|---|---|---|---|
| LW | 0.24 | - | - | 0.70 | 0.73 |
| FD | 0.40 | 0.23 | - | 0.21 | 0.61 |
| MD | 0.40 | 0.15 | 0.20 | 0.50 | 0.20 |
| Lean wt. | - | - | - | 0.27 | 0.39 |
| Fat wt. | - | - | - | - | 0.29 |

Heritabilities on diagonal, genetic correlations above diagonal, phenotypic correlations below (- = not required). All refer to a constant age end-point.

## DERIVATION OF ECONOMIC VALUES

Economic values of genetic improvement can be calculated from at least three viewpoints - from the individual producers' viewpoint, in the interests of national economy, or from a new investors' viewpoint (Moav, 1973). In this study economic values were calculated from the individual producers' viewpoint. This assumes that any extra produce, resulting from genetic improvement, can be sold without a reduction in profit/unit produce. Since genetic improvement is likely to be slow, and since new markets are continually being sought for NZ lamb, this assumption seems valid.

Economic values for carcass lean and fat weights were derived by estimating the marginal profit or loss (marginal return - marginal cost) resulting from a 1 kg increase in lean weight or fat weight, compared to that in the average carcass of lambs slaughtered in 1984.

### Marginal returns

In NZ export lamb carcasses are assigned to grades according to carcass weight (CW) and estimated fat depth at the 12th rib (GR). Payment for carcasses varies according to the grade. Marginal returns for lean and fat were calculated as follows :-

(i) A population of 100000 lambs was generatad by Monte Carlo simulation, with the same means and standard deviations (s.d.) of CW and GR as those of lambs slaughtered in 1984. A phenotypic correlation of 0.7 between CW and GR was assumed.

(ii) Simulated carcasses were assigned to grades acording to CW and GR, and the value of the carcass was calculated from 1985/86 prices. Net total returns were calculated as carcass value plus an assumed constant wool/skin value, less killing and processing charges etc.

(iii) Carcass lean and fat weights were predicted from CW and GR measurements using equations derived by A.H. Kirton (personal communication).

(iv) Multiple regression of lean and fat weights on carcass net return resulted in the equation : NZ $ return = a + 5.19 lean (kg) - 3.57 fat (kg).

Because the carcass payment schedule operates on discrete grades, the partial regression coefficients above represent the average effect of increasing lean by 1 kg at a constant fat weight, and vice versa.

## Marginal costs

Marginal costs were estimated for lambs with an extra kg lean (plus increased bone) or an extra kg fat, compared to the 1984 average lamb, by :-

(i) Estimating the increase in metabolisable energy (ME) requirements for maintenance and growth from birth to 190 days of age.

(ii) Estimating the costs of producing this extra ME from the same area of land, by increasing grass production/ha, and increasing the use of forage crops. Costs published by the NZ Meat and Wool Boards' Economic Service (1984) were used, inflated to 1985/86 levels. The marginal costs of production were estimated as NZ $0.12 per kg lean and NZ $0.15 per kg fat, leading to marginal profits of NZ $5.07 and NZ $-3.72 per kg lean and fat respectively.

## RESULTS

Selection indices were derived using Cunningham's (1970) Selind computer program. Table 2 shows index coefficients for the full index, and for reduced indices based on LW and FD or LW and MD alone. Correlations between these indices and genotypic values of individual traits in the aggregate breeding value are shown in Table 3. The correlations between the indices and the aggregate breeding value (which are directly proportional to expected response to selection) are also shown in Table 3. Sensitivity analyses were conducted, as outlined by Simm (1983). The most likely change in economic values in future would be an increase in the value of lean, relative to fat. If the value of lean increases by 50 %, selection on the current full index is expected to be 90 % as efficient as selection on a newly derived index. With ± 0.1 changes in individual heritabilities or genetic correlations the efficiency of selection on the current index never fell below 94.7 %, and in most cases only fell to about 99 %.

Table 2. Index coefficients for different indices (coefficients apply to standardised deviations from the mean)

| Index measurements | Coefficient per s.d. | | |
|---|---|---|---|
| | LW | FD | MD |
| LW, FD, MD | 0.25 | -0.58 | 0.48 |
| LW, FD | 0.44 | -0.58 | - |
| LW, MD | 0.01 | - | 0.49 |

Table 3. Correlations between different indices and individual traits in the aggregate breeding value (ABV), or the overall ABV.

| Index measurements | Correlation with : | | |
|---|---|---|---|
| | Lean wt. | Fat wt. | Overall ABV* |
| LW, FD, MD | 0.19 | -0.05 | 0.23 |
| LW, FD | 0.16 | -0.02 | 0.18 |
| LW, MD | 0.23 | 0.10 | 0.15 |
| LW | 0.34 | 0.36 | 0.07 |

* s.d. of ABV = NZ $3.20

## GENERAL DISCUSSION AND CONCLUSIONS

Results in Table 2 show that the indices derived here have more emphasis on *in vivo* estimates of FD and MD than on LW. This is reflected in the high expected rates of genetic change from selection on the full index, compared to selection on indices with LW and FD, LW and MD or on LW alone. Selection on LW alone is expected to lead to only 29 % of the economic response achievable through selection on the full index. Although selection on growth rate, estimated lean tissue growth rate or estimated carcass lean weight avoids direct evaluation of economic weights, there are implied, unknown, economic weights involved. Also, selection on these criteria assumes an increased return for increased lean meat production, but ignores the economic consequences of increased fat production. Much greater emphasis is placed on *in vivo* measurements when lean and fat are explicitly defined in the aggregate breeding value. Despite the fact that economic selection indices involve many assumptions, the full index derived here was fairly insensitive to a substantial increase in the relative economic value of lean, and to changes in heritabilities and genetic correlations.

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