# AN ANALYSIS OF INVESTMENT IN ADVANCED BREEDING PROGRAM DESIGNS FOR BEEF CATTLE

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## SUMMARY
Investment in breeding programs incorporating two-stage selection and measurement of net feed intake (NFI) was assessed for designs using performance test information only, or including information from progeny tests. Both designs were profitable relative to a performance test scenario without NFI measurement. Profit from optimally designed performance tests (where 5% to 30% of candidate sires for the breeding unit were performance tested for NFI) was higher than profit from optimal progeny test designs (2% to 5% of candidate sires progeny tested). This suggests that progeny testing may not be justified when analysed at an industry-wide level. However, accuracy of selection and genetic gain were greater from progeny testing. Accounting for risk/return relationships and market share might mean that progeny testing is justified at the level of an individual business.
**Keywords:** Breeding program, selection, beef cattle, performance test, progeny test.

## INTRODUCTION
In the past, most beef cattle breeding programs involved comparatively low levels of investment in recording of criteria on which to base selection decisions. Typically, performance information on selection criteria (weight at strategically chosen ages, fertility and more recently ultra-sound scan measurements) were collected only on candidates for selection in seedstock herds. More recently, the level of investment in advanced recording programs being used by industry has increased markedly, with the incorporation of new, more expensive criteria traits in breeding programs (eg. measurement of feed intake), and a move towards recording of criteria on commercial animals in sire progeny tests. With higher levels of investment in breeding programs occurring, greater attention to breeding program design and economic analysis of alternative designs is warranted. This paper uses a model of investment in breeding programs to compare breeding programs utilising performance testing only (with and without measurement of feed intake) or a combination of performance and progeny testing.

## METHODS
"ZPLAN", a model of investment in breeding schemes described by Nitter *et al.* (1994), was used for the analysis. The breeding program modelled followed that described by Archer and Barwick (1999), and consisted of a two tier self-replacing population of 200,000 breeding cows, with 10,000 cows in the breeding unit and the remainder in the commercial unit. Genetic improvement was only generated in the breeding unit, and transferred to the commercial unit through the use of bulls selected from the breeding unit. Twenty bulls per year were selected for use in the breeding unit as AI sires, and each sire was used for an average of 2.5 years. Sires for the commercial unit were used by natural mating.

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The breeding objective was based on production of 650 kg liveweight steers fed for the high quality Japanese market where marbling is valued. Further details on the breeding objective are given by Archer and Barwick (1999) and Barwick *et al.* (1999). Phenotypic and genetic parameters used were from BREEDPLAN and from literature values where available. Feed intake traits were expressed as net (or residual) feed intake (NFI) for both the objective traits (intake of cows and growing progeny were treated as correlated traits (assumed $r_g$=.65) in the objective) and as a selection criterion. Parameters for net feed intake (NFI) were taken from two recent Australian studies of Arthur *et al.* (2001) and the CRC for Cattle and Meat Quality project (Johnston, Robinson and Reverter, unpublished results).

**Selection criteria and information sources.** The base model (Bull performance test – NFI) was chosen to represent a seedstock sector where most performance criteria currently available in BREEDPLAN V4.1 are routinely recorded on selection candidates. These criteria included weight (at birth, 200, 400 and 600 days of age and on mature cows), fertility traits (days to calving, calving difficulty score and scrotal size) and scan traits (fat depth at $12^{th}/13^{th}$ rib and P8 site, eye muscle area and percent intra-muscular fat, with separate criteria for bulls and heifers), but did not include NFI. Information sources included records on individuals, paternal half sibs, sire, dam, and half-sibs of the sire and dam. The number of animals in half-sib classes were calculated from relevant biological and technical co-efficients describing herd structure. Criteria recording costs were similar to those used by Graser *et al.* (1994).

**Modelled breeding program variations.** Two advanced breeding program designs were modelled to include additional levels of recording over and above the base model described. Both designs incorporated a two-stage selection process for choosing bulls for use by the breeding unit, and a sub-routine of Wade and James (1996) which calculates response under two-stage selection was adapted and incorporated into the Zplan code. The first design (Bull performance test + NFI) examined selection of sires for the breeding unit using individual performance information on NFI. After weaning, a proportion of bulls (from 2 - 30%) were selected using information available on the individual (weight at birth and 200 days) and on relatives. These bulls then had the criterion of NFI measured (at a cost of $300 per animal) in addition to weights, scan traits and scrotal size already measured in the base model. The top 20 of these bulls (based on an index including all available information on the individual and relatives) were selected as AI sires for the breeding unit, and first used at 2.5 years of age. All bulls were available for selection as sires for the commercial unit irrespective of whether they were chosen for measurement of NFI, but NFI measurements on individuals were not included in the index used to select commercial sires.

The second design (progeny test) examined selection of sires for the breeding unit based on a combination of performance and progeny-test information. Bulls for progeny-testing were selected later (at 400 days of age) and with more available information than bulls selected for performance testing, as fewer bulls are likely to be progeny-tested than performance tested. From 1% to 20% of bulls were selected for progeny-testing using an index with information on the individual (weight at birth, 200 and 400 days, scrotal size and scans) and relatives. These bulls were then performance tested for NFI and progeny-tested. The progeny test generated information on 10, 15 or 25 steer progeny per sire, including weights (at birth, 200, 400 and 600 days), scans, NFI during feedlot finishing (at $300 per steer) and carcass measurements (fat depth, dressing % and marbling score). It was assumed that heifers generated from the progeny test were retained with measurement of weights (as young heifers and as mature cows), scans and days to calving. The scan criteria measured on steers were assumed to be the same trait as those normally measured on heifers. As the progeny test was conducted under commercial conditions, NFI and carcass characteristics measured on progeny test steers were assumed to be the same trait as in the breeding objective. All other measures on progeny test or seedstock animals were treated as criteria correlated to the objective traits. After the progeny test was completed, sires for the breeding unit were selected from the tested bulls using an index of all available information, and first used at 5 years of age. Bulls for the commercial sector were selected at the same age and using the same individual information (although more information from relatives) as for the performance test only model.

