

New Zealand Society of Animal Production online archive

This paper is from the New Zealand Society for Animal Production online archive. NZSAP holds a regular annual conference in June or July each year for the presentation of technical and applied topics in animal production. NZSAP plays an important role as a forum fostering research in all areas of animal production including production systems, nutrition, meat science, animal welfare, wool science, animal breeding and genetics.

An invitation is extended to all those involved in the field of animal production to apply for membership of the New Zealand Society of Animal Production at our website www.nzsap.org.nz

[View All Proceedings](#)

[Next Conference](#)

[Join NZSAP](#)

The New Zealand Society of Animal Production in publishing the conference proceedings is engaged in disseminating information, not rendering professional advice or services. The views expressed herein do not necessarily represent the views of the New Zealand Society of Animal Production and the New Zealand Society of Animal Production expressly disclaims any form of liability with respect to anything done or omitted to be done in reliance upon the contents of these proceedings.

This work is licensed under a [Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License](http://creativecommons.org/licenses/by-nc-nd/4.0/).



You are free to:

Share— copy and redistribute the material in any medium or format

Under the following terms:

Attribution — You must give [appropriate credit](#), provide a link to the license, and [indicate if changes were made](#). You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

NonCommercial — You may not use the material for [commercial purposes](#).

NoDerivatives — If you [remix, transform, or build upon](#) the material, you may not distribute the modified material.

<http://creativecommons.org.nz/licences/licences-explained/>

Comparison of weight-selected Romney hoggets for growth and ultrasonic fat and eye muscle dimensions

J.N. CLARKE, J.L. DOBBIE, K.R. JONES, A.E. ULJEE AND A.L. WRIGGLESWORTH

AgResearch, Ruakura Agricultural Centre, Private Bag 3123, Hamilton, New Zealand.

ABSTRACT

Lines of Romney sheep selected for either weaning (WWW) or yearling body weight (TYW and HYW) for 25 years were compared relative to their respective controls in a common environment using two unselected crops of male and female progeny. The weaning weight (WWW) line and one of the yearling weight (TYW) lines were derived from a common base flock, of diverse origin. The WWW line maintained a similar body weight advantage of approximately 20% over its control at 5, 8, 10 and 14 months of age. All control lines showed very similar average body weight trends with age (28.0 ± 0.5 , 33.9 ± 0.05 , 35.3 ± 0.06 and 42.6 ± 0.7). In contrast the yearling weight lines showed increasing divergence with age from 22% in February to 28% (TYW) and 31% (HYW) at 13 months. All lines, and especially the yearling weight lines showed some weight increase over the winter (May to July).

Eye muscle depth and width changed little over the winter compared with the previous autumn or the following spring, in contrast to fat depth trends which increased in all lines but for which however, there was little divergence among the yearling weight lines during the winter. All selected lines had significantly lower eye muscle dimensions at the same liveweight than their controls (by 4% for width and 5% for depth). Lines also showed contrasting divergence in average weight-adjusted fat depth relative to their controls, especially those derived from the same base population. As judged by reductions in subcutaneous fat depth, the WWW line lost its initial leanness superiority (4% lower fat depth) during the winter, the TYW line increasing its superiority (16-17% lower fat depth) during the winter and spring. The other yearling liveweight line (HYW) showed only half the leanness superiority over its control at these times. Thus, lines selected for improved growth alone had different patterns of muscle and especially subcutaneous fat development in a desirable direction for commercial lean lamb production, but responses were variable.

Keywords: selection lines; growth; fat and muscle development; genetic parameters.

INTRODUCTION

Current selection practices in both dual-purpose and meat breeds of sheep give high emphasis to increasing lamb growth rates through selection estimates of body size. Often considerable culling of flock replacements on size takes place prior to their first winter, and before their first mating at 18 months of age. While there is considerable literature on the inheritance of liveweight at these ages, less is published on the genetic relationships of liveweight with carcass composition for New Zealand sheep. Waldron *et al.* (1992) present compositional data for 6 month old lambs in relation to their liveweight at commercial slaughter weights. Compositional relationships with live animal traits beyond that age will need to rely on indirect assessments of carcass merit or on indirect assessment of relationships using live animal information on relatives of the slaughtered animals.

The present study uses ultrasound technology for the indirect assessment of body composition in live animals for three lines of New Zealand Romney sheep subject to long-term selection for high liveweight growth, and their corresponding unselected controls.

