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# The calculation of a simple lean-growth index for young sheep

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## ABSTRACT

A lean-growth index (LGI) incorporating growth rate and the proportion of that growth which is fat is calculated by first converting live-weight differences into differences in weight of lean tissue and then adjusting these values using an estimated breeding value for fat depth.

The adjustment of fat depths for weight is by within-flock double-log regression or by specifying a constant exponent in the relationship between fat depth C and live weight. Simulation studies suggested that the constant-exponent method was superior for smaller groups of sheep.

Improvements in LGI by selection appear more likely to arise from genetic increases in growth rate than from decreases in weight-corrected fatness, but the inclusion of fatness in the index should lead to the production of lambs that can be taken to heavier weights before becoming overfat.

**Keywords** Lean growth index; fatness; lamb growth

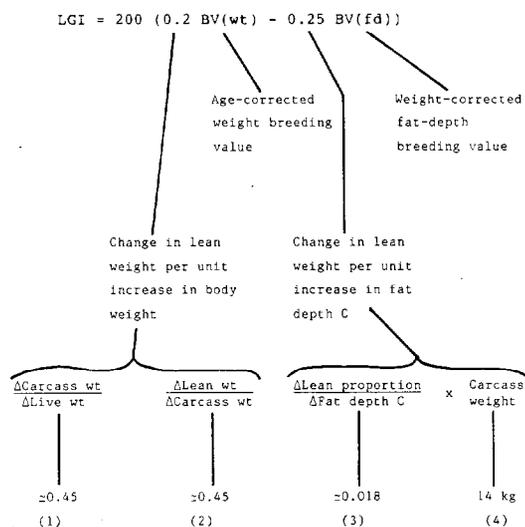
## INTRODUCTION

The quantity of lean tissue grown or accumulated by a certain age is an important meat-animal characteristic, which may be improved either by increasing overall animal growth rates or by increasing the proportion of lean tissue in the body. Consequently assessments of genetic potential for lean production need to be based on genetic information about both body growth rate (such as Sheeplan breeding values for weight), and the propensity for animals to grow lean rather than non-lean tissue.

The lean tissue content of live animals is difficult to assess in a direct way, but can often be predicted from measures of fatness because of close inverse relationships between fatness and leanness (Kempster *et al.*, 1976; Wood *et al.*, 1980). In the present paper a means of combining breeding values for age-corrected weight and weight-corrected fat depth into a single index is described, and 2 alternative ways of adjusting fat depths to a constant weight are compared.

## THE LEAN GROWTH INDEX

A lean-growth index (LGI) was developed to rank potential breeding animals on the basis of predicted growth rate of lean tissue. The procedure (Fig. 1) involves first converting live-weight deviations



**FIG. 1** The lean growth index (LGI) equation together with an explanation of its components. The values given at the bottom of the figure are discussed in the text.

(BV(wt)) into lean-tissue-weight deviations using standard conversion factors, and then adjusting these for fatness (BV(fd)). The constant 200 is included to

produce index values that can be presented as whole numbers.

In converting age-adjusted body-weight deviations first to carcass-weight deviations, and then to lean-tissue-weight deviations, it could be argued that marginal rates of change of these weights relative to each other should be used because deviations rather than total weights are being considered. However, in practice it is the difference in growth rates that the lean-tissue deviations should reflect, and it would seem reasonable to make such comparisons at the same body weight so that faster growing lambs are not penalised by assessing them only on the extra weight they have put on to a certain age, as it is well known that the proportion of lean is lower in each succeeding unit of carcass weight that is gained (Fourie *et al.*, 1970). Neither of these 2 alternatives (i.e. marginal rates of change  $\nu$  average weight-adjusted composition) seems clearly superior, so the constants in Fig. 1 are intermediate values. Thus, value (1) (Fig. 1) is higher than typical dressing-out % values for lambs (Kirton *et al.*, 1984) but lower than marginal rates of increase in carcass weight relative to body weight (Fourie *et al.*, 1970; Wood *et al.*, 1983; Kirton *et al.*, 1984). Similarly value (2) (Fig. 1) is lower than the % lean content of most lamb carcasses (Kempster *et al.*, 1976), but higher than the marginal increase in lean weight/unit increase in carcass weight (Fourie *et al.*, 1970; Vesely and Peters, 1972; McClelland *et al.*, 1976; Thompson *et al.*, 1979; Wolf *et al.*, 1980; Wood *et al.*, 1980; Butterfield *et al.*, 1983). It is known that both values (1) and (2) will change with changes in body weight, but this should not introduce significant error in ranking animals as the changes will be such that one will tend to cancel the other (Fourie *et al.*, 1970).

