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# Responses to selection for lean tissue growth in Dorset Down sheep

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## ABSTRACT

Responses to selection using a lean tissue growth index were estimated from performance data of the Lincoln University Dorset Down flock. Data were available for ewes (n=922) born in the years 1984 - 1991 and rams (n=816) born in 1984 - 1992. Data were from two closed lines, one control and the other selected for high lean tissue growth. Initially selection was on the basis of an index comprising measurements of live weight and fat depth. Subsequently muscle depth was incorporated into the index. Ewes and rams born in spring each year were run separately at pasture from weaning (late summer) onwards. Performance testing was in the following autumn for ewes and winter for rams. Measurements were live weight and *in vivo* ultrasonic fat and muscle depths. Responses were calculated from regression of the difference between the line means for breeding value against time. Breeding value estimates were derived by AIREML analyses.

Both sexes exhibited desirable responses in all component traits: rams; +0.290kg/yr, +0.019mm/yr and -0.013mm/yr and ewes; +0.154kg/yr, +0.028mm/yr and -0.028mm/yr for live weight, muscle and fat depths respectively. Increases in muscle depth occurred after it was incorporated into the selection index.

**Keywords:** selection response; lean tissue growth; live weight; fat and muscle depths.

## INTRODUCTION

Early results from sheep studies selected for lean tissue growth raised under *ad libitum* feeding conditions on high energy and high protein diets in the United Kingdom were consistent with theoretical responses, although realised responses were smaller in magnitude (Cameron and Bracken, 1992; Bishop, 1993). Lower realised than predicted responses may reflect the way the indices used were constructed and the genetic antagonism between lean and fat weight as sheep grow. Such an antagonism could be greater than expected if genetic parameters used to construct the index differ from those of the population to which the index is applied (Nsoso, Young, Beatson and Bell, 1994). For example, in constructing their selection index, Cameron and Bracken (1992) assumed a genetic correlation of 0.15 between live weight and the selection index. However, subsequent analysis of their own data gave an estimate of 0.67. Use of poor estimates for genetic and phenotypic parameters can lead to acceptance of breeding objectives which do not maximise economic returns or rejection of breeding objectives which maximise economic responses (Sheridan, 1988).

Inaccurate measurement or estimation of tissue content will also reduce responses to selection. Ultrasonic measurements of subcutaneous fat and muscle depths have been used with success in the pig industry to reduce fatness and increase lean meat content (Kempster, Cuthbertson and Harrington, 1982). In sheep, the precision achieved for measurement of subcutaneous fat depth has been rather low (Simm, 1987). This is partly due to the amount of subcutaneous fat. A lower proportion of total carcass fat in sheep (0.12) is in the subcutaneous depot compared with pigs (0.16) and sheep are smaller in absolute terms, so total depth of subcutaneous fat is lower (Kempster, Cook and Grantley-Smith, 1986; Simm, 1987). This limited accuracy of ultrasound devices has been reported to have led to small change in cumulative selection differential values in sheep lines selected for low fat depths (Cameron and Bracken, 1992; Bishop, 1993).

To date all reports on selection for lean tissue growth based on indices comprising live weight, fat and muscle depths have been based on central performance tests under indoor feeding regimes. This paper reports estimates of responses to selection for lean tissue growth under pastoral grazing conditions and compares these with those from similar sheep studies conducted under *ad libitum* indoor feeding conditions on high energy, high protein diets.

## MATERIALS AND METHODS

Performance data were obtained from the Lincoln University Dorset Down flock for ewes born in 1984 to 1991 and rams in 1984 to 1992. Genetically, the flock is divided into two closed lines, one control and the other selected for high lean tissue growth.

All animals were born in spring and run at pasture. Complete data sets were available for autumn measurements in ewes and winter measurements in rams. Rams were performance tested in winter because earlier work at Lincoln University has shown that heritability and relative responses in fat depth are higher in winter than autumn or spring (Beatson, 1987).

