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.

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/

Proceedings of the New Zealand Society of Animal Production 1984, Vol. 44: 243-247

Expected selection responses in lamb carcass composition and weight

G. L. BENNETT and J. N. CLARKE

Ruakura Animal Research Station
Ministry of Agriculture and Fisheries, Hamilton

ABSTRACT

Expected rates of genetic change in lamb growth and composition were calculated for 2 different selection goals; increase in lean growth rate (LRG) and decrease in weight-adjusted % fat (APF). Carcass fatness was measured in a number of ways on an animal's own or its relatives' performance. Under either selection goal, all selection programmes resulted in reduced APF and increased carcass weight. When the goal was LGR, none of the selection programmes reduced % fat adjusted for age. All selection programmes for either selection goal improved lean weight but there was little improvement over selection for live weight alone. Alternatively, use of fat measurements did not decrease lean weight improvement and resulted in leaner carcasses. Changing carcasses from 13.5 kg and 25% fat to at least 15 kg and no more than 24% fat was most quickly achieved by selecting against APF.

Keywords Sheep; carcass; genetic change; selection; fat; growth; ultrasound; specific gravity; clones

INTRODUCTION

Selection responses in lamb carcass weight and composition depend on the usual factors—heritability, selection intensity and generation interval (Dickerson and Hazel, 1944). However, selection responses for leanness and weight are also affected by accuracy of the lean measurement and by the allocation of selection emphasis between growth and leanness. Various tools are or will be available to breeders. These include the simple measures of weight and linear fat depth up to the developing technologies of computerised tomography (CT) scanning (Skjervold *et al.*, 1981) and splitting embryos to make clones (Willadsen, 1979). Any combination of emphasis on growth and leanness is possible. The appropriate combination depends on the reason for selling lambs (age, weight or fatness), what a farmer is paid for (carcass or lean weight) and the cost of producing the lamb (Bennett and Kirton, 1983). Biological objectives such as lean tissue growth rate have been suggested as a way to overcome short-term fluctuations in product prices and input costs (Fowler *et al.*, 1976), but this has been questioned by Tess *et al.* (1983).

This paper compares some predicted selection responses contrasting the effects of different selection objectives, selection programmes and measures of carcass composition. Two selection objectives, lean growth rate (LGR) and fat % adjusted for weight (APF), are compared for their effects on the close relationship between weight and fat that characterises animal growth and development. Selection programmes compared are own, sib, progeny and clone performance. Composition measurements compared as selection criteria are ultrasonic loin fat depth (UFD), carcass rib tissue depth (GR), carcass specific gravity (CSG) and for clones, carcass APF.

METHOD

Numerous assumptions are necessary to make predictions of selection responses. Heritabilities and genetic correlations in Table 1 for live weight (LWT), carcass weight (CWT), APF, loin fat depth (CFD), GR and eye muscle area (EMA) are based on a review of the literature and unpublished data from Ruakura. Heavy emphasis was placed on the results of Botkin *et al.* (1969), Botkin *et al.* (1971), Wolfe *et al.* (1981) and unpublished Ruakura data on Southdown × Romney lambs. Each of these studies had 45 to 65 sires and included measurements of fat on half carcasses. Within-animal regressions of traits on age were from the Ruakura data in which lambs were slaughtered weekly as they reached randomly pre-determined slaughter ages of 21 or 26 weeks. Differences between the 2 slaughter ages were divided by 35 to estimate average within-animal development change/d. Between-animal phenotypic variances were also estimated from these lambs.

UFD and CSG were included as possible selection criteria. Few reports on the genetic relationships of these criteria with carcass fat are available. A combination of assumptions and phenotypic relationships was used to synthesise the genetic parameters for UFD and CSG found in Table 1. UFD and CFD were assumed to measure the same thing, i.e., true loin fat depth. Assumed correlations of CFD and UFD with true loin fat depth were 0.9 and 0.8 respectively, yield-

TABLE 1 Genetic parameters assumed in calculations (heritabilities on diagonal, phenotypic correlations above and genetic correlations below).

