
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Selection for productive traits on back fat depth in ewe lambs

J. C. McEWAN*, P. F. FENNESSY**, J. N. CLARKE†, S. M. Hickey†, M. A. Knowler*

ABSTRACT

A sheep breeding experiment at Woodlands Research Station consists of 5 self-contained Romney selection lines (closed in 1973). Four lines are selected respectively for dam's number of lambs born (dam NLB), 100-day weight, hogget fleece weight, and a production index in which all 3 traits are combined, while the fifth line is a randomly selected control.

Back fat thickness was measured in the 1982 born ewe lamb progeny at approximately 8 and 14 months of age. Relative to the controls (back fat 6.3 mm) the dam NLB (5.0 mm) and the production index (4.8) lines had 20% lower back fat depths ($P<0.01$) in May after covariance adjustment for live-weight. The differences were slightly lower when measured in November. The fat thickness of the 100-day weight and hogget fleece weight line progeny were similar to the controls. The heritability of back fat depth adjusted for live weight by half-sib analysis was 0.28 ± 0.13 (s.e) in May.

The implication is that there are no major genetic antagonisms between leanness and the production traits recorded under Sheeplan and the evidence suggests that those using the Sheeplan index may be indirectly selecting for leaner progeny.

Keywords Ultrasonic; sheep; back fat depth; production traits; heritability; genetic correlation; selection

INTRODUCTION

The fat content of sheep meats is too high (Wood, 1982). The New Zealand Meat Producers Board has recently instituted grading changes to discourage the production of fatty carcasses. Options immediately available to the farmer to reduce fat content in lambs include, changing sire breed (Kirton *et al.*, 1974) and leaving ram lambs entire (Kirton *et al.*, 1982).

A long-term solution is to breed a leaner sheep. While this is a slow process the gains achieved are cumulative and permanent. Recent estimates of the phenotypic and genetic relationships among lamb carcass traits (Bennett *et al.*, 1982; Wolf *et al.*, 1981) allows expected responses to be evaluated for meat breeds.

If leanness is to be included as a selection objective in dual purpose breeds, a relationship of body composition with fecundity and wool production as well as live weight is essential. In the present study correlated changes in back fat depth after selection for a variety of productive traits within the Romney breed were examined. Half sib estimates of the traits were also obtained and compared with the realised changes.

MATERIALS AND METHODS

A long-term sheep breeding experiment being conducted at Woodlands Research Station consists of 5 self-contained selection lines. Each selection line forms a closed breeding group with 5 two-tooth rams being single sire mated annually within each line. The lines were closed in 1973 and originated from a common base flock comprising a sample of over 60 sources of the New Zealand Romney breed.

Three lines are selected for a particular production trait, viz. dam's number of lambs born (dam NLB), 100-day weight and hogget fleece weight. The fourth line is selected on a production index comprising all 3 traits while the fifth is a randomly selected control.

The ewes from the selection lines are run together as a mob throughout the year except during joining when they are grazed separately but on similar pasture. Similarly all stock within the ewe lamb or ram lamb mobs are treated as equally as possible with regard to grazing management and routine farm practices.

The 1982 born ewe lamb progeny from these selection lines were measured for back fat depth using an ultrasonic scanner AIDD (3) (Gooden *et al.*, 1980). The ewe lambs were unculled and consisted of all surviving lambs born to ewes mated during the first 34 days of joining; lambs had been weaned at about 90 days of age. The animals represented approximately the third generation since selection began. The lambs were weighed on 24 May (8 months of age) and divided

*Woodlands Research Station, Ministry of Agriculture and Fisheries, Invercargill.
**Invermay Agricultural Research Centre, Ministry of Agriculture and Fisheries, Mosgiel.
†Ruakura Agricultural Research Centre, Ministry of Agriculture and Fisheries, Hamilton.

randomly into 6 groups which were then scanned over the subsequent days, a different operator being used each day. Back fat depth was measured on both the left and right side at a position over the eye muscle above the 12th rib. The procedure was repeated in November when the lambs were about 14 months of age.

