ECONOMIC BENEFIT OF INCLUDING COMPUTED TOMOGRAPHY MEASUREMENTS IN A LARGE TERMINAL SIRE BREEDING PROGRAMME

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SUMMARY

The marginal economic benefit of incorporating computed tomography (CT) into a terminal sire breeding programme was estimated for an operation with a 1400 ewe nucleus generating rams for use over 100,000 commercial ewes. A mating ratio of 1:80 was used for both flocks. Sires for the nucleus were used as ram lambs for a single year. Commercial rams were first used as two-tooths for three years. Selection intensities for rams and ewes in the nucleus were 2.41 and 0, and generation intervals 1 and 3 years, respectively. Genetic and phenotypic parameter estimates from Waldron *et al.* (1992) and parametric bootstrapping were used to generate a probability distribution for breeding index improvement of carcass traits using selection based on CT relative to ultrasonics. The REVs used were +\$6.00 and -\$5.00 per kilogram of lean and fat, respectively. Internal rates of return (IRR) were calculated for the cumulative probability distribution. Two-stage selection, using ultrasonics first and CT on a subset second, was optimised using "NEWSTAGE" (Wade and James 1996). The costs of ultrasound and CT scanning were set to \$3 and \$270 per head, respectively, for the NEWSTAGE analysis. A gene flow model was used to account for transfer of the improved genetics from the nucleus to the commercial flock. The optimal proportion of ram lambs to CT scan was determined to be 13 percent of rams born. For a single year's investment (i.e. one year's CT scanning) the cumulative net present value was positive by year three (evaluation occurred in year zero) and was near maximal by year ten. The risk of incorporating CT into a large terminal sire breeding programme was estimated as a 0.07 probability of making an IRR of less than ten percent.

Keywords: Computed tomography, *Ovis aries*, two stage selection, terminal sire, carcass composition

INTRODUCTION

Computed tomography (CT) scanning of sheep for genetic improvement of carcass growth and composition is generally accepted as offering considerable benefit over the use of ultrasonics (Jopson *et al.* 1995; Young *et al.* 1996). While the magnitude of these gains is significant, the measurement costs of CT relative to ultrasonics are also markedly greater. The actual economic benefit to the farmer will depend on a number of factors including selection intensity, generation interval and the design of breeding structures to disseminate improved genetics. Similarly, discount rate and errors in estimation of heritabilities and phenotypic and genetic correlations for carcass quality traits will also affect the magnitude of the economic benefit. Finally, the cost of CT scanning in New Zealand is prohibitive for CT scanning all ram lambs in a nucleus. A two-stage selection process using ultrasonics and then CT on a reduced set of rams has previously been proposed as an efficient use of CT (Jopson *et al.* 1995). Proportions scanned in each selection stage also required optimisation.

This paper examines the economic benefit of including CT into an existing large vertically integrated terminal sire breeding programme. Proportions of rams evaluated by CT were optimised. Sensitivity of the results to discount rate and imprecise genetic parameter estimates were also examined.

MATERIALS AND METHODS

Carcass trait genetic and phenotypic parameter estimates from Waldron *et al.* (1992) were used to estimate the genetic gain by selecting directly for carcass lean and fat compared to ultrasonic linear measures as described in Jopson *et al.* (1995). Selection based on CT lean and fat was assumed to be equivalent to direct selection on carcass muscle and fat (Afonso 1992). Parametric bootstrapping (Efron 1982) was applied to generate 10,000 new sets of genetic and phenotypic parameter estimates based on the original estimates as described in Jopson *et al.* (1995). REVs of +$6.00 and -$5.00 per kilogram for carcass lean and fat, respectively, were used to calculate the economic benefit of the index and were based on REVs currently in use for terminal sire breeds by the New Zealand Animal Breeding Trust (J.N. Clarke *pers. comm.*). The indices from each iteration of the bootstrap were used to calculate a probability distribution function (pdf) of the additional benefit per unit of selection intensity for using CT compared to ultrasonic linear measures.

Two-stage selection, using ultrasonics on a proportion of animals and then CT on a subset of these, was optimised using "NEWSTAGE" (Wade and James 1996), a program to optimise the allocation of limited resources in a one- or two-stage selection process. For the analysis, ultrasonic and CT scanning costs were set to $3 and $270 per head, respectively, and parameter estimates from Waldron *et al.* (1992) used. Gene flow was used to calculate the net present value (NPV) of the marginal benefit of incorporating CT into a breeding programme for a single year of selection with a ten year horizon. The breeding structure used was similar to that of the Landcorp Lamb Supreme breeding programme (Nicoll 1995). Briefly, a nucleus of 1400 ewes was used to generate rams for subsequent use over 100,000 commercial ewes with all progeny slaughtered. Sires for the nucleus were ram lambs used for a single year. Commercial rams were first used as two-tooths for three years. Mating ratios were set at 1:80 for both flocks. Reproductive rates were 114% available for selection per ewe mated for the nucleus, and 100% lambs sold per ewe mated in the commercial flock. Selection intensity for rams in the nucleus was 2.41. Ewes in the nucleus were assumed to be randomly selected so selection intensity was zero. Generation interval was 1 year for rams and 3 years for ewes. Cumulative return over the ten year period was calculated between 5 and 15% discount rates. The effects of errors in the genetic and phenotypic parameter estimates on the NPV of the operation were examined by calculating the internal rate of return (IRR) for the pdf generated by bootstrapping.

