PRELIMINARY HERITABILITY ESTIMATES FOR CARCASS YIELD AND MEAT QUALITY TRAITS IN BEEF CATTLE

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SUMMARY
The Cattle and Beef Co-operative Research Centre (CRC) has initiated a large cattle breeding program with the primary aim of estimating genetic parameters for growth, carcass yield and meat quality. Data taken from approximately 2,000 cattle and representing some 200 sires were analysed to estimate the heritabilities of percentage retail beef yield and the meat quality traits of percentage intramuscular fat and tenderness in two muscles. The results indicate that there is considerable scope for genetic improvement in retail beef yield ($h^2 = 0.46 \pm 0.10$). The heritability estimates for meat quality traits were not significantly different from zero, although these analyses were based on smaller numbers of progeny. Because the pre- and post-slaughter environmental influences were minimized, there was little variation in tenderness (LD phenotypic variance $= 0.5 \text{kg}$).

Keywords: Beef cattle, genetic parameters, carcass yield, meat quality.

INTRODUCTION
Prior to the 1980's, traits of primary importance in beef production were related to either reproductive or growth performance. Whilst these traits are still of major economic significance, the consumer is recognised as the ultimate arbiter in the beef supply chain. Failure to satisfy the consumer will have a huge bearing on the long term viability of the industry. Consequently, both geneticists and animal scientists have focused more of their attention on those traits which influence the visual appeal, and more importantly, the palatability of beef. Whilst this covers a wide range of traits, consumer surveys (e.g. Hearmsaw and Shorthose 1994) support the conclusion that the amount and distribution of fat, relative to the proportion of muscle, dominates with respect to visual appeal and tenderness is by far the most important beef palatability trait.

Retail beef yield, that is the weight of trimmed boneless meat, is a commercial measure of carcass composition and is the major factor governing carcass value. Retail yield is inversely proportional to carcass fatness. The results from several studies (e.g. Koch et al. 1982 and Gregory et al. 1995) suggest that retail beef yield and traits associated with carcass fatness (e.g. marbling, fat depth and fat trim weight) are moderately to highly heritable. The estimates of heritability of tenderness, on the other hand, appear much more variable. In their study, Dinkel and Bush (1973) concluded that the best estimate of heritability for tenderness was zero. Similarly, Gregory et al. (1995) reported a negligible heritability of 0.05, whilst both Koch et al. (1982) and Wheeler et al. (1996) reported moderateheritabilities of 0.31 and 0.37, respectively. The variation between these estimates is probably associated with large environmental influences on tenderness, especially those which
occur in the first 24 hours after slaughter. Failure to control these factors will result in considerable non-genetic variation in tenderness and may make detection of genetic differences difficult.

The Cattle and Beef Industry Co-operative Research Centre (CRC) has initiated a large cattle breeding program designed to quantify both the genetic and non-genetic variation in carcass and meat quality. The program will provide genetic estimates of traits encompassing growth performance, carcass quality and yield and meat quality of current industry sires. The design of the program will also allow quantification of the interaction between genotype and finishing environment (i.e. pasture versus grain and sub-tropical versus temperate grow-out) and of the performance of straightbred versus crossbred progeny. In this paper the first genetic parameter estimates for carcass yield and meat quality traits are reported.

MATERIALS AND METHODS
The design of the CRC Straightbreeding Project has been detailed previously by Robinson (1995). Briefly, straightbred progeny from seven breeds (Murray Grey, Angus, Shorthorn, Hereford, Brahman, Santa Gertrudis and Belmont Red) were bred on co-operating properties and purchased at weaning. Link sires within each breed were used to enable adjustment for herd of origin effects. Two-thirds of the progeny bred in northern Australia (Brahman, Santa Gertrudis and Belmont Red) were grown-out in central Queensland. The remaining one-third and all the southern bred progeny (Murray Grey, Angus, Shorthorn, Hereford) were grown-out on properties in north eastern NSW. In both the north and the south, progeny of individual sires were finished on grain and pasture to three market weights (400 kg, 520 kg and 600 kg liveweight). Additional nutritional treatments were applied to southern grow-out cattle during their backgrounding phase (i.e. prior to final finishing on pasture or in the feedlot).

Prior to slaughter, every effort was made to minimise stress during handling, transport and lairage of the cattle. Within five minutes of stunning, all carcasses were effectively electrically stimulated (45 V peak voltage, 36 pulses/s for 40 seconds) to avoid cold shortening. After chilling for 20-24 hours, two muscles, m. longissimus (LD) and m. semitendinosus (ST) were taken from one side of each carcass and frozen at -20°C. Each side was then boned to retail specifications where the external fat coverage was trimmed to 2-3 mm and the manufacturing meat trim was adjusted to an 85% chemical lean content. Individual primal cuts, bones, manufacturing meat trim and subcutaneous and intermuscular fat trims were weighed. Retail beef yield was defined as the combined weight of trimmed boneless primal cuts and the adjusted manufacturing meat trim and expressed as a percentage of total recovered weight of the side after boning.

