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Genetic and phenotypic parameters associated with lean tissue growth in Dorset Down sheep

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ABSTRACT

Genetic and phenotypic parameter estimates were derived from performance data collected over nine years for the Lincoln University Dorset Down flock. Data were for animals born each spring and run at pasture. Ewes ($n=922$) were measured in autumn and rams ($n=819$) in winter. Measurements were live weight and *in vivo* fat and muscle depths.

Genetic and phenotypic parameters were estimated using multi-variate AIREML analyses by fitting an individual animal model with animal as a random effect, birth rank, age of dam and year of birth as fixed effects and age at measurement as a covariate. Multi-variate heritability estimates (\pm s.e.) for live weight, fat and muscle depths were $0.42(\pm 0.04)$, $0.30(\pm 0.04)$ and $0.30(\pm 0.05)$ for rams and $0.26(\pm 0.01)$, $0.20(\pm 0.05)$ and $0.13(\pm 0.03)$ for ewes respectively. Estimates of genetic correlations were generally moderate to high for the two sexes. The genetic correlation between live weight and fat depth was significantly different for the two sexes, with rams (0.42 ± 0.10) having a higher value than ewes (0.24 ± 0.02). Phenotypic correlations differed between the sexes, with estimates for ewes being slightly higher. For both sexes, parameter estimates were different from those used to derive the indices used to select for lean tissue growth, ram estimates being consistently higher while those for ewes were more equivocal.

Keywords: genetic parameters; phenotypic parameters; lean tissue growth; live weight; fat depth; muscle depth; sheep; selection.

INTRODUCTION

Growth rate and carcass composition are important because they affect financial returns to different sectors of the New Zealand meat industry (Simm, Young and Beatson, 1987; Kirton, 1989; Clarke, Waldron and Rae, 1991; Waldron, Clarke, Rae, Kirton and Bennett, 1992). As lambs grow they put on fat and lean together, giving rise to a genetic antagonism between weight of lean and weight of fat in the carcass (Clarke *et al.*, 1991) in terms of economic value.

In biological and economic terms the efficiency of lean meat production in sheep would be improved if the proportion of waste fat in the carcass was reduced (Simm, 1987; Glimp and Snowden, 1989; Cameron and Bracken, 1992). Genetic improvement through selection for lean tissue growth, although relatively slow, provides cost-effective permanent improvement in carcass composition (Simm *et al.*, 1987; Simm and Dingwall, 1989; Simm, 1992).

Single or multi-trait selection objectives can be employed to alter body composition in sheep. However, single trait selection can result in undesirable correlated responses in other traits of economic importance, hence the preference for multi-trait selection using an index (Simm, 1986). This is because with a selection index, genetic and phenotypic correlations between traits in the aggregate breeding value and the index are used to maximise the rate of genetic improvement whereas this vital information is ignored under single trait selection (Falconer, 1989).

Adaptation of ultrasound devices to measure body composition *in vivo* in sheep has led to increased interest in selection to alter body composition (Simm, 1987; Simm, 1992). There are many possible indicators of body composition that could be

included in selection objectives. Reliable estimates of genetic and phenotypic parameters are required to identify suitable predictors for use in a selection index for lean tissue growth (McEwan, Dodds, Davis, Fennessy and Hishon, 1991; Waldron *et al.*, 1992) but few have been reported for ultrasound measurements in sheep. Overestimation of such parameters would lead to acceptance of breeding objectives which do not maximise economic returns whereas underestimation would lead to rejection of breeding objectives which could maximise economic returns (Sheridan, 1988).

Genetic and phenotypic parameters used in derivation of the indices used to select the Dorset Down flock whose data were used in the present study were either taken from the literature or assumed (Simm *et al.*, 1987). Evaluations of similar programmes overseas under indoor *ad libitum* feeding regimes have shown lower responses to selection than predicted and have yielded different parameter estimates than suggested by the literature (Cameron and Bracken, 1992). Low realised responses may be due to realised parameter estimates differing from those used in index construction.

This paper reports genetic and phenotypic parameters associated with lean tissue growth for ewes in autumn and rams in winter from a Dorset Down flock run under pastoral feeding conditions.

MATERIALS AND METHODS

Data were available for performance of the Lincoln University Dorset Down flock, for animals born between 1984 and 1992, inclusive. A more detailed description of this data is given by Nsoso, Beatson, Young and Logan (1994). Briefly, the data were from two lines, one control and the other

selected for lean tissue growth using two of the economic selection indices of Simm *et al.* (1987). Initially selection was undertaken using an index incorporating measurements for live weight and fat depth. For 1987 born animals onward, muscle depth was incorporated into the index for reasons outlined by Nsoso *et al.* (1994). Genetic and phenotypic parameter estimates are reported for ewes in autumn (n=922) and rams in winter (n=819).

Prior to estimation significant ($p < 0.10$) fixed effects and covariables were identified using SAS GLM procedures (SAS, 1989). Genetic and phenotypic parameters were estimated using multi-variate AIREML analyses based on Restricted Maximum Likelihood using the average information matrix as second derivatives in quasi-Newton procedure (D.L. Johnson, pers.comm.). The model of analysis was an individual animal model with animal being the only random effect and birth rank, age of dam and year of birth as fixed effects and age at measurement as a covariate. Body measurements for ewes and rams were analysed as separate traits since they were measured at different times. Thus multi-variate analyses involved joint analysis of four traits, two from ram and two from ewe data sets *e.g.* ram winter live weight, ram winter fat depth, ewe autumn live weight and ewe autumn fat depth.