ANALYSIS

The data collected was analysed by fitting least square models with both fixed and random effects (Harvey, 1977). The design of the experiment allowed estimation of heritabilities and genetic correlations by 2 methods. Firstly comparison of the differences between selected lines and the random control line provides estimates of the realised genetic correlations. Secondly paternal half sib analysis of the 25 sire groups produced estimates of heritabilities and genotypic and phenotypic correlations. The latter method may bias the estimates of heritabilities downwards due to the non-random selection of rams within most selection lines.

RESULTS AND DISCUSSION

Factors Affecting Back Fat Depth (Table 1)

Back fat depth measurements in May were affected by operator ($P<0.001$) although there appeared to be no interaction with other factors suggesting a linear shift in reading the instrument. As expected live weight prior to scanning affected fat thickness ($P<0.001$). A linear fit was found to be suitable, although a logarithimic curve has been used by others. The coefficient of the slope of back fat thickness on live weight was 0.257 mm/kg which is comparable to values for animals of similar live weight, sex and level of fatness (Coop *et al.*, 1979). Day of birth also accounted for a small proportion of the variation in back fat thickness ($P<0.05$) with later born lambs being leaner. Other non genetic effects were either non significant or accounted for only a minor proportion of the variation.

Selection lines ($P<0.01$) and sires within selection lines ($P<0.001$) had a significant effect on May back fat depth. This was also apparent when back fat thickness was measured ultrasonically in November although the difference between selection lines was lower. The data were further analysed to provide estimates of heritability and genetic correlations.

Heritabilities of Ultrasonic Back Fat Depth (Table 2)

Except for the weaning weight estimate all the heritabilities were significant. The live weight and live-weight gain estimates were similar and showed a rising trend with age as reported by Baker *et al.* (1979).

Heritabilities and genetic correlations of May back fat depth are presented in 3 ways, namely at a constant age (back fat depth), at a constant weight (Index P), and as a weight restricted index (i.e., adjusted for the genetic correlation between back fat depth and May live weight; Index G). The first 2 are both important because commercially animals are slaughtered when they reach a certain weight. However it is obviously more practical to measure back fat depth at one time and hence the relationship between the 2 is required. In contrast selection on Index G would result in a decrease in fat depth but no correlated change in live weight as explained by Turner and Young (1969).

A value of 0.23 was obtained for May back fat depth while the weight constant value was 0.28. The heritability estimate of back fat thickness in November was higher at 0.45 but was not significantly different from the May value. The values suggest heritability for ultrasonic back fat thickness in sheep is moderate to high. The values are comparable to estimates from weight-adjusted carcass measurements of 0.54 ± 0.13s.e. (Botkin *et al.*, 1969); 0.21 ± 0.11 (Wolf *et al.*, 1981) and 0.28 (Bennett *et al.*, 1982).

The residual error distribution from the analysis was slightly skewed. Although not large enough to question the validity of the results, this suggests the response to selection for back fat thickness may be asymmetrical, with a lower response when fat depth is being reduced.

TABLE 1 Means of live weight (kg) and back fat thickness (mm) in the selection lines[1].

Selection line	Live weight		Back fat thickness		Back fat thickness adjusted for weight	
	May	Nov	May	Nov	May	Nov
Selection line						
Control	33.9	46.4	5.97	4.62	6.31	4.98
Production index	38.0	51.3	5.30	4.49	4.76	4.09
Dam NLB	35.0	47.8	4.96	4.13	4.99	4.27
100-day weight	38.1	50.7	6.81	4.95	6.11	4.65
Hogget fleece weight	35.6	47.4	6.36	4.75	6.23	4.96
Approximate SE[2]	0.86	1.11	0.38	0.35	0.34	0.30

[1] Effects due to age of dam, birth and rearing rank, birth day, docking group and operator removed from all data presented.

[2] Standard error derived by using sire variation within sublines as the error term.