A range of meat quality measurements were made on the fresh and cooked muscle samples. For the purposes of this paper only the measurements of intramuscular fat percentage (marbling) and tenderness, as determined by mechanical shear force, are reported. Intramuscular fat percentage of the LD was determined by chloroform extraction. Shear force was measured on cooked muscle samples as described by Bouton et al. (1975). The only departure from their technique was that muscle samples were cooked in a water bath at 70°C rather than 80°C for one hour.
In this analysis, data from approximately 2,000 progeny were used. The actual number of animals included in the analysis of each trait differed (Table 1). This was either because specific covariates were not available (i.e., date of birth), or because the meat quality measurements had not been completed on all cattle slaughtered to date.

Univariate mixed models were fitted using the GENSTAT V5 (1994) REML procedure. Contemporary group (cross-classifying year, market weight, finishing nutrition, backgrounding treatment, sex and location) was fitted as a fixed effect. As the animals were sourced from different herds, herd of origin (nested within breed) was also fitted as a fixed effect. Sire was fitted as a random effect. The traits analysed included retail beef yield percentage and the meat quality measurements of intramuscular fat percentage (LD only) and LD and ST shear force. Age at slaughter (range 370 to 1030 days) and carcass weight (range 120 to 440 kg) were fitted as covariates in all analyses. Both were fitted within market weight x location (north and south) x finishing nutrition (pasture or feedlot). Carcass weight was significant for retail beef yield percentage but not for the meat quality traits. Age at slaughter was significant only in the case of ST shear force. Non-significant (P>0.05) covariates were not included in the final models. T-tests were used to assess whether the heritability estimates were significant from zero.

RESULTS AND DISCUSSION

Table 1. Numbers of animals used, number of sires in analyses and the phenotypic range and mean for retail beef yield percentage, LD and ST shear force (kg) and intramuscular fat percentage

<table>
<thead>
<tr>
<th>Trait</th>
<th>Number in analysis</th>
<th>Number of sires</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail beef yield %</td>
<td>1977</td>
<td>204</td>
<td>57</td>
<td>78</td>
<td>68</td>
</tr>
<tr>
<td>LD shear force</td>
<td>791</td>
<td>120</td>
<td>2.5</td>
<td>8.7</td>
<td>3.9</td>
</tr>
<tr>
<td>ST shear force</td>
<td>741</td>
<td>120</td>
<td>2.9</td>
<td>7.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Intramuscular fat %</td>
<td>395</td>
<td>61</td>
<td>0.5</td>
<td>13.3</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Moderate heritabilities were observed for the retail beef yield percentage (Table 2). These estimates are comparable to other published estimates (e.g., Dinkel and Busch 1973, Koch et al. 1982 and Gregory et al. 1995). Moreover, they indicate that there is considerable scope for genetic improvement in retail beef yield. The size of the standard error for this estimate requires that some caution still be exercised when interpreting the result.

The heritability estimate for intramuscular fat % was not significantly different from zero. This is probably due to the small number of animals used in the analysis (n = 395). However, the observed
heritability estimate of 0.4 falls within the range of heritabilities reported in the literature (0.36 - 0.56, Gregory et al. 1995 and Wheeler et al. 1996).

Table 2. Estimates of heritability and phenotypic variance for percentage retail beef yield and meat quality traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Heritability</th>
<th>Approximate standard error</th>
<th>Phenotypic variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail beef yield %</td>
<td>0.46</td>
<td>0.10</td>
<td>4.1</td>
</tr>
<tr>
<td>LD shear force</td>
<td>0.30</td>
<td>0.14</td>
<td>0.5</td>
</tr>
<tr>
<td>ST shear force</td>
<td>0.13</td>
<td>0.11</td>
<td>0.3</td>
</tr>
<tr>
<td>Intramuscular fat %</td>
<td>0.41</td>
<td>0.22</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Heritabilities of shear force tenderness measurements were not significantly different from zero, although LD shear force approached significance. These results suggest that where best practice, in terms of pre- and post-slaughter management is applied, there is little variation in tenderness (phenotypic variance LD - 0.5 kg'). In their study comprising 14 sire breeds, Wheeler et al. (1996) reported a larger phenotypic variance (2.07 kg') in shear force of the LD. Although low voltage (68 volts) electrical stimulation was used in their study, it was applied 45 minutes after stunning and the total time of stimulation was only 9 seconds. This would not be classed as effective electrical stimulation and consequently may have led to greater environmental variation in tenderness in their study. To place this into perspective, where best post slaughter practice has not been applied, LD shear forces of >10 kg have been reported (Thompson et al. unpublished).

The accuracy of estimates for the traits presented here will improve as the results for more progeny and sires become available. The results are nevertheless encouraging and as more progeny are processed it will allow us to more accurately estimate genetic correlations between traits and genotype by environment interactions.

REFERENCES

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