Value (3) in Fig. 1 is a component likely to vary between animals and between classes of animals. Kempster *et al.* (1976) reported values from 0.0065 to 0.0158 for 7 groups of lambs differing in breed type, with significant breed effects on both the intercept and slope of the relationship between % lean and fat depth C. However, they noted that the advantage of using separate lines for the different breeds was only marginal. Similar results were obtained from further analyses of the data of Wood *et al.* (1980) (Fig. 2) where, although both breed and sex significantly affected the above relationship, their inclusion in the model reduced the RSD for % lean only from 2.66 to 2.49. The genetic regression of % lean on backfat depth was calculated from Wolf *et al.* (1981) to be 0.020. Weight-corrected fat depth values are in terms of mm deviations from a mean of 3 mm, with a carcass weight (14 kg) which is acceptable for this level of fat. The heritability of ultrasonic fat depth adjusted for weight was taken as 0.25 (Wolf *et al.*, 1981; Fennessy *et al.*, 1982). For the average of 2, 3 or 4 weight-adjusted fat depths taken in different

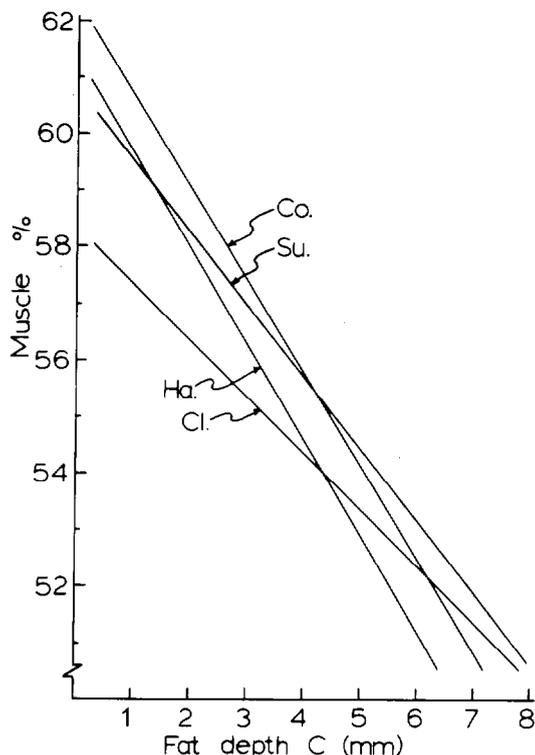


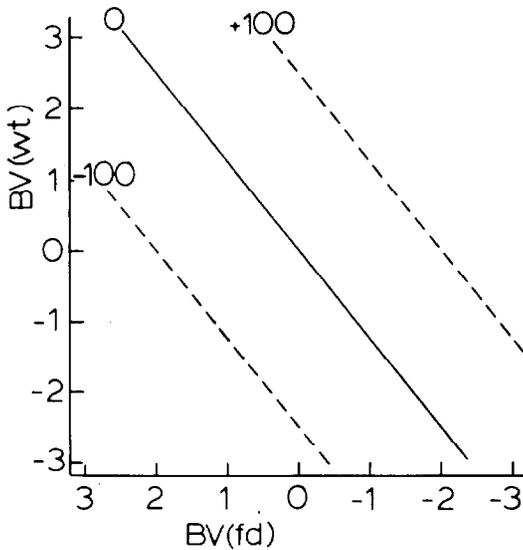
FIG. 2 Regression lines showing how carcass muscle % decreased with increasing fat depth C for a group of 348 lamb carcasses of 4 breeds (Co = Colbred,  $n=95$ ; Su = Suffolk,  $n=100$ ; Ha = Hampshire,  $n=83$ ; Cl = Clun,  $n=70$ ). In a model incorporating items for fat depth C, breed, sex and their interaction,  $R^2=0.571$  and  $RSD=2.49$ . (Data of Wood *et al.*, (1980)).

seasons the heritability was calculated to be 0.33, 0.375 and 0.4 respectively, assuming a genetic correlation of 1.0 and a repeatability of 0.5.

#### ADJUSTING FAT DEPTHS FOR WEIGHT

The method for weight correction taken as a standard involved fitting a log/log regression relating fat depth to live weight and then calculating percentage deviation values (Purchas *et al.*, 1982), which were converted to mm by assuming a mean fat depth of 3 mm. This technique is satisfactory when reasonable numbers of animals are in the group, but may be unreliable if numbers are low or if the range of live weights is very low. An alternative is to assume a slope for the log/log relationship and to calculate an intercept for each animal. The resulting equation is used to calculate a fat-depth deviation from a specified standard fat depth/live weight point. This method will be termed the "constant exponent" method as the assumed slope of the regression equation becomes an exponent if the relationship is converted to a non-log form.