MATERIALS AND METHODS

The lines studied are described by Clarke and Johnson (1993). Two lines were selected on yearling liveweight (YW) and a third selected on weaning weight (WW), or

more strictly 100-day liveweight soon after weaning at about 12 weeks of age). One of the yearling weight lines (HYW) was established from a foundation flock of commercial Romney ewes at the Whatawhata Research Station in 1967, by the late G.K. Hight. It had its own control flock (HCO) in which replacements were selected at random (Johnson *et al.* 1994). Both were transferred to the Tokanui Research Station in 1981 where the present study was conducted. A second single trait line selected entirely on yearling liveweight (TYW) was established at Tokanui in 1973. It had its own unselected control line (TCO), both coming from a base population established in 1970-72 and representing more than 50 commercial and registered Romney flocks (Clarke and Johnson 1993). The weaning weight line (WWW) also derived from this same base, being established at the Woodlands Research Station alongside its unselected control (WCO) in 1973. A sample of this line representing half the original flock was transferred to Tokanui in 1991. Each of these lines had been maintained as a self-contained breeding flock based on up to 150 mixed age ewes mated to 5 new two-tooth rams each year.

All surviving ram and ewe hoggets born in these 6 selection and control lines in 1993 and 1994 were weighed and ultrasonically scanned in March (6 months of age), May (8 mo.), July (10 mo.) and October/November (14 mo.) in the year following their birth. Scanning was done by the same operator using an Aloka scanner (model SSD

500) with 5MHz transducers (models UST-588U and UST-5017M), purpose-built offsets and animal-confining crate (animals free-standing). A transverse image of the eye muscle and overlying fat was taken on the right side of each animal, immediately posterior to the 13th rib. Muscle width (A) was measured as the widest lateral width of this muscle. Muscle depth was measured as the greatest depth at right angles to A. Subcutaneous fat depth (C) was measured directly above B.

Growth and development trends of the 6 lines to 14 months of age were estimated from a least squares mixed model analysis fitting sires as a random effect within lines while adjusted for the additional fixed effects of year of birth, sex, year by sex, birth-rearing rank, age of dam and birth day. Genetic parameters were estimated by restricted maximum likelihood using an animal model fitting the same fixed main effects and average information methods (AIREML - Johnson and Thompson 1994; ASREML - Gilmour *et al.*, 1995). Yearling liveweights for all parents of the scanned animals were included in the analyses in an attempt to accommodate the effects of selection and provide within-line estimates across all selection and control lines.

RESULTS

Growth Trends

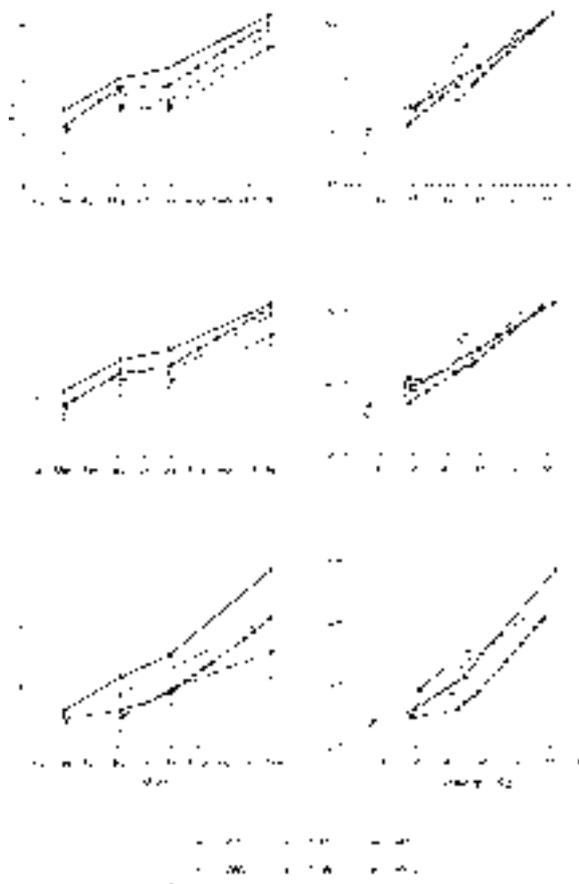
Age trends in liveweight are presented in Table 1. They were very similar for all control lines regardless of their source. The WWW line maintained an 18 to 20% superiority over its control at all ages but was significantly ($P < .01$) lighter than the lines selected on YW at 14 months of age. The YW lines by contrast, showed increasing divergence in liveweight with age, to 28% (TYW) and 31% (HYW) at 14 months.

Developmental Indicators

Line differences in the developmental trends of muscle and fat dimensions with age and liveweight are presented graphically in Figure 1.