Table 1. Percentiles of the probability distribution for the marginal benefit per nucleus progeny per unit selection intensity for a breeding index of CT compared to ultrasonics

Percentile	5%	25%	50%	75%	95%
Index improvement	$0.10	$0.58	$1.41	$2.62	$4.72

RESULTS

The NEWSTAGE analysis indicated that the optimal allocation of resources between selection stages was to ultrasonically scan all ram and ewe lambs in the nucleus, and to subsequently CT scan 13% of ram lambs. For a single year of CT scanning, the additional investment in year 0 would therefore be around $27,300. The breeding index improvement pdf generated by parametric bootstrapping for CT over ultrasonics was skewed to the right (Table 1). Using the median value for the pdf, the cumulative returns calculated for discount rates ranging between 5 and 15% are presented in Figure 1. Revenue was positive by year three for all discount rates tested, with diminishing returns continuing for each year until at least year ten. At a 10% discount rate the NPV of the gross margin for incorporating CT into a breeding program currently using ultrasonic scanning was $257,000 over ten years. A reduction in discount rate gave a greater profit in year three and throughout the entire ten year period.

The distribution of IRR was found by transforming the pdf of marginal benefits (obtained by bootstrapping) and the results are presented in Figure 2. This resulted in a distribution that was skewed to the left. The probability of achieving less than the desired IRR is defined as the risk (Forbes 1984). The dashed lines in Figure 2 indicate the probability for IRR ranging from 10 to 40%. Probability of the IRR being less than 10, 20, 30 or 40% was 0.07, 0.20, 0.50 or 0.94, respectively.

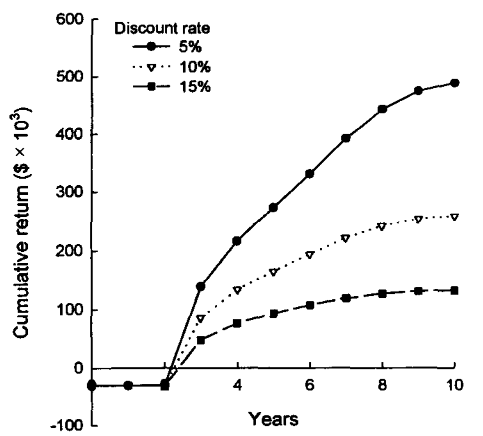

Figure 1. Return for a single year of selection using CT at various discount rates.

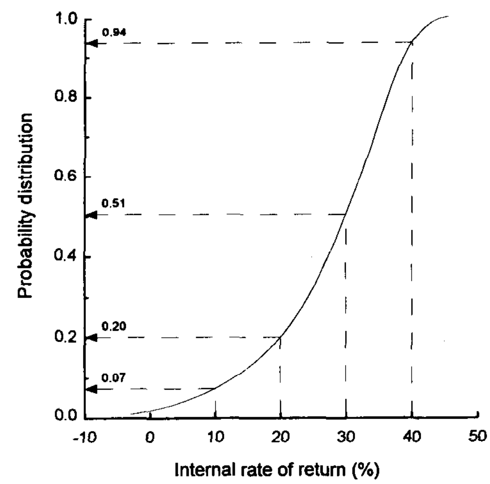

Figure 2. Probability of IRR for including CT in a large terminal sire breeding program.

DISCUSSION

Uncertainty in the underlying assumptions of an economic evaluation generates risk and requires careful evaluation to determine the sensitivity to these factors. In the current evaluation, a pdf was generated to estimate the risk involved in using imprecise genetic and phenotypic parameter estimates. This was undertaken for the following reasons. The results presented here are marginal benefits, i.e. the benefit estimated for CT compared to that estimated for ultrasonics. As such, the errors are amplified because errors are associated with genetic parameters used for both scanning techniques. Secondly, increasing lean and decreasing fat is genetically antagonistic. Therefore, small errors in the estimation of relationships between these traits may have a large influence on the NPV. Finally, the parameter estimates of Waldron *et al.* (1992) were calculated from a relatively small sample size of 1500 progeny from 105 Romney and Romney-cross sires. In spite of this, risk due to any imprecision in the parameter estimates of Waldron *et al.* (1992) in the breeding program described above is relatively low. For example, the probability of making an IRR of less than 20% was 0.20, and few genetic improvement programmes achieve this IRR. Variability in economic values for lean and fat was not examined. Considerable annual variation has been reported in New Zealand (Waldron *et al.* 1991) but the lean to fat price ratio has remained relatively stable. The ten year horizon over which the benefits are captured will have an averaging effect on the REVs meaning that unfavourable REVs in any given year will not have as large an effect as might otherwise be expected.

CT scanning is obviously profitable in a large scale breeding operation. Scale of enterprise has a number of advantages including being able to use expensive evaluation tools like CT (Nicoll 1995). However, the majority of the benefits are probably captured through having a vertically integrated breeding structure, so as to rapidly move the improved genetics from the nucleus into the commercial flock and harvest the resulting progeny. Also, the example evaluated had a high selection intensity and short generation interval. The benefits are likely to be reduced with lower selection intensity, longer generation interval or lack of vertical integration. The influence of selection intensity, generation interval and breeding structure on the cost benefit analysis requires careful examination. Thompson *et al.* (1996) reported that increased scale of enterprise resulted in a shorter period to neutral dollars and increased profitability at 15 years. Estimate variability, discount rate and two-stage selection were examined in this study. The effect of all factors should be considered together in subsequent work.

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