OPTIMISING RECORDING STRUCTURES OF A BEEF CATTLE BREEDING SCHEME

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SUMMARY
The recording and age structure of a commercial breeding scheme was optimised using a genetic algorithm. Genetic merit of the breeding program with selection on best linear unbiased prediction (BLUP) was estimated deterministically using a multiple-trait selection index approach. This approach accounted for the loss in variance due to selection and the build up of pedigree over generations. Traits examined were feed intake, tenderness and growth. Particular attention was paid to the recording structure for feed intake, a major contributor to genetic gain and recording costs. A multiple stage selection approach was applied to select sires for use in the nucleus. Assuming cost of central testing for feed intake is $500 per sire, it would be profitable to test the best 30 sires per year. A combination of performance and progeny testing sires would be optimal if the cost testing each of the progeny of a sire was less than $100.
Keywords: Optimisation, breeding schemes, beef cattle, differential evolution

INTRODUCTION
Traditionally Australian beef breeding schemes have focused on recording of, and selection upon, growth, fertility and more recently real time ultrasound scans. Current interest in the efficiency of feed utilisation and an increase in consumer focus has led to inclusion of tenderness and feed intake in the breeding objective (Charteris *et. al.* 2000). However, both these traits are expensive to measure in comparison to current selection criterion traits (Archer and Barwick, 2001). Estimates of the cost of recording feed intake vary depending on whether performance is measured on-farm or in central test stations. Archer and Barwick (2001) estimated that central testing cost approximately $500 per sire. It is expected that testing on-farm may be cheaper, particularly in a vertically integrated system where progeny of the tested sires are already destined to be finished on a grain diet. In this situation the cost of grain feeding would not be incurred as a direct cost of the progeny test.

Recording performance of sires for feed intake as a selection criterion for Australian beef sires at an industry level is warranted (Archer and Barwick 2001). They also found that a combination of performance and progeny testing the same sires was not profitable. But their approach did not allow for more than two stages of selection. It would be expected that progeny testing a subset of performance tested sires, for use in the breeding nucleus, would be more profitable than selecting sires on performance test only. The current study includes four stages of selection, firstly the number of sires to performance test for feed intake, secondly number to progeny test for feed intake, thirdly tenderness progeny test and lastly selection of sires for use within the nucleus in a vertically integrated beef breeding operation.

MATERIALS AND METHODS
Differential evolution (DE) was used to find the maximum net return from recording feed intake and tenderness in a vertically integrated beef scheme. The function maximised consisted of cumulative

genetic merit returned from the breeding scheme during 20 years, minus the cost of recording feed intake and tenderness measurements. Figure 1 provides an overview of the records collected on nucleus cattle and the age at which sires and dams produced progeny. Weight records were collected on all animals within the nucleus and all progeny tested animals. Additionally where feed intake was measured on sires they were available for breeding at three years of age, whilst sires were 5 years of age before progeny test results were available. Sires with progeny information for tenderness were selected from sires progeny tested for feed intake.

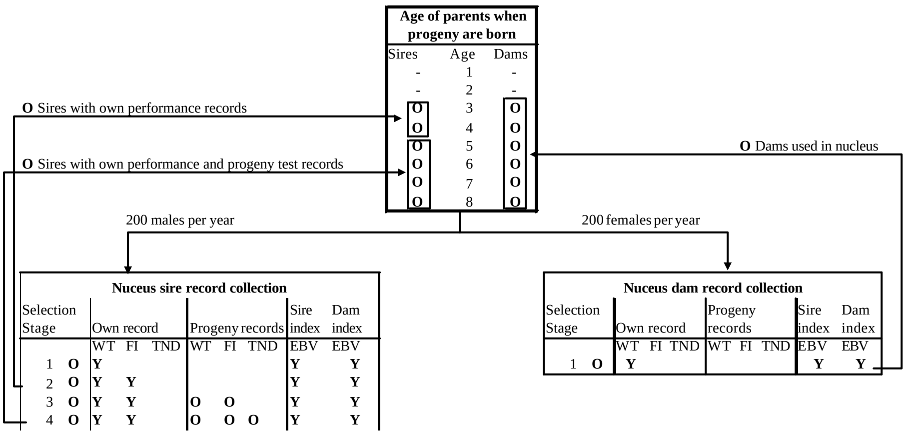

Figure 1. Records collected (Y) from nucleus sires and dams at each stage of selection, and age (years) at which they produced progeny. Traits recorded included 400 day weight (WT), feed intake (FI) and tenderness (TND). Parameters optimised (O) included age of parents when progeny were born, number of sires in each selection stage and number of progeny records.