Animals born in 1984 and 1985 prior to establishment of the lines in 1986 were treated as controls. From 1986 onward, animals in the lean tissue growth line were selected on the reduced index of Simm, Young and Beatson (1987), comprising live weight (LW) and ultrasonic fat depth (FD) (index 1 below). Animals born in 1987 and later, were selected on the full index of Simm *et al.*(1987), comprising live weight (LW), muscle (MD) and fat (FD) depths (index 2 below). Animals born in 1989 and later were the progeny of rams selected on index 2. Index 1 was used initially because muscle depth could not be measured accurately with the AIDD model 3 ultrasound machine (developed by the Auckland Industrial Development Division of DSIR) in use at the time. Inclusion of MD became possible with procurement of a later, more accurate model of ultrasound machine.

1986 - 1988: 0.44LW - 0.58FD (index 1)

1989 onwards: 0.25LW - 0.58FD + 0.48MD (index 2)

When index 1 was used for selection, six (6) two-tooth rams were used annually in each of the lines, but this number was reduced to five (5) in each line at the time index 2 was introduced. For both indices, rams selected for breeding in the lean tissue growth line were those with the highest index ranking whereas in the control line rams were chosen such that their average index was zero. In both lines only rams without physical defects were used. The number of rams which were available for selection each year are shown in Table 1. A total of 100 sires were used including sires used in 1984 and 1985. Two sires did not sire any progeny surviving to measurement, giving a weighted average sire family size of 17.8 ± 8.3. Approximately 50% of hogget ewes tested in the lean tissue growth line are selected for high index values and kept as replacements each year. In the control line, replacement ewes are chosen such that their average index is zero. Similar proportions (25-30% per year) of ewes are replaced in the two lines. Mixed age ewes are culled for age or poor reproductive performance. Culling of surplus ewe hoggets soon after autumn measurement is necessary to provide flexibility in management and allows higher levels of feeding for retained ewes and ram hoggets still under test. The weighted generation interval was 2.65, with the average age of dam being 3.30 years.

The data consisted of 608 single born and 1133 multiple births lambs, with 819 ram lambs and 922 ewe lambs. At the time of live weight measurement and tissue depth scanning, rams were 347±16 days old (range 298 - 376 days) and ewes were 258±14 days old (range 210 - 286 days).

**TABLE 1:** Number of rams performance tested each year. Rams performance tested in 1984 and 1985 were treated as controls.

| Year of Birth | Number of rams available for selection | |
|---|---|---|
| | Control line | Lean Tissue Growth line |
| 1984 | 80 | - |
| 1985 | 82 | - |
| 1986 | 42 | 58 |
| 1987 | 30 | 54 |
| 1988 | 34 | 52 |
| 1989 | 41 | 79 |
| 1990 | 38 | 61 |
| 1991 | 31 | 61 |
| 1992 | 28 | 76 |

Fat and muscle depths were measured over the 12th rib. Muscle depth measurement was the classical B measurement and fat depth was measured on the widest part of fat over the eye-muscle which is slightly more lateral than the C measurement of Palsson (1939) as described by Young and Deaker (1994). From 1984 to 1986 fat depth was measured using an AIDD(3) machine. However, for 1987 and later born animals fat depth and muscle depth were measured using a real time B-mode ultrasound scanner fitted with a UST-58101-5 probe operating at 5-MHz (Aloka SSD-210 DXII, Aloka Co. Ltd., Japan).

Prior to estimating responses to selection, significant ($p<0.10$) fixed effects and covariables to be included in AIREML models were determined using SAS GLM procedures (SAS, 1989). Classes of birth rank and age of dam were reduced to two (2) and three (3) respectively due to there being few triplets and quadruplets, and lack of performance differences between progeny from four (4) year or older ewes.