	LWT	CWT	APF[a]	CFD or GR[a]	EMA[a]	UFD[a]	CSG[a]
LWT	.25	.95	.00	.00	.00	.00	.00
CWT	.95	.25	.00	.00	.00	.00	.00
APF[a]	−.25	−.25	.35	.50	−.15	.45	−.70
CFD or GR[a]	−.10	−.10	.55	.30	−.15	.72	−.39
EMA[a]	.00	.00	−.30	−.30	.30	−.13	.12
UFD[a]	−.10	−.10	.55	1.00	−.30	.24	−.35
CSG[a]	.25	.25	−1.00	−.55	.30	−.55	.21
σ_P[e]	3.27 kg	.179 kg	3.09%	.93mm[b]	.67sq cm	.67mm	.90[d]
Average within-animal regression on age (/d)	.1131 kg	.0641 kg	.1122[c] %	.0329[bc] mm	.0301[c] sq cm	.0329[c] mm	−.0468[cd]

[a] Adjusted for weight by slaughter allocation or by the estimated within animal regression.
[b] Refers to CFD only.
[c] Not adjusted for weight.
[d] CSG × 100.
[e] Phenotypic standard deviation.

ing a phenotypic correlation of 0.72 between them. CSG and APF were considered to measure the same thing, i.e., true chemical fat. This is an unsubstantiated assumption and probably over-values CSG as a selection criteria. Assumed correlations of APF and CSG with true chemical fat were 0.95 and −0.74 respectively, resulting in a phenotypic correlation of −0.70. The regression of CFD on UFD was assumed to be 1.0, and the regression of APF on CSG was assumed to be 240. Heritabilities, genetic correlations and phenotypic variances and correlations were derived from these assumptions.

Selection objectives were APF and a linear approximation of LGR derived as: 0.51375 CWT − 0.135 APF. The approximation is based on an average carcass weight of 13.5 kg with an average of 25% fat. The 0.51375 is the marginal increase in non-fat CWT/kg change in CWT and −0.135 is the change in non-fat CWT/1% increase in APF at the average carcass weight.

To quantify annual selection responses for large breeding flocks it was assumed that 1 sound ram lamb or 1 sound 2-tooth ewe were produced for each ewe mated and that 15% died or became unsound in each succeeding year of use. Ram lambs were assumed to be able to mate 40 ewes and 2-tooth rams were assumed to mate 70 ewes. Some selection programmes used outside flock ewes to produce half-sibs or progeny for slaughter only. The number of flock ewes used did not affect the total number of stud ewes.

The 8 selection programmes studied were selection on:

1. Own live weight (OLW): The top 5% of ram lambs and top 70% of 2-tooth ewes are selected on the basis of own LWT.
2. Own ultrasonic loin fat depth (OUF): All ram lambs are measured for UFD. The top 5% of ram lambs are selected on an index of LWT and UFD. The top 70% of 2-tooth ewes are selected on LWT.
3. Sibs' ultrasonic fat depth (SUF): All rams and ewes are measured for UFD. The top 5% of ram lambs and 70% of 2-tooth ewes are selected on an index of LWT, UFD, half-sib LWT and half-sib UFD.
4. Sibs' carcass rib tissue depth (SGR): Selected ram lambs are mated to 20 stud and 20 flock ewes. All progeny from flock ewes are slaughtered. Selection of the top 10% of ram lambs and 70% of 2-tooth ewes is on an index of LWT, half-sib GR and half-sib CWT.
5. Sibs' specific gravity (SSG): Same as SGR except selection based on LWT, half-sib CSG and half-sib CWT.
6. Progeny test rib fat depth (PGR): The top 13.5% of ram lambs based on LWT, are mated to 20 flock ewes and the progeny slaughtered. Selection of the best 25% of progeny tested rams for 2-tooth mating is based on an index of progeny CWT, and progeny GR. The best 70% of 2-tooth ewes based on LWT are selected.
7. Progeny test specific gravity (PSG): Same as PGR except progeny tested sires are selected on an index of progeny CWT and progeny CSG.
8. Clone % fat (CPR): We assume that identical twins can be reliably produced by splitting embryos. The best 50% of 2-tooth ewes are chosen on an index of LWT, and UFD and are assumed to produce male clones with a probability of 40%. At birth, 1 of each male clone

is selected at random for slaughter at about 6 months of age. Carcasses from slaughtered males are minced for APF and the best 25% of clone ram lambs are selected on the basis of CWT and APF. The best 70% of 2-tooth ewes on the basis of LWT and UFD are retained in the breeding flock.

Equilibrium rates of response were calculated assuming a multivariate normal distribution. Effects of initial and continued selection on the multivariate distribution were ignored (Dickerson and Hazel, 1944; Bennett and Swiger, 1980). Large flocks were assumed to allow for maximum selection intensity with negligible increases in inbreeding. Ten years of response were determined by dividing 10 times the average superiority of sires and dams by their average age at the birth of their progeny.

