GENETIC AND ECONOMIC EVALUATION OF IGF-1 AS AN INDIRECT SELECTION CRITERION IN BEEF CATTLE

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INTRODUCTION

With the accumulation of substantial amounts of new information for the previously unmeasured trait insulin-like growth factor (IGF-1), it is timely to make an analysis of the benefits of selection using this information. Alternative breeding schemes for livestock need to be assessed for their efficiency in making genetic progress and for their return and profit for the investment made. Levels of IGF-1 in blood are phenotypically associated with a variety of traits including growth, body size, food conversion efficiency, milk production, and carcass characteristics (Davis et al., 1995).

Feed intake is an economically important trait but also expensive to measure. If an indirect trait has sufficient heritability, a high genetic correlation with feed intake and is less costly to measure, indirect selection might become a supplement to direct selection. The benefits of indirect selection using IGF-1 are not only dependent on the achievable response but also on the costs of recording the indirect selection criterion. The aim of the study is to compare the genetic gain, profit and response to varying selection strategies using direct selection and indirect selection on residual feed intake (RFI) and IGF-1 in association with other traits. For the evaluation of selection criteria in an economic context we used the computer program ‘ZPLAN’ (Karras et al., 1997).

MATERIALS AND METHODS

ZPLAN uses a deterministic approach to predict genetic gain considering the impact of one round of selection. The approach models the flow of genes from the breeding sector to the commercial sector and uses selection index theory to calculate genetic gain and the discounted economic benefits accrued over a specified time period, in this study 25 years.

Population structure. The population structure was similar to that previously described for the Australian beef cattle industry (Graser et al., 1994). A total population of 200 000 animals was modelled, with 5 % comprising the breeding unit. Selection only occurs in the breeding unit, with no outside replacements. The flow of genes occurs through the movement of bulls selected from the breeding nucleus to the commercial herd, 1 567 bulls are selected for use within the commercial unit each year. Twenty bulls per year are selected for use as AI sires within the breeding unit and used on average 2.5 years. Sires for the commercial unit are utilised by natural service for 3 years.

Breeding Objective. The breeding objective was based on production of 650 kg live weight steers for the high quality Japanese B3 market where a premium is paid for marbling and steers finished within a long-fed (200d+) feedlot production framework. Mature cow weight,
reproductive traits and other carcass traits also form an important part of the breeding objective. The breeding objective and derivation of economic values for RFI were described by Barwick et al. (1999).

**Selection criteria and information sources.** The base model constitutes the seedstock sector where neither RFI nor IGFI-1 is recorded on the selected animals. The selection criteria used include weight (200d, 400d, 600d and mature cow weight), fertility traits (days to calving, calving difficulty and scrotal circumference) and scan traits (fat depth 12th/13th rib and P8 site, eye muscle area and intra-muscular fat percentage). The selection system assumes availability of cross-herd genetic evaluation and transfer of bulls between herds. Information sources included records on individuals, paternal half sibs, sire, dam and half-sibs of the sire and dam. Initially bulls are selected at weaning with individual information including birth, 200d weight, relatives’ information and IGFI-1 if measured. Second stage selection has additional individual information with scan traits, scrotal size, and 400d and 600d weight. Depending on the scenario individual RFI information is also available at this second stage selection. No progeny information is used in the selection of bulls. Cows are selected after their first calf. The number of animals providing information to a selection index is determined by biological and technical parameters that set the population dynamics such as survival rates, productive lifetime, age at first calving, AI conception and calving rate.

**Input parameters.** The fixed and variable costs and time of recording of criteria were similar to those previously described by Graser et al. (1994). The additional measurement of IGFI-1 and RFI was modelled, alternative costs were investigated for RFI tests ($450, $300, and $150) and for IGFI-1 measurement ($30, $20 and $10) to compare various recording strategies and to analyse if less expensive recording would affect their use. The phenotypic and genetic parameters used were similar to those described by Barwick et al. (1999). Further genotypic and phenotypic relationships with IGFI-1 were obtained from Johnston et al. (2001). IGFI-1 is moderate to highly heritable (0.32) and demonstrates strong positive correlations with IMF %, P8 and rib fat. Studies in other species have shown strong positive correlations with feed efficiency and initial estimates confirm this with feed intake in cattle (Johnston, 2001 pers. comm). Traits for which correlations with IGFI-1 were unavailable were assumed to be zero. A matrix bending routine was used to ensure positive definite genetic and environmental variance-covariance matrices.

**Recording scenarios used in the analysis.** Trait recording was modelled to reflect different strategies of use of RFI and IGFI-1 information recorded within the nucleus. A basic breeding scheme is evaluated first. Scenario 2 and 3 consider the measurement of RFI. Scenarios 4 have IGFI-1 recorded as second stage criteria on males while 4 and 5 have IGFI-1 measured on all males and all animals respectively. Scenarios 7-10 consider the effect of higher and lower genetic correlations between IGFI-1 and RFI and the measurement of all males for IGFI-1 with and without RFI tests.