Component traits breeding values were derived by multivariate AIREML analyses based on Restricted Maximum Likelihood using the average information matrix as second derivatives in a quasi-Newton procedure (D.L. Johnson, pers. comm.). An individual animal model was fitted with animal as a random effect, birth rank, year of birth and age of dam as fixed effects and age at measurement as a covariate. Differences between lines in mean breeding values were regressed against year of birth to obtain responses to selection. For muscle depth, only those years in which it was included in the selection were used for regression.

## RESULTS

Environmental effects observed (Table 2) were similar to those reported elsewhere (Warmington and Beatson, 1986; Cameron and Bracken, 1992; Bishop, 1993). Animals were heavier and had greater fat and muscle depths if they were single or early born or from an older dam. Yearly environmental effects were random.

Both rams and ewes exhibited desirable changes in breeding value for all component traits (Figures 1 & 2 and Table 3). The trends in responses for live weight in both sexes and ram fat depth appear to oscillate *i.e.* up one year and down the following year (Figures 1 and 2). In rams, response in muscle depth was apparent only after 1989 when it was incorporated into the selection index (Figure 1). Average rates of response were higher in rams for live weight but lower for fat and muscle depths than in ewes (Table 3).

## DISCUSSION

Similar studies have also shown that live weight and *in vivo* measurements are influenced by non-genetic effects like age at measurement, age of dam and birth rank (Young and Simm, 1990; Cameron and Bracken, 1992; Bishop, 1993). Adjusting for such non-genetic effects improves the accuracy with which breeding values are estimated and hence the efficiency of selection (Fogarty and Luff, 1985; Warmington and Beatson, 1986).

Trends in selection response for component traits reported here are generally consistent with findings from similar studies (Young and Simm, 1990; Cameron and Bracken, 1992; Bishop, 1993), although smaller in magnitude (Table 3). The most obvious difference between the results of the present study and those of the literature is the dominance of live weight in responses. This could be the result of several effects.

Simm *et al.* (1987) weighted the indices used in this experiment to increase lean by 59g and decrease fat by 18g a year based on a 2.26 year generation interval and an average selection intensity of 1.26. Expressed as percentage of the

**TABLE 2:** Estimates of significant environmental effects for live weight (LW), fat depth (FD) and muscle depth (MD); subscripts R and E stand for rams and ewes respectively. Effects are presented for birth rank (BR) ; age of dam (AOD); year of birth; age at measurement in autumn or winter (AGE) derived by AIREML analyses. A dash (-) indicates an effect was not statistically significant (p>0.10) in preliminary SAS GLM procedure analyses. Average live weights and tissue depths for these animals are reported by Nsoso *et al.* (1994).

| Effect | | Estimates of Environmental effects | | | | | |
|---|---|---|---|---|---|---|---|
| | | $LW_R$(kg) | $FD_R$(mm) | $MD_R$(mm) | $LW_E$(kg) | $FD_E$(mm) | $MD_E$(mm) |
| BR | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | -2.752 | -0.136 | -0.460 | -2.972 | -0.320 | -0.790 |
| AOD | 2 | 0 | 0. | 0 | 0 | - | - |
| (year) | 3 | +2.165 | -0.006 | +0.420 | +1.349 | | |
| | 4 | +2.335 | +0.164 | +0.740 | +1.704 | | |
| Age(/d) | | 0.115 | - | - | 0.132 | 0.020 | 0.051 |
| Year of Birth | | | | | | | |
| | 84 | 0 | 0 | - | 0 | 0 | - |
| | 85 | -3.255 | +0.090 | - | -4.829 | +0.290 | - |
| | 86 | +6.312 | +1.570 | - | -1.200 | +0.219 | - |
| | 87 | +8.469 | +2.180 | 0 | -2.667 | -0.594 | 0 |
| | 88 | -8.006 | -1.630 | -5.664 | -0.836 | -1.580 | +0.345 |
| | 89 | -6.085 | +0.170 | -3.168 | -8.117 | -1.556 | -1.870 |
| | 90 | +5.307 | +0.388 | -0.646 | -2.178 | -1.080 | +0.922 |
| | 91 | -6.158 | -0.195 | -2.038 | -4.699 | -1.268 | -1.324 |
| | 92 | -3.658 | +0.461 | +0.456 | - | - | - |

**FIGURE 1:** Trends in selection response for rams. Lean tissue growth line mean minus control line mean for breeding values (BV) output from AIREML. 1989 spring born animals were the first progeny resulting from use of index 2. Error bar = 2 x SED.