RESULTS

Expected results of 10 years of selection are shown in Table 2. When interpreting these results it is important to realise that weight and age adjusted changes do not occur simultaneously and only simultaneously occurring results have financial rewards. Responses in APF and EMA were calculated on a carcass weight adjusted basis using estimates in Table 1. Ratios of the within-lamb regressions of APF and EMA on age to the within lamb regression of CWT on age (Koch *et al.*, 1982) were used to derive age adjusted results. Non-fat carcass weight (Lean) was calculated by difference from the expected carcass weight and expected % fat adjusted for age.

The interrelationships of CWT, % fat and age are shown in Figure 1. The slope of the line is the ratio of the average within-animal regressions of % fat and CWT on age and is an indication of the average % fat linear developmental trend over a 30-day period. Other lines represent expected CWT and % fat over the same 30-day period in flocks selected for 10 years. Age adjusted results can be compared by using the midpoint of each line, APF can be compared in the vertical direction and CWT adjusted for % fat can be compared along a horizontal line.

Expected changes in age adjusted weight and carcass weight adjusted EMA and APF are favourable under all selection programs and both selection goals

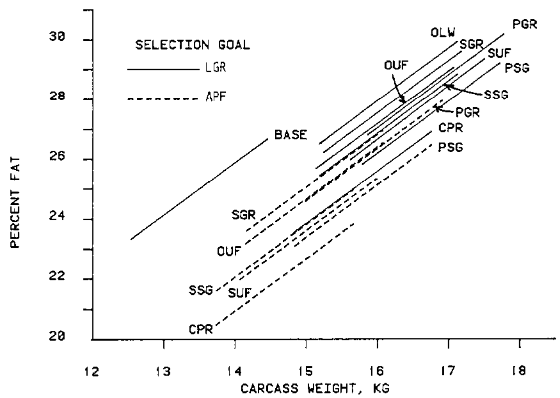

FIG. 1 Average within-animal developmental interrelationships of CWT and % fat over a fixed 30-day period following 10 years of selection using different selection schemes (see text) and objectives (LGR and APF).

TABLE 2 Expected genetic responses to 10 years of selection for LGR or against APF adjusted for CWT. See text for definitions.

Selection programme	Objective	Age adjusted				CWT adjusted	
		CWT (kg)	Fat (%)	EMA (sq cm)	Lean (kg)	APF (%)	EMA (sq cm)
OLW	any	2.7	3.2	1.25	1.5	−1.4	.00
OUF	APF	1.6	−.2	1.01	1.2	−3.0	.25
	LGR	2.6	2.4	1.31	1.6	−2.2	.09
SUF	APF	1.5	−1.3	1.09	1.4	−4.0	.37
	LGR	3.1	2.7	1.57	1.9	−2.7	.12
SGR	APF	1.6	.3	.96	1.2	−2.6	.20
	LGR	2.7	2.9	1.32	1.6	−1.8	.05
SSG	APF	1.2	−1.7	.77	1.2	−3.8	.21
	LGR	2.7	2.1	1.33	1.6	−2.5	.07
PGR	APF	2.4	1.3	1.35	1.6	−3.0	.20
	LGR	3.3	3.5	1.62	1.9	−2.3	.06
PSG	APF	2.3	−.2	1.27	1.8	−4.2	.19
	LGR	3.3	2.5	1.63	2.0	−3.2	.10
CPR	APF	1.2	−2.9	.88	1.3	−5.0	.32
	LGR	2.3	.2	1.26	1.7	−3.8	.18

(Table 2). Age adjusted EMA and Lean increased favourably for all selection programs and both selection goals. However, age adjusted % fat tended to increase with selection for LGR because CWT increased and less emphasis was placed on fatness.

Selection for APF was improved by the use of UFD measured on rams only or on rams and ewes. Using slaughter sibs' fat depth information (SGR) gave similar results to OUF while use of the more accurate CSG decreased APF about as much as SUF. PGR and PSG resulted in APF decreases similar to those for OUF and SUF, respectively; however, they also had greater increases in CWT. CPR was the most effective selection programme for reducing APF.

Selection for LGR by OUF, SGR, SSG and CPR compared to OLW resulted in only 5 to 15% improvement in Lean. SUF, PGR and PSG resulted in 25 to 35% improvements in Lean compared to OLW, but this was primarily due to increased carcass weight and not reduced APF. In other words, using sib or progeny information on LWT alone would probably give nearly the same increases in Lean.

