RESPONSE TO SELECTION FOR AGE AT PUBERTY IN AN ANGUS HERD

C. A. Morris and N. C. Amyes
AgResearch, Ruakura Research Centre, PB 3132