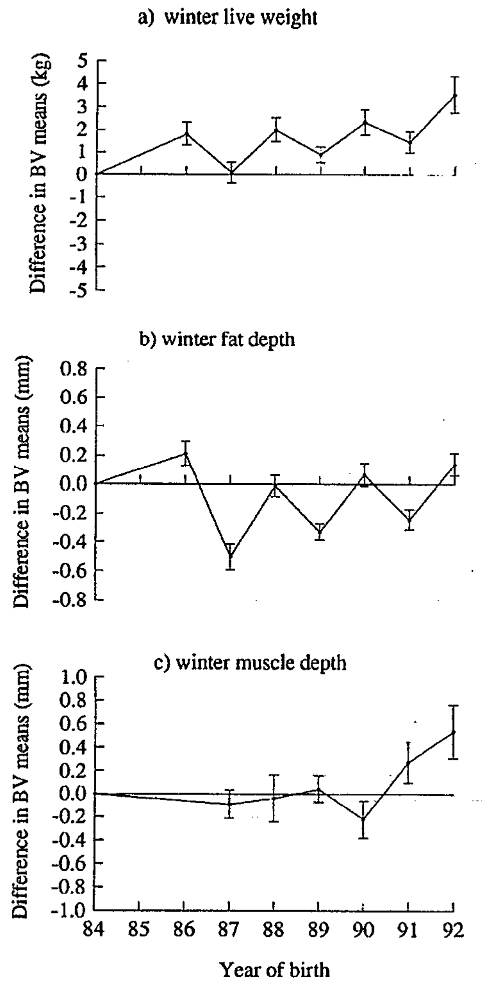


**FIGURE 2:** Trends in selection response for ewes. Lean tissue growth line mean minus control line mean for breeding values (BV) output from AIREML. 1989 spring born animals were the first progeny resulting from use of index 2. Error bar = 2 x SED.

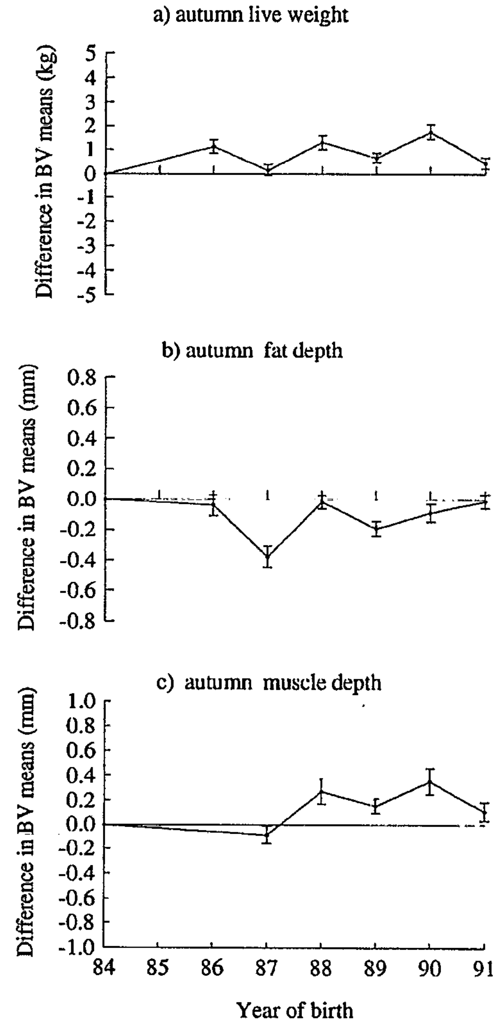

**TABLE 3**: Rates of response - regression coefficients for breeding values on time with the line forced to pass through the origin (where breeding value = 0 and year = 1985 for live weight and fat depth, and breeding value = 0 and year 1986 for muscle depth).