The relative accuracy of the within-flock regression method v the constant-exponent method was assessed by a simulation study in which a large population of sheep was specified with regard to weight, fat depth, and the relationship between these 2 variables. The "true" fat depth deviation based on the whole population (n = 10 000) was compared with deviations obtained using the 2 methods within samples from the population (Table 1). Only the heavier than average animals were sampled because in practice it is likely that farmers will submit only heavier animals for ultrasonic fat depth measurement because of earlier selection.



**FIG. 3** Lines joining points of equal LGI on a graph of increasing weight breeding values (BV(wt)) on the vertical axis and decreasing fat depth breeding values (BV(fd)) on the horizontal axis. It can be seen that movement from the 0 to the +100 line, for example, can be achieved by either increasing BV(wt) or reducing BV(fd).

For the constant-exponent method comparisons were made at a range of exponent values and, as expected, the accuracy of the method declined as the deviation of the assumed exponent from the true value increased. However, the mean correlation was higher for the constant-exponent method when the sample size was 20, and was as high or higher than the regression method for exponent values between approximately 0.8 and 2.4 (Table 1) when the sample size was 40. It is not known what the true exponent value is for the fat depth/body weight relationship or the extent to which it varies significantly between different groups of animals.

**DISCUSSION**

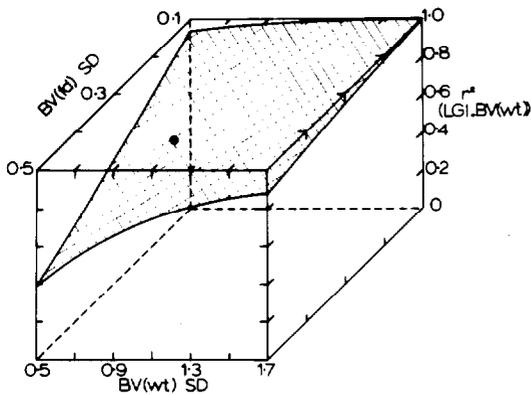
The extent to which LGI values are determined by the breeding values of weight and fatness is shown in Figs 3 and 4. Fig. 3 shows combinations of the BV's which give rise to equivalent LGI's, while Fig. 4 shows the proportion of variation in LGI accounted for by variation in the 2 components of the index. It is clear from Fig. 4 that, for the standard deviation ranges considered, the weight BV accounted for most of the variation in LGI. However, the inclusion of fatness in the index should mean that lambs can be taken to heavier weights before becoming unacceptably fat. More rapid changes in fatness could be achieved by single-character selection on fat-depth BV.

The form of the LGI equation (Fig. 1) has been kept simple by ignoring correlations among its components, and by using a standard carcass weight thereby ignoring the multiplicative determination of lean weight from carcass weight and leanness. These features are unlikely to be critical for the genetic improvement of lean growth rate since weight tends to dominate the index and the 2 components of the index are not unfavourably correlated (Wolf *et al.*, 1981).

The constant-exponent method of adjustment seems to offer a reasonable alternative to either adjustment using a fixed equation, which can be

**TABLE 1** Means and standard deviations for correlation coefficients between "true" fat depth deviations obtained for sheep in a large (n = 10 000) simulated population and deviations calculated with 10 samples of either 20 or 40 animals in the weight range from 55 to 70 kg. Within-sample deviations were calculated either by the within-flock regression method or the constant-exponent method. For the overall population: live weight = 50 kg (SD = 10) fat depth = 3.8 mm (SD = 1.5) and fat depth = - 2.11 (weight)<sup>1.57</sup> (r = 0.74).

Sample size	Regression method	Exponent value in the constant exponent method							
		0.6	1.0	1.4	1.6	1.8	2.2	2.6	
40	Mean	0.979	0.968	0.988	0.999	1.000	0.998	0.988	0.969
	SD	0.030	0.016	0.005	0	0	0.002	0.004	0.008
20	Mean	0.944	0.976	0.992	0.999	1.000	0.999	0.990	0.975
	SD	0.060	0.010	0.004	0.001	0	0	0.004	0.011



**FIG. 4** Changes in the relationship between LGI and weight breeding value ( $r^2$ , LGI. BV(wt)) for various combination of standard deviations of fat depth breeding value (BV(fd)SD) and weight breeding value (BV(wt)SD). The encircled dot on the response surface represents a BV(fd)SD of 0.33 (Bennett and Clarke, 1984) and a BV(wt)SD of 0.88 (Clarke and Rae, 1976) to give an  $r^2 = 0.82$ .

reliably estimated but is slightly biased for most flocks, or within-flock adjustments, which are unbiased but may not be reliably estimated. It may be the most appropriate method to use, particularly when the sample number is below a certain level, say 40 animals. However, further information is required on the variability of the exponent in the fat depth/live weight relationship, so the use of within-flock regressions to correct for weight remains the method of choice for larger groups.

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