By contrast to the control lines which showed similar development in A with age, the weight-selected lines displayed higher eye muscle development ($P < .01$) over their respective controls (on average by 3 mm). Development of A was highest in the HYW line (which displayed

FIGURE 1: Developmental trends of selection and control lines in adjusted ultrasonic dimensions by age and liveweight: A = muscle width (mm), B = muscle depth (mm), C = subcutaneous fat depth (mm).



on-going winter development during the winter in contrast to the other lines), both YW lines showing similar developmental superiority at each age. The WWW line showed enhanced ($P < .05$) eye muscle development in March (the age closest to the time of selection), but reduced ($P < .05$) eye muscle development at other ages in comparison to the TYW line selected from the same base population but on liveweight taken at a later age. On a liveweight basis, the selected lines showed lower ($P < .05$) A measurements than their controls, the difference being of the order of 5% at marketing liveweights for heavy-weight lamb production

TABLE 1: Adjusted liveweight means (kg) of the selection and control lines and their standard errors (in brackets).

Selection line Source	Criterion	No. Animals	Approximate date measured			
			March 3	May 6	July 2	October 22
Woodlands	Con (WCO)	100	28.2(0.46)	33.9(0.50)	35.3(0.51)	42.3(0.63)
Tokanui	Con (TCO)	99	27.8(0.57)	33.8(0.63)	35.4(0.63)	42.8(0.78)
Whatawhata	Con (HCO)	98	28.1(0.50)	34.1(0.54)	35.3(0.55)	42.7(0.68)
Woodlands	WW (WWW)	123	33.9(0.41)	40.3(0.45)	41.7(0.46)	50.9(0.56)
Tokanui	YW (TYW)	161	34.3(0.42)	41.4(0.46)	44.0(0.46)	54.1(0.57)
Whatawhata	YW (HYW)	133	34.7(0.42)	42.2(0.46)	44.9(0.47)	55.8(0.58)

WW = weaning weight; YW = yearling weight

(40-50 kg). The HYW line displayed developmental superiority ($P < .05$) over the other lines during the winter on this basis, the other selected lines tending to be less well-developed than this line.

Patterns of development in B were very similar to those for A, although there was greater variation among the control lines.

At all ages fat development was highest in the HYW line, the divergence over its control increasing markedly with age, especially after winter. Of the two lines selected from a common base population, that selected at the younger age (WWW) was considerably fatter than its control in May and July ($P < .01$), but not in March or November, than that selected later (TYW). However, despite their similar growth rates, its control line (WCO) was significantly leaner ($P < .05$) than the other control lines in the late autumn, winter and spring. On a liveweight basis, fat development was reduced in the selected lines relative to their controls and in the WCO control compared with the other control lines ($P < .05$). At marketing weights for heavy-weight lamb production the advantage of the TYW line over its control was of the order of 0.8 mm (30%). The other yearling weight line had only half of this commercial advantage. The WWW line had no advantage relative to its control (WCO), over this liveweight range.

Genetic parameters

Pooled within-line estimates of genetic parameters for autumn liveweights and scan dimensions (average of the estimates for March and May measurements, covering the period of greatest interest to sheep breeders in this country), are presented in Table 2.

Heritabilities were high for autumn liveweight, moderate for muscle depth and width but low for fat depth, in the range of published values for young lambs (Nsoso *et al.* 1994; Connington *et al.* 1995; Fogarty 1995), but at the lower end of the range for fat depth. Genetic correlations were higher than the corresponding phenotypic values, especially for associations of other traits with fat depth, for which standard errors were also high. Of special note for the genetic improvement of carcass leanness using ultrasound selection was the greater genetic independence of A with C than of B with C (as found for carcass measurements (Waldron *et al.* 1992). This feature, together with the relative size of their heritabilities, indicate that both muscle indicators have potential to assist in the genetic control of body composition by selection.

DISCUSSION

Selection at the later (yearling) age brought about greater improvement in early lamb growth than earlier selection (shortly after weaning). While this is to be expected from most age trends in published estimates of heritability and phenotypic variation (e.g. Clarke & Johnson 1993), the pooled within-line estimates of heritability for the animals scanned in this trial did not predict this trend, being higher at the younger age even when allowance was made for litter effects which are expected to be of greater importance in young animals.

TABLE 2: Animal model REML estimates of adjusted liveweights and scan dimension (average of March and May estimates) pooled within all selection and control lines: heritabilities on diagonal (bold), phenotypic correlations above and genetic correlations below diagonal (standard errors in brackets).

Trait	W (kg)	A (mm)	B (mm)	C (mm)
W	0.48 (0.058)	0.58 (0.019)	0.65 (0.017)	0.33 (0.024)
A	0.75 (0.082)	0.28 (0.063)	0.73 (0.013)	0.24 (0.026)
B	0.71 (0.072)	0.86 (0.056)	0.37 (0.065)	0.29 (0.025)
C	0.68 (0.21)	0.39 (0.42)	0.59 (0.46)	0.08 (0.053)
σ_p	4.5	4.9	2.8	0.84
\bar{x}	35	52	25	2.6

W = liveweight; A = eye muscle width; B = eye muscle depth; C = fat depth over eye muscle