DE was used to optimise the following parameters; the age structures for males and females, the number of sires to performance and progeny test, and progeny testing capacity. Progeny test capacity was the total number of progeny born in the commercial herd which were produced with the specific aim of evaluating the performance of their sire. From these parameters the cumulative genetic merit and cost of the breeding scheme were calculated. The cost of measurement included the cost of measuring a nucleus sire's own performance and performance of a sire's progeny for feed intake plus the cost of tenderness measurement. The economic weights and genetic parameters for feed intake were obtained from Ponzoni and Newman (1989) and Charteris et.al. (2000) for tenderness (Table 1).

The cumulative merit of each breeding scheme proposed was calculated in a number of steps. A multiple-trait approximation of BLUP selection was used to estimate variance of breeding values and the accuracy of selection indices as per Villanueva *et.al.* 1993. Variances and accuracies of the indices were used to estimate response to selection. Information sources in the selection index included half sib mean, accuracy of the EBV of the dam's half sibs, plus the individual's own record, accuracy of the sire's EBV, accuracy of dam's EBV and progeny. Where information was lacking the appropriate information source was removed from the index. The loss of variance due to selection and the accuracy of parental EBV were accommodated for in the multiple-trait selection index using the method described by Villanueva *et.al.* (1993).

Table 1. Genetic, phenotypic and economic parameters used

Trait	σ_P	h^2	Economic weight ($ per cow per year)	Genetic and phenotypic correlations (Phenotypic above diagonal)		
				400 Day WT	Feed Intake	Tenderness
400 Day weight (KG)	35	0.4	0.327	-	0.7	0.0
Feed Intake (KG)	140	0.4	-0.327	0.5	-	0.0
Tenderness (shear force KS)	1.02	0.35	-10.47	0.0	0.0	-

At each selection stage new records are added in the calculation of selection index, hence the indexes for each stage of selection are highly correlated. To account for the effect of the correlations between indices on selection intensity, under multiple stage selection the subroutines of Genz (1992) were used. The selection intensities and variances of the selection indexes were used to estimate the average genetic merit of each group from which the cumulative merit of commercial animals sold was calculated using a tabular method of gene flow (Meuwissen 1989). To examine the sensitivity of the breeding scheme to the cost of measuring feed intake the costs of recording own performance and collecting progeny records were varied independently. Tenderness measurement cost was fixed at $20 per animal tested and was measured only on progeny of selected nucleus sires. The objective to be maximised was the cumulative merit of the breeding program minus costs, expressed per commercial breeding female per year over 20 years.

RESULTS AND DISCUSSION

Table 2 presents the changes in optimal breeding scheme design, and cumulative net returns in the commercial herd, as the cost of recording feed intake is varied. These net returns represent an average annual genetic gain of between 0.45 to 0.37 genetic standard deviations. When recording costs testing the performance of a sire or each sires progeny increased, profit decreased. With increased costs per progeny test space the number of sires to be tested remained relatively constant, while the number of progeny tested per sire decreased. At current prices for recording feed intake of a sire ($500), a combination of performance and progeny testing should be considered when progeny testing is $100 or less per space.

At an industry level Archer and Barwick (2001) examined the profitability for either measuring sire feed intake performance or a combination of sire performance and progeny testing, however their approach did not allow for more than two stages of selection. Their study found it was most profitable to performance test 5-15% of sires. Additionally they found that progeny testing, whilst more profitable than not measuring feed intake was less profitable than performance testing alone. In agreement with Archer and Barwick (2001) our results suggest that for a breeding scheme supporting 15,000 commercial females per year, it is profitable to performance test for feed intake. A combination of performance and progeny testing would be warranted if the cost of progeny testing is below $100 per animal tested.

Table 2 Net returns from breeding program, number of sires with performance records and size of annual progeny test for different testing costs for feed intake

Own Performance Cost($/Head)	Progeny performance test cost ($/Head)			
	0	50	100	200
Cumulative net returns in commercial herd expressed over 20 years				
0	600	579	576	575
50	587	564	563	562
500	515	492	486	480
1000	499	477	471	462
5000	450	418	413	405
Number of bulls performance tested				
0	200	198	198	198
50	189	181	189	189
500	33	29	29	40
1000	19	21	21	21
5000	0	6	8	8
Size of progeny test				
0	1000	74	28	0
50	1000	61	25	0
500	1000	105	63	0
1000	1000	124	70	0
5000	1000	139	76	0

ACKNOWLEDGEMENTS
Thanks to Twynam Pastoral Company for financial support through the SPIRT scholarship scheme.

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