TABLE 2 Half-sib estimates for heritability and the phenotypic mean variation.[1]

Character	$h^2 \pm$ s.e.	mean $\pm \sigma p$
Weight (kg)		
Weaning	0.154 ± 0.105	19.7 ± 2.40
March	0.341 ± 0.148	31.0 ± 3.32
May	0.462 ± 0.173	36.1 ± 3.97
November	0.485 ± 0.180	48.7 ± 5.05
Gain (weaning-May)	0.420 ± 0.164	16.4 ± 2.79
Hogget fleece weight (kg)	0.742 ± 0.226	2.79 ± 0.41
Back fat depth (mm)		
May	0.230 ± 0.123	5.87 ± 2.18
Index P, May[2]	0.280 ± 0.134	5.76 ± 1.96
Index G, May[3]	0.241 ± 0.126	5.83 ± 2.01
November	0.451 ± 0.174	4.59 ± 1.63

[1] Effects due to age of dam, birth rearing rank, birth day, docking group and operator removed from all data presented.
[2] Back fat depth adjusted for phenotypic relationship between back fat depth and May live weight.
[3] Back fat adjusted for genetic relationship between back fat depth and May live weight.

Realised and Half Sib Estimates of Genetic Correlations (Tables 3 and 4)

The values obtained were similar to those previously published. However in most cases the values are only poorly estimated due to the limited number of animals and sires available in this study.

The results suggest that selection for live weight in sheep will result in animals that are heavier and fatter at a particular age but that are leaner at a particular live weight as discussed by Thompson (1982). In particular the realised and half-sib genetic correlations of May back fat thickness (adjusted for weight) with 100-day weight ($r_G = -0.10$) and May live weight ($r_G = -0.30$) are similar to those of Bennet *et al.*, 1982, ($r_G = -0.03$) and Wolf *et al.*, 1981, ($r_G = -0.3$) respectively.

The dam NLB and production index lines (which includes a large weighting for dam's number of lambs born) show considerable indirect selection for low subcutaneous fat when corrected to a constant live weight (Index P). This results in the genetic correlation between fecundity as estimated by dam's number of lambs born and back fat thickness (Index P) being

TABLE 3 Estimates of realised genetic correlations with May back fat thickness.

Trait selected	May back fat depth[1] (constant age)	May back fat depth[2] (constant live weight)
Production index	-0.29	-0.69
Dam NLB	-0.64	-0.84
100-day weight	0.41	-0.10
Hogget fleece weight	0.15	-0.03

[1] Adjusted for age of dam, birth rearing rank, operator, birth day.
[2] Adjusted for age of dam, birth rearing rank, operator, birth day, May live weight.

TABLE 4 Estimate of genotypic and phenotypic correlations[1] with back fat depth (by paternal half-sib analysis).

	Genotypic correlations			Phenotypic correlations		
Characters	May	Index P	Index G	May	Index P	Index G
Weight (kg)						
Weaning	0.17	-0.44	-0.16	0.27	-0.05	0.11
March	0.30	-0.34	-0.04	0.37	-0.03	0.18
May	0.33	-0.30	0.00	0.44	0.00	0.23
November	0.17	-0.43	-0.16	0.30	-0.09	0.10
Gain: Wean-May	0.41	-0.22	0.08	0.39	0.04	0.22
Hogget Fleece[3]	-0.35	-0.68	-0.55	0.17	-0.09	0.04
Back fat (mm)						
May						
Index P[2]	0.80			0.90		
Index G[2]	0.94	0.95		0.97	0.97	
November	0.97	0.79	0.9	0.52	0.36	0.45

[1] Phenotypic correlations above 0.15 are significant at the 1% level. Genetic correlations have standard errors ranging in the 0.2 to 0.4 for the upper part of the table and 0.03 to 0.2 for the lower section.
[2] Index traits as explained in Table 2.
[3] Hogget fleece weight grown between January and October.

large and negative ($P<0.05$). The value of -0.84 for the correlation suggests that selection for dam NLB will be 55% as effective as selecting for reduced fat depth (Index P) after allowing for the estimated heritability of the 2 traits. It is not known whether this is a result of a redistribution of fat within the carcass or an actual reduction in carcass fat content.

Thompson (1982) drew attention to the fact that better lactating and more prolific breeds tend to have fat redistributed from the subcutaneous regions into internal depots. These breeds are also leaner at the same live weight, although this is probably influenced by their mature size. Bennett *et al.* (1984) has shown that long term selection for fecundity in sheep has resulted in small reductions in back fat thickness. Purser (1982) reported that sheep selected for long cannon bones had 20% higher fecundity (lambs weaned/ewes mated) and their lambs were leaner. Obviously further work should be done both in measurement of fat depth, carcass composition and fat distribution in experiments where selection for fertility has occurred.

