RESPONSE TO SELECTION FOR LEAN TISSUE GROWTH IN SHEEP AS ASSESSED BY X-RAY COMPUTER TOMOGRAPHY

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SUMMARY

A population of Dorset Down sheep were selected for nine years to increase lean tissue growth using a three trait index combining information on liveweight, muscle depth and fat depth. Response to selection was assessed by X-ray CT for weight and composition of the carcass by comparison of animals sampled from a selected line (n=12) and a control line (n=10). Carcass tissue weights were assessed at 266 days of age from 16-19 slices evenly spaced along the long axis of the body of each animal.

Selection led to increases in liveweight (+11%, $P<0.05$) and carcass weight (+7%, $P<0.098$). At the same liveweight, selection line animals had a lower carcass fat proportion (-15% $P<0.01$) and a higher carcass muscle proportion (+4%, $P<0.05$). It is concluded that selection has acted to increase mature size rather than appetite.

Keywords: selection; lean tissue growth; X-ray CT; sheep

INTRODUCTION

Selection to reduce fat and increase lean tissue in sheep is an important objective in many markets (Simm 1987). Early selection strategies combined information on liveweight and on ultrasonic fat depth to achieve this objective. However a more efficient selection approach uses data from these two traits together with muscle depth to create greater divergence in the response of adipose and muscle growth (Simm, Young & Beatson 1987).

A selection experiment was initiated at Lincoln University in 1984 to verify the theoretical approach proposed by Simm and co-workers. Dorset Down sheep were sourced from industry and inter-bred for two seasons. Following this, two lines were established; one selected (SEL) for increased lean tissue growth and one unselected control (CTRL). Selection was on the basis of the lean tissue growth index (LTGI) reported by Simm *et al.* (1987) where the aggregate breeding value (with relative economic values) was carcass lean deviation (+$5.77) plus carcass fat deviation (-$3.97). Index traits (with weightings for deviations) were liveweight (+0.25), eye muscle depth (+0.48) and fat depth (-0.58).

Establishment of an X-ray CT scanning facility at Lincoln University in 1994, provided the opportunity to compare the SEL and CTRL lines. A sample of ram lambs from each line were scanned comprehensively so carcass tissue size could be determined.

MATERIALS AND METHODS

A fuller description of the lines was given by Nsoso *et al.* (1994). Briefly, the SEL line comprised 150 ewes and the CTRL line 100 ewes, each divided into sire groups of 25 ewes. In order to reduce inbreeding one ram lamb was chosen from each sire family on the basis of LTGI. In the SEL line, the ram with the highest LTGI was chosen, while in the CTRL line rams were selected so that the average LTGI was zero for that line and the LTGI standard deviation was similar to that in the original unselected population. Rams were used for one mating season only at 19 months of age. Approximately 50% of ewe lambs were kept as replacements in the SEL line and average ewe age was 3.3 years.

In 1995 thirteen rams (266±5 days old) from each line were sampled across three weight ranges (high, medium and low) within line. They were scanned by X-ray CT using the Cavalieri approach described by Young *et al.* (1996). Briefly, 16-19 "slices" through the body were taken at equal spacing along the long axis, with the first slice position chosen at random. Problems with data transfer meant that complete image sets were available for only ten CTRL and twelve SEL rams. Image files were transferred to a PC, converted to a bitmap format and analyses performed using software written by Dr N.B. Jopson (AgResearch, Invermay, New Zealand). The carcass was defined from one slice in front of the shoulder to one slice below the knee, with internal organs removed. Skin was included in the carcass as it was not feasible to remove it from each image. For each sheep, fat, muscle and bone areas from each "gutted" slice were summed and the total multiplied by the interslice distance to obtain tissue volumes. These were then multiplied by mean tissue densities of 0.93, 1.03 and 1.55 kg/dm^3 for fat, muscle and bone respectively (Jopson, pers. comm.) to obtain tissue weights.

General linear model procedures were used to assess differences between line means with and without liveweight as a covariate.