σ_p = phenotypic standard deviation; \bar{x} = mean

Selection for YW produced more extreme changes in ultrasonically scanned eye muscle dimensions than did selection soon after weaning. Muscle cross-sectional dimensions were increased on an age basis and reduced when comparisons were made at the same liveweight. Selection line differences in the development of subcutaneous fat depth showed similar general trends but were even more heterogeneous. One of the YW lines showed only small age-related fat depth changes relative to its control during the autumn and winter, but was leaner by 14 months and considerably leaner than its control on a liveweight basis, most of the divergence arising during the winter. This leanness response was also in contrast to the line selected for WW from the same base population, which on a liveweight basis showed a similar level of fat development to its unselected control. This control flock which had been bred in a different environment (Southland) than the others (and different from the environment (Waikato) in which the lines were compared), consistently showed a reduced level of fat development on both an age and liveweight basis.

Within-line estimates of genetic parameters coming from this study go some way to explaining line differences in the development of fat and eye muscle dimensions with age, although low heritabilities were found for fat development in comparison with previously published evidence. This evidence is also compatible with the observed 'maturity' effects of liveweight selection at different ages on fat and eye muscle dimensions relative to liveweight. These predict that liveweight selection at later ages tends to give lower ratios of correlated responses in fat and muscle dimensions relative to the corresponding correlated response in liveweight, than the ratio (i.e. weight-adjusted dimensional responses) observed in unselected animals, at these earlier stages of development.

The genetic parameter estimates also give guidance to developing selection indices capable of improving lean growth without concomitant changes in fat dimensions (Anon 1994). However, as pointed out, there is a "cost" to this approach which is reflected in the reduced genetic gain in liveweight in comparison with that which could

otherwise be achieved without any restriction on associated changes in its components (or their indicators). Our parameter estimates confirm that this cost is greater for the control of subcutaneous fat depth than for the control of cross-sectional eye muscle dimensions. They also confirm the value of including more than one indicator of eye muscle area in both cases.

CONCLUSIONS

Lines selected for weaning or yearling liveweight have been successful in improving early lamb growth to market ages and liveweights. Also, lines selected for liveweight can have different patterns of muscle and especially subcutaneous fat development, the commercial benefits depending on whether lambs are marketed on an age or liveweight basis. On a liveweight basis fat depth changes were commercially favourable, more noticeably so from yearling compared to early post-weaning selection.

Ultrasound measurements of fat and eye muscle dimensions offer prospects for reducing this uncertainty of compositional responses, but in most cases are expected to reduce the progress that could otherwise be made in improving liveweight growth.

ACKNOWLEDGEMENTS

Financial support was provided by the Foundation for Research, Science and Technology.

REFERENCES

- Anon 1994. Selecting rams for lean lamb production. In 'Breeding Matters' No. 4, New Zealand Animal Breeding Trust, Massey University, Palmerston North, 2 pp.
- Clarke, J.N.; Johnson, D.L. 1993. Lessons from New Zealand sheep selection experiments. Proceedings of a symposium in honour of Professor A.L. Rae, Eds. S.N. McCutcheon and H.T. Blair, Massey University, pp. 52-68.
- Connington, J.; Bishop, S.C.; Waterhouse, A.; Simm, G. A. 1995. A genetic analysis of early growth and ultrasonic measurements in hill sheep. *Animal Science* **63**: 85-93.
- Fogarty, N.M. 1995. Genetic parameters for liveweight, fat and muscle measurements and reproduction in sheep : a review. *Animal Breeding Abstracts* **63**: 101-143.
- Gilmour, A.R.; Thompson, R.; Cullis, B.R. 1995. Average information REML, an efficient algorithm for variance components estimation in linear mixed models. *Biometrics* **51**: 1440-1450.
- Johnson, D.L.; Thompson, R. 1994. Restricted maximum likelihood estimation of variance components for univariate animal models using sparse matrix techniques and a quasi-Newton procedure. *Proceedings of the World Congress on Genetics Applied to Animal Production* **18**: 401-403.
- Johnson, D.L.; Hight, G.K.; Dobbie, J.L.; Jones, K.R.; Wrigglesworth, A.L. 1994. Single trait selection for yearling fleece weight or liveweight in Romney sheep. I. Direct responses. *New Zealand Journal of Agricultural Research* **38**: 115-122.
- Nsoso, S.J.; Young, M.J.; Beatson, P.R.; Bell, S.T. 1994. Genetic and phenotypic parameters associated with lean tissue growth in Dorset Down sheep. *Proceedings of the New Zealand Society of Animal Production* **54**: 251-253.
- Waldron, D.F.; Clarke, J.N.; Rae, A.L.; Kirton, A.L.; Bennett, G.L. 1992. Genetic and phenotypic parameter estimates for selection to improve lamb carcass traits. *New Zealand Journal of Agricultural Research* **35**: 287-298.