The realised genetic correlation suggests little relationship between wool production as estimated by hogget fleece weight and Index P. In contrast the half sib estimate is significantly large and negative. A tentative interpretation is that the relationship is not antagonistic in the direction economically desired.

CONCLUSION

Although further work is imperative the results suggest that ultrasonically measured back fat thickness in young sheep is moderately heritable and suggests a large negative genetic correlation between fecundity as estimated by dam's number of lambs born and weight-adjusted back fat thickness.

The genetic relationships of wool production and weaning weight with back fat thickness at a constant live weight, while often not statistically significant, suggest no major antagonisms between selection for reduced fat depth and these traits if animals are slaughtered at a constant weight.

The implication is that present recording systems in New Zealand exemplified by Sheeplan may be indirectly selecting for leaner progeny if animal selection is based on the index values provided.

ACKNOWLEDGEMENTS

The advice of Dr G. L. Bennett and the assistance of C. D. Mathieson, M. V. Howarth and K. J. Knowler is gratefully acknowledged.

REFERENCES

Baker R. L.; Clarke J. M.; Carter A. H.; Diprose G. D. 1979. Genetic and phenotypic parameters of New Zealand Romney sheep. *New Zealand journal of agricultural research* **22**: 9-21.

Bennett G. L.; Johnson D. L.; Kirton A. H. 1982. Genetic variation of Southdown lamb carcass traits. New Zealand Ministry of Agriculture and Fisheries Agricultural Research Division annual report. p. 33.

Bennett G. L.; Clarke J. M.; Rattray P. V.; McLean K. S. 1984. Relationship of subcutaneous fat depth and weight changes induced by stocking rate in four lines of lambs. *Proceedings of the New Zealand Society of Animal Production* **44**: 215-218.

Botkin M. P.; Field R. A.; Riley M. L.; Nolan J. C.; Roehrdasse G. P. 1969. Heritability of carcass traits in lambs. *Journal of animal science* **29**: 251-255.

Coop I. E.; Clark V. R.; Jay N. P. 1979. Fat content of heavyweight lamb carcasses of several breeds and crosses. *New Zealand journal of experimental agriculture* **7**: 103-6.

Gooden J. M.; Beach A. D.; Purchas R. W. 1980. Measurement of subcutaneous back fat depth in live lambs with an ultrasonic probe. *New Zealand journal of agricultural research* **23**: 161-5.

Harvey W. R. 1977. Users Guide for LSML 76 Mixed Model Least Squares and Maximum Likelihood Computer Program. Ohio State University.

Kirton A. H.; Clarke J. N.; Hickey S. M. 1982. A comparison of the composition and carcass quality of Kelly and Russian castrate, ram, wether, and ewe lambs. *Proceedings of the New Zealand Society of Animal Production* **42**: 117-118.

Kirton A. H.; Carter A. H.; Clark J. N.; Sinclair D. P.; Jury K. E. 1974. Sires for export lamb production. *Proceedings of the Ruakura Farmers' Conference* 29-41.

Purser A. T. 1982. Implications of sheep selection experiments. Proceedings World Congress Sheep and Beef Cattle Breeding, Vol. 1: Eds, R. D. Barton and W. C. Smith. Dunmore Press, Palmerston North, New Zealand. Page 239-248.

Thompson J. M. 1982. Genetic manipulation of fatness in lamb carcasses. *Proceedings of the Australian Society of Animal Production* **14**: 54-57.

Turner H.; Young S. S. Y. 1969. Quantitative Genetics in Sheep Breeding, MacMillan, Australia.

Wolf B. T.; Smith C.; King J. W. B.; Nicholson D. 1981. Genetic parameters of growth and carcass composition in crossbred lambs. *Animal production* **32**: 1-7.

Wood J. D. 1982. Factors controlling fat deposition in meat animals. *Proceedings of the New Zealand Society of Animal Production* **42**: 113-116.