THE IMPACT OF COST RESTRICTIONS ON PREDICTED GENETIC GAIN IN A BREEDING PROGRAM UTILISING ADVANCED REPRODUCTIVE TECHNIQUES

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SUMMARY
The profitability of mate selection programs using reproductive technologies was investigated. A beef herd was used as a case study. Actual prices of semen and multiple ovulation and embryo transfer (MOET) were included and funds available for the breeding program varied to examine the effect on predicted genetic value of the program. Increasing the amount of money spent on artificial insemination (AI) greatly increased predicted progeny index. However, increasing the number of MOET progeny only marginally increased predicted progeny index. A cost-benefit analysis showed that this marginal increase in predicted progeny index values would not result in MOET being economically rational for this commercial cattle breeding operation.

Keywords: mate selection, breeding program design, cost.

INTRODUCTION
Advanced reproductive techniques in breeding programs have been used to increase genetic gain, although it also has the potential to increase cost and inbreeding rate. Toro et al. (1991) utilised mate selection to constrain inbreeding while using MOET, with no reference to the cost of implementing such a program. In 1991, computing capacity, algorithms for maximising complex functions and current genetic theory did not allow joint optimisation of inbreeding rate and genetic gain in large populations. By restricting the average relationships between selected animals, inbreeding rate can be restricted to a predetermined level (Muewissen 1997). If such an approach is extended to include mate selection, breeding programs can simultaneously consider genetic gain, inbreeding and crossbreeding by weighting the importance of each in a mate selection index (MSI) (Kinghorn and Shepherd 1999). It also becomes possible to include costs, management issues and other logistical constraints by penalising the MSI where such a constraint is broken.

The inclusion of these key components (genetic gain, inbreeding rate and cost) in an MSI can be used to answers some practical questions: what is the effect on progeny mean index of spending different amounts of money on the breeding program, and, given a set amount of capital, how is this most effectively used? With such information, a rational approach for a breeder to use when allocating matings in the herd is to maximise the return on each dollar spent in the mating program. This paper investigates the effect of increasing the funds available for seedstock and breeding costs on the predicted rate of genetic gain and profit in a beef herd, at a predefined rate of inbreeding.

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MATERIALS AND METHODS
Pedigree and selection index values of Angus cattle were obtained from the Twynam Pastoral Company Pty. Ltd. (TWYNAM). Selection index values were calculated using BREEDOBJECT (Barwick et al. 1992) with the index targeting the B3 Japanese market. A candidate list of 550 cows and an AI list including semen costs for 33 outside bulls was obtained from TWYNAM. For natural mating bull candidates, home bred two year old bulls were included at a nominal cost of $2000 each. This comprised an opportunity cost of not sending these bulls to commercial stations ($1000) and an additional management cost of $1000 per year. It was assumed that once a bull was retained in the home herd, its additional cost per mating was zero. Artificial insemination cost included two components; an operational cost ($40) that assumed a 60% success rate plus an individual dose cost for each sire. MOET cost consisted of an initial outlay for including a female for one round of MOET ($800) and a cost per calf incorporating the cost of synchronising recipients and embryo implantation ($340). The cost of MOET assumed that on average six embryos were obtained with a success rate of 50% of embryos implanted resulting in birth. A maximum of two rounds of MOET were permitted. The number of matings (planned pregnancies) was set at 100 and a 100% calving rate was assumed for simplicity.

As the index value is based on the returns in commercial operation, changes in index values in the nucleus do not truly represent returns to the operation as a whole. An approximate benefit value for changes in the index value in the nucleus was calculated. It was assumed that 50% of the male progeny were used in the commercial herd and each bull was mated for one year to 50 commercial cows. Then the dollar benefit to the enterprise as a whole for an index unit increase in the nucleus per mating in the nucleus would be as follows; 50 male calves x 50% selected x 50 matings each x 50% of genes transmitted to the progeny/ 100 matings in the nucleus = $6.25.

A MSI that weighted genetic gain (midpoint of parental index), inbreeding rate and cost was developed. The MSI maximisation was carried out through mate selection using the Total Genetic Resource Management (TGRM) program of Kinghorn and Meszaros (pers. comm. 2001). The MSI was penalised appropriately for mating sets that fail to meet either an inbreeding or cost constraint. Weightings were applied to these penalties to ensure that all constraints were met where possible.

RESULTS AND DISCUSSION
Figure 1 presents the relationships between realised cost, genetic gain and numbers of progeny born to various reproductive technologies. As the funds available increased so too did the predicted genetic gain. At the lowest possible breeding program cost, the predicted progeny merit index was $51.40. At this point only sires from the home herd were selected and it was not possible to meet the inbreeding rate constraint. As funds available were increased to $60 per mating, AI sires were used and the inbreeding constraint was met. After this point the inbreeding rate constraint was always achieved. The number of AI matings increased as the money spent on the breeding program increased. Once the amount of money spent on the breeding program reached $100 per mating, all calves were born to AI. After this point MOET matings began and increased slowly with the money spent. As the actual returns for gain are realised in the commercial operation it was necessary to model the effect of increasing genetic gain for the commercial tier of the operation (Figure 2).
Net returns per mating increased with increasing money spent on the breeding program up until $100 per mating (Figure 2). As MOET was not implemented until $150 per mating, this suggests that it may not be economically sensible to include MOET in this breeding program. As of $100 per mating, the net return decreases, with zero net returns reached at around $400 per mating (Figure 2).

Figure 1. Realised average cost per progeny and midpoint of parental index (index curve) and number of progeny born to various reproductive techniques (all other curves).

The current strategy examines the best use of resources with the target being average predicted progeny merit. As this approach does not account for the extra benefit from accumulation of genetic merit in the nucleus over generations, there may be circumstances where it is desirable to utilise reproductive technologies to change the predicted distribution of progeny, or use reproductive technologies in a tactical approach. In the long term, it may be desirable to produce a small number of elite progeny to produce natural mating bulls for back up matings in the nucleus. To evaluate the success of this strategy, another measure of the superiority of mating sets would be required and it may be necessary to predict forward and optimise over a longer time frame. With simple modifications, other cost issues such as cost of migrating stock between units and size of the nucleus herd to service commercial herds could also be included in the MSI.
IMPLICATIONS
Using the current approach, breeders can make an informed decision on the amount of money to be spent on their breeding program. The effect on progeny merit value of spending more or less on the breeding program can be evaluated. Once the funds available for the program are decided upon, the optimal balance of these technologies and a tailored mating list including these technologies can be produced. The use of AI and spending more money on AI has a large effect on predicted progeny merit. A crude-cost benefit analysis showed that MOET would not be economically rational in this breeding program. The incorporation of practical considerations such as cost should increase the uptake of new tools such as TGRM in practice.

Figure 2 Cost benefit and money spent on breeding program.

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