| Trait | Rams | Ewes | Rams# | Rams++ |
|---|---|---|---|---|
| LW(kg/year) | +0.290 | +0.154 | +0.639 | +0.240 |
| FD (mm/year) | -0.013 | -0.028 | -0.356 | -0.150 |
| MD (mm/year) | +0.019 | +0.028 | +0.295 | +0.370 |

# breeding value divergence responses from Cameron and Bracken (1992) which were subjected to the same analysis of response as data from the present study.

++ phenotypic divergence responses from Young and Simm (1990).

mean, responses observed for live weight and fat depth were similar in magnitude (0.4 - 0.7%), and consistent with these objectives. Apparently smaller changes in muscle depth (0.07 - 0.11%) may be due to poorer accuracy of the regression since there were fewer data used.

Fat depth and muscle depth are genetically correlated (Young and Simm, 1990; Cameron and Bracken, 1992; Bishop, 1993) and it is this correlation that the index is working against. It may be that this correlation is greater than expected and that the index derived by Simm *et al.* (1987) favours live weight more than expected. Nsoso *et al.* (1994) report moderately high genetic correlations between fat depth and muscle depth for the rams (0.61±0.16) and ewes (0.56±0.16) of this study. Unfortunately, no estimate of this genetic correlation was reported by Simm *et al.* (1987) for comparison, as it was not required for derivation of the index.

Accuracy of selection may have been lower in the flock studied. Since animals were grazed at pasture, they were smaller and had lower fat and muscle depths than those of Young (1990). Measurement errors, particularly for tissue depths, would have a greater effect on prediction of breeding values. Additionally, early generation ultrasound scanners, which were used early in the selection programme, were less accurate than later models (Cameron and Bracken, 1992).

Absolute rates of response to selection should be viewed with caution in this study and that of Young and Simm (1990) since in both cases, a two trait index was used at the start of the programme. Subsequently, both programmes used similar 3 trait indices. However, responses shown for the present study do highlight the dominance of live weight and the marked change in muscle depth response once it was incorporated into selection index.

Response rates are generally lower in the present study than similar studies (Young and Simm, 1990; Cameron and Bracken, 1992). Direct comparison of the results of the present study with those of Cameron and Bracken (1992) cannot be made since theirs is a divergent selection designed to change body composition without changing live weight. The generation interval for rams in the present study (2 years) was longer than the one year of the studies of Young and Simm (1990) and Cameron & Bracken (1992). This would decrease rates of response. Selection intensity was not greatly different in the present study from the previous studies as far as can be ascertained from published information. The accuracy with which tissue depths were measured (discussed above) could also reduce response rates in these traits.

Higher response rates in rams than ewes or vice versa are difficult to explain since management, sex and time of measurement were confounded. Differences in response rates may be genetic in origin since heritability estimates for index component traits have been reported to differ significantly for the sexes (Nsoso *et al.*, 1994). The few studies that have reported responses to selection for lean tissue selection have only performance tested rams (Young and Simm, 1990; Cameron and Bracken, 1992; Bishop, 1993). Further investigations are being conducted to ascertain the nature of differences between the males and females reported here.

Consideration of Figure 1 indicates that it is critical to include muscle depth in indices designed to improve lean tissue growth. Significant responses in muscle depth only occurred after its inclusion in the index. However, more data need to be collected to verify this given that this response was not clearcut in ewes (Figure 2) and that the data represent selection under two different, albeit similar, indices.

Reasons for the oscillation in responses for live weight for the two sexes and ram fat depth are under investigation. In particular, whether there were different ram selection efficiencies in the initial selections *i.e.* in 1986 and 1987 of the 1984 and 1985 born rams respectively.

## CONCLUSIONS

Index selection has lead to improvement in lean tissue growth. Such indices must incorporate measurements of muscle depth.

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