DISCUSSION

The choice between LGR and APF is perplexing. LGR is the choice for reducing the per animal related production costs per unit of carcass lean, but APF is related to the price and saleability of the meat. One can take the stance that LGR is the sole objective in which case the various carcass fat measures contribute little to increasing LGR. Alternatively, one can say that LGR selection using fat measurements does not decrease LGR yet results in a superior carcass. The extra cost of making these measurements has to be balanced against the rewards for superior carcasses.

Another way of looking at the problem is to see which goal produces the desired changes in weight and fatness. Frazer (1983) has suggested that carcasses should be increased by 1.5 kg while reducing the fat in these carcasses by 1%. Jointly these changes are equivalent to a decrease of 3.63% in APF.

TABLE 3 Years required to reach desired genetic changes of a 1.5 kg increase in CWT and a decrease of 3.63 % in APF.

Selection programme	APF: CWT	APF: APF	LGR: CWT	LGR: APF
OLW	5.6	25.4[a]	5.6	25.4[a]
OUF	9.3	12.0[a]	5.8	16.5[a]
SUF	9.8[a]	9.0	4.9	13.2[a]
SGR	9.2	14.1[a]	5.5	19.7[a]
SSG	12.5[a]	9.5	5.6	14.3[a]
PGR	6.1	12.0[a]	4.5	15.8[a]
PSG	6.5	8.5[a]	4.6	11.3[a]
CPR	12.6[a]	7.3	6.5	9.6[a]

[a] The most time-consuming response for each selection goal and selection programme.

Table 3 gives the years it would take to reach these desired changes assuming that seasonal pasture growth requires that the 1.5 kg increase in CWT be put on by the same age as lambs are now slaughtered. The desired change in APF was generally the most rate limiting, especially under the LGR objective. For all selection programmes except CPR, selection against APF jointly achieved the desired changes sooner. CPR reached the desired changes sooner by selection for LGR.

When interpreting the results of this paper it is important to remember that numerous assumptions were made. These assumptions affect OLW, SGR, PGR and CPR less than OUF, SUF and PSG. It was further assumed that maximum selection intensity was possible and there was no selection for other important traits. It should also be remembered that the fat measurements are only effective when combined with age structures and selection intensities that take advantage of their capabilities. For instance, cloning does not inherently reduce fat but it does provide for the opportunity to select against fat.

REFERENCES

Bennett G. L.; Kirton A. H. 1983. What our meat breeds have to offer. *Proceedings of the Ruakura farmers' conference* **35:** 25-27.

Bennett G. L.; Swiger L. A. 1980. Genetic variance and correlation after selection for two traits by index, independent culling levels and extreme selection. *Genetics* **94:** 763-775.

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

Botkin M. P.; Riley M. L.; Field R. A.; Johnson C. L.; Roehrkasse G. P. 1971. Relationship between productive traits and carcass traits in lambs. *Journal of animal science* **32:** 1057-1061.

Dickerson G. E.; Hazel L. N. 1944. The progeny test as a supplement to earlier culling in livestock. *Journal of agricultural research* **69:** 459-476.

Fowler V. R.; Bichard M.; Pease A. 1976. Objectives in pig breeding. *Animal production* **23:** 365-387.

Frazer A. E. 1983. The quantities and types of sheepmeat required. *Proceedings of the Ruakura farmers' conference* **35:** 7-10.

Koch R. M.; Cundiff L. V.; Gregory K. E. 1982. Heritabilities and genetic, environmental and phenotypic correlations of carcass traits in a population of diverse biological types and their implications in selection programs. *Journal of animal science* **55:** 1319-1329.

Skjervold H.; Gronseth K.; Vangen O.; Evensen A. 1981. *In vivo* estimation of body composition by computerized tomography. *Sanderdruck aus Zeitschrift fur Tierzuchtung und Zuchtungsbiologie* **98:** 77-79.

Tess M. W.; Bennett G. L.; Dickerson G. E. 1983. Simulation of genetic changes in life cycle efficiency of pork production. II. Effects of components on efficiency. *Journal of animal science* **56:** 354-368.

Willadsen S. M. 1979. A method for culture of micromanipulated sheep embryos and its use to produce monozygotic twins. *Nature* **277**: 298-300.

Wolfe 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.