**Model outputs.** The model calculated total costs (incurred in the breeding unit) and returns (obtained from the commercial unit) from a single round of selection, discounted over a 25 year investment horizon. Costs, returns and profit were expressed as $ per cow in the population. Annual genetic gain in the breeding objective was expressed as $ per year. Further details of the methods for calculating model outputs are given by Nitter *et al.* (1994).

## RESULTS AND DISCUSSION

Profit per cow from the breeding programs modelled are shown in Figure 1. The base model (Bull performance test – NFI) is given to represent the current "typical" breeding program where all bulls are performance recorded for standard criteria other than NFI, and are available for selection as breeding unit sires. The profit from performance testing including measurement of NFI and using two stage selection (Bull performance test + NFI) was greater than the base model when 2% to 30% of bulls were selected for NFI measurement, indicating that including a NFI performance test in a two-stage selection process is profitable. Moreover, the response in profit to varying the proportion of bulls tested was almost flat from 5% through to 30%. In contrast, profit from progeny testing was optimised when 2% to 5% of bulls are progeny tested, depending on the number of steer progeny tested per sire. Even at optimal levels, progeny testing was not as profitable as 2-stage performance testing including NFI, although it was still significantly more profitable than the base situation.

The greater profit achieved by the 2-stage performance test design was due to the lower recording costs of this program compared to the progeny test programs. The annual genetic gain (Figure 2) and the economic return (before accounting for costs) generated from progeny testing in the optimal range (3-5% of bulls tested) were greater than the performance test design. This result occurred despite the generation interval being 4.99 years for progeny testing compared with 3.74 years for performance testing. However the increase in return from extra levels of recording in the progeny-test design were not sufficient to offset the increase in costs above the 2-stage performance test design.

Comparison between 2-stage performance testing and progeny testing based on profit alone would suggest that progeny-testing should not be recommended for inclusion in industry breeding programs. However, other issues not covered by the model might influence the comparison when decisions are made by industry participants. One such issue is the potential to increase market share in an industry where ownership is fragmented with-in and across sectors. The annual genetic gain in the breeding objective generated from progeny-testing is higher than the genetic gain generated from performance testing (Figure 2). Thus individual breeders choosing to progeny-test and generate higher genetic gains may be able to increase market-share, and the investment in progeny testing may be justified after increased market share is accounted for. Thus optimal decisions on an industry-wide basis (as modelled here) are not necessarily optimal for individual businesses within a fragmented industry.

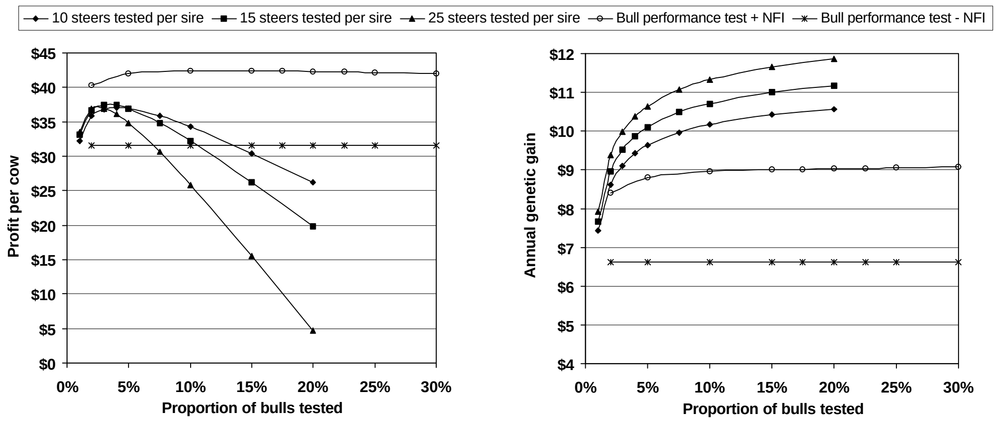


**Figure 1. Profit per cow for performance test and progeny test models.**

**Figure 2. Annual genetic gain in the breeding objective for performance test and progeny test models.**

A second issue to consider over profit alone is that of risk. While profit from including progeny testing in breeding programs is lower, the accuracy of selection is considerably higher. The index used to select sires for the breeding unit (after the second stage of selection) had a correlation with the breeding objective of 0.41 for performance testing, compared with 0.69, 0.74 and 0.79 for progeny-testing with 10, 15 and 25 steers per sire respectively. Thus returns (on an industry-wide basis) are likely to be less variable when progeny testing is used. However, deterministic models such as Zplan are generally not suited to incorporating risk in analysing investment decisions. This analysis has shown that increased investment in collecting information on a proportion of potential seedstock sires, whether by performance testing only or including progeny testing, is likely to be profitable at an industry-wide level. However, other models are required to better analyse the impact of investment at the level of individual businesses, and to incorporate assessment of returns relative to risk.

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