**RESULTS AND DISCUSSION**

**Neither RFI nor IGFI-1 measured.** Scenario 1 considers the situation where all criteria are measured except IGFI-1 or RFI and will be the base from which change in profit will be
considered. For the base scenario a profit of $35.28 is realised. Table 1 summarises economic and genetic returns from the various scenarios.

**Measurement of RFI.** Numbers of bulls tested at second stage was optimised with respect to profit with percentages shown in table 1. Scenario 2 with two-stage selection for RFI is most profitable when between 10 and 25% of the breeding bulls are tested. There was little difference in profit between 10 and 25%. Profitability dramatically decreases with higher testing costs of $300 and $450 when testing more than 25%, results not shown. The percentage returns from traits in the objective show an increased contribution from RFI with small decreases in all the other traits. Scenario 3 requires knowledge of IGF-1 in all males before second stage selection for RFI. This is the most profitable scheme $48.40 (137.2%), the increased information before selection for RFI testing gives increased index accuracy and decreases the number of animals required for testing. The three different price structures for RFI test made 5%, 7% and 10% the most optimal percentage tested for the RFI cost of $450, $300 and $150 respectively. Trait returns are notable for the large increase in RFI and corresponding decreased contribution of growth and carcass characteristics.

**Table 1. Comparison of various recording scenarios of IGF-1 on males and females, with and without concurrent RFI measurement for returns, cost and profit (relative to base scenario)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>IGF-1 m./f.</th>
<th>$r_{RFI,IGF-1}$</th>
<th>2nd stage % tested</th>
<th>RFI tested</th>
<th>Returns ($A)</th>
<th>Costs ($A)</th>
<th>Profit ($A)</th>
<th>Profit (%)</th>
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<tr>
<td>1</td>
<td>--/--</td>
<td>0.4</td>
<td>--</td>
<td>no</td>
<td>39.54</td>
<td>4.26</td>
<td>35.28</td>
<td>100</td>
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<td>--/--</td>
<td>0.4</td>
<td>15$^B$</td>
<td>yes</td>
<td>47.52</td>
<td>6.63</td>
<td>40.88</td>
<td>115.9</td>
</tr>
<tr>
<td>3</td>
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<td>5.34</td>
<td>48.40</td>
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</tr>
<tr>
<td>4</td>
<td>x/--</td>
<td>0.4</td>
<td>40$^B$</td>
<td>no</td>
<td>44.19</td>
<td>4.46</td>
<td>39.73</td>
<td>112.6</td>
</tr>
<tr>
<td>5</td>
<td>x/--</td>
<td>0.4</td>
<td>--</td>
<td>no</td>
<td>45.41</td>
<td>4.87</td>
<td>40.54</td>
<td>115.2</td>
</tr>
<tr>
<td>6</td>
<td>x/x</td>
<td>0.4</td>
<td>--</td>
<td>no</td>
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<td>5.48</td>
<td>40.95</td>
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<td>--</td>
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<td>38.33</td>
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<tr>
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<td>9</td>
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<td>--</td>
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<td>4.87</td>
<td>43.85</td>
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<tr>
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<td>51.92</td>
<td>5.51</td>
<td>46.41</td>
<td>131.5</td>
</tr>
</tbody>
</table>

$^A$ IGF-1 second stage criteria. $^B$ RFI second stage criteria. $^C$ Both RFI traits (mature cow and yearling) assumed to have the same correlation.

**Measurement strategies for IGF-1 without RFI.** Scenario 4, measured IGF-1 as a second-stage selection criterion with other information available at this time including carcass scan traits, scrotal size, and 400d and 600d weight. The most profitable strategy was measurement of 40% of the males. This could be the strategy of choice if the direct measurement of feed intake were unavailable. An assumption made was that genetic correlations with IGF-1 do not alter with age. Scenarios 5 and 6 are blanket testing of all males and all animals at time of weaning. While the measurement of males was the most cost effective, measurement of all animals provided the higher gain and profit. Larger emphasis is placed onto increasing returns from growth and decreased on RFI compared to scenarios where RFI is measured.
Variation in IGF-1 – RFI genetic correlation. Scenarios 7-10 model the effect of varying correlations between IGF-1 and RFI, as parameters can be population specific or may change as more information is gathered. Reducing the genetic correlation from 0.40 to 0.30 (scenario 7 and 8) resulted in a decreased profit relative to the higher correlations due to decreased response in RFI. Increasing the correlation to 0.5 (scenario 9 and 10) saw a corresponding increase in profit when only using IGF-1 information but slightly less when using both information sources, compared with a correlation of 0.4.

CONCLUSION
The implication from this study is that IGF-1 can be best used as a screening test in a two-stage selection policy to identify animals to be placed into RFI trials. The profitability of the selection is increased in three ways: a decrease in the number of animals placed into the feeding trials, returns from lower feeding costs and lastly improvements in marble score. The number of animals measured in RFI tests will depend on the cost of the trial but less costly trials also affect accuracy of the test. Scenarios 4-6 demonstrated that just using IGF-1 without further RFI measurements would also raise profit of the breeding scheme. Cost of IGF-1 had little impact on profit and its implementation as an indirect selection criterion. Generally, the more animals measured for IGF-1 the more profit but some strategies with limited investment gave a better return per dollar spent.

REFERENCES