RESULTS AND DISCUSSION

At scanning there were no significant differences between lines in age or in number of scan slices but selected animals were 5.3kg (+11%) heavier (Table 1). Composition of the carcass was not significantly different when comparison was made at the same age although trends indicated that the heavier carcasses (+7%) of SEL animals contained less fat (-8%), more muscle (+2%) and more bone (+3%) per kilogram of carcass (Table 2). Comparison at equal liveweight (Table 3) increased the magnitude of line differences for composition traits which became statistically significant for muscle and fat. At the same liveweight, SEL animals had similar sized carcasses with 15% less fat and 4% more muscle per kilogram.

Using the data from comparison at equal age, selection has led to +1.35kg of muscle and -0.01kg of fat. Using the relative economic values of Simm *et al.* (1987), carcasses of the SEL animals would have been worth $7.75 more than those of CTRL animals.

Table 1. Age, liveweight and number of scan slices for the CTRL and SEL lines (mean±sem).

Variable	CTRL	SEL	SEL-CTRL
age, d	266.7±1.4	264.6±1.6	NS
liveweight, kg	49.8±1.88	55.1±1.47	*
number of slices	16.6±0.1	16.8±0.1	NS

Table 2. Adjusted means (±se) for carcass composition in CTRL and SEL lines.

Variable	CTRL	SEL	SEL-CTRL
total carcass tissue, kg	22.57±0.74	24.21±0.68	(P=0.098)
carcass fat, g/kg	201±8.4	185±7.7	NS
carcass muscle, g/kg	606±7.7	616±7.0	NS
carcass bone, g/kg	193±5.1	199±4.6	NS

Table 3. Adjusted means (±se) for carcass composition in CTRL and SEL lines; liveweight fitted as a covariate.

Variable	CTRL	SEL	SEL-CTRL
total carcass tissue, kg	23.62±0.42	23.33±0.38	NS
carcass fat, g/kg	210±7.1	178±6.4	**
carcass muscle, g/kg	598±6.5	622±5.9	*
carcass bone, g/kg	192±5.5	200±5.0	NS

Simm *et al.* (1987) predicted responses for a 13.6kg carcass of +59g/yr and -18g/yr for lean (muscle) and fat weights. These would lead to +0.53kg and -0.16kg of lean and fat over the nine years of selection represented by this study. Adjustments need to be made for the greater carcass size of sheep in the present study as well as developmental effects. Simm *et al.* (1990) reported increases in response to a similar selection index of +2.2g/kg and -1.1g/kg for lean and fat as carcass weight increased from 16.7 to 22.3kg. Such an effect explains the greater response in CT muscle weight but not the smaller response in CT fat weight.

Nsoso *et al.* (1994) reported response rates in index component traits for this population of +0.290kg/yr (LW), -0.013mm/yr (FD) and +0.019mm/yr (MD), indicating that a relatively greater response in fat should have been observed in the present study. This apparent difference could be due to several factors. Firstly, if the animals were less mature at the same age, muscle depth responses may have been smaller since it is a later maturing dimension (Young 1990). Secondly, the response in fat at the ultrasound site under selection may have been relatively greater than that seen for carcass fat overall. given that the ultrasound data for fat showed greater responses than those observed by CT, investigation of fat distribution is warranted in these animals.

Carcass composition data showed that selected animals had relatively more muscle and relatively less fat in their carcasses. However the greater lean tissue growth (bone and muscle) led to animals being larger overall and hence had similar carcass fat weights albeit at different carcass fat proportions. Selection could have increased mature size so that animals were larger but less mature at a fixed age based on the theory of genetic size-scaling (Taylor 1985). Alternatively selection could have led to greater appetite at the same body size which would increase growth rate. The former reason seems more plausible as the latter reason would be expected to lead to greater absolute fat weights at the same age.

It is concluded that selection to improve lean tissue growth using the index of Simm *et al.* (1987) led to significant increases in carcass value; carcasses increased in weight without showing increases in fat weight. Such a response is consistent with selection leading to increases in mature size such that animals were heavier and less mature at the same age.

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