RESULTS

Means and phenotypic standard deviations for each trait are reported in Table 1. These show that rams in winter were larger than ewes in autumn, which could be due to age, sex and management. Ewes were relatively fatter than rams.

TABLE 1: Mean values (x) and phenotypic standard deviations (s) in brackets and number of observations (n) for traits under analysis

Trait	Rams			Ewes		
	n	x	(s)	n	x	(s)
Live weight (kg)	819	57.84	(7.78)	922	43.67	(5.09)
Fat depth (mm)	819	3.73	(1.50)	922	4.00	(1.40)
Muscle depth (mm)	557	28.25	(3.01)	586	24.73	(2.37)

Table 2 shows moderate to high genetic and moderate phenotypic parameter estimates for index component traits. Heritability estimates were significantly different for the two sexes, with those of rams being higher in magnitude. The only significantly different genetic correlation between the sexes was that for live weight and fat depth, with the ram estimate being higher. Phenotypic correlations were different between the two sexes, with the ewe estimates being higher, significantly so for that between fat depth and muscle depth. Genetic correlations between the sexes for the same trait were 1.00 ± 0.09 , 0.93 ± 0.24 and 0.65 ± 0.16 for live weight, muscle depth and fat depth respectively.

DISCUSSION

While parameter estimates generally fall within the range of literature reports (Young and Simm, 1990; Cameron and Bracken, 1992; Bishop, 1993), differences between the sexes for heritability of live weight provide evidence that sex

TABLE 2: Part I - Genetic and phenotypic parameters of rams and ewes associated with growth (standard errors in brackets). Heritabilities - along diagonal, phenotypic correlations above diagonal and genetic correlations below diagonal. Part II - Total variance for traits measured as genetic variance plus residual variance (*i.e.* total phenotypic variation less effect of fixed effects).

	Rams			Ewes		
	LW	FD	MD	LW	FD	MD
Part I						
LW	0.42 (0.04)	0.34 (0.03)	0.47 (0.03)	0.26 (0.01)	0.38 (0.02)	0.54 (0.04)
FD	0.42 (0.10)	0.30 (0.04)	0.33 (0.04)	0.24 (0.02)	0.20 (0.05)	0.45 (0.03)
MD	0.64 (0.15)	0.61 (0.16)	0.30 (0.05)	0.82 (0.22)	0.56 (0.16)	0.13 (0.03)
Part II						
	34.04	1.34	5.06	19.44	1.63	4.97

differences occur as suggested by Parratt *et al.* (1989) who examined autumn and spring live weights. Differences in the present data set are the result of genetic variance and covariance estimates being a higher proportion of total (co)variance in rams than in ewes.

Why estimates of genetic (co)variance should be higher in rams while estimates of environmental (co)variance would be higher in ewes is not clear. A degree of confounding occurs with the two sexes being managed in separate mobs and measurement occurring at different times. It may be that preferential feeding of rams allowed them to express their genetic potential better allowing more accurate estimates of genetic (co)variances, but the sampling errors presented do not support this. The difference in "split" between genetic and environmental (co)variation for ewes and rams may simply be an artefact of data structure. However, consideration of sire family size and other statistics did not reveal any obvious differences between the ewe and ram data sets. It could be postulated that autumn and winter measurements are different traits insofar as they are controlled by different sets of genes, albeit largely overlapping. Such an argument is plausible if live weight, fat and muscle depths were influenced by physical changes associated with the onset of breeding in the autumn for ewes, but not for rams later in the winter. However, no additional evidence was available to evaluate such a hypothesis.

Differences in genetic and phenotypic parameters between sexes, if real, are important in instances where indices derived from parameter estimates obtained from one sex are applied to the other sex. All pioneering studies of lean tissue growth selection reported in the literature to date have selected their breeding animals using indices derived from parameters obtained from the literature or assumed (based on knowledge of similar traits in similar genotypes or species). In all cases only rams were performance tested. Findings from this study support the proposal of Parratt *et al.* (1989) that genetic parameters between the sexes differ. Although this effect has not been fully investigated, it may be a reason why responses observed in some selection index studies (*e.g.* Cameron and Bracken, 1992; Bishop, 1993) have been lower than theoretical predictions. Further work is being undertaken to investigate the degree to which responses to selection

are affected by differences in genetic parameter estimates between the sexes.

Genetic and phenotypic parameter estimates derived from the ram data set in the present study were generally higher than those used to derive the selection indices (Simm *et al.*, 1987). Young and Simm (1990) and Cameron and Bracken (1992) also reported different realised parameter estimates than those assumed from the literature. Application of assumed parameter estimates which are significantly different from realised estimates would also lead to realised responses differing from predicted responses.

CONCLUSIONS

Genetic and phenotypic parameter estimates can differ between sexes. Sub-optimal responses observed in the literature may be the result of realised parameters differing from those used to derive the selection indices or because parameters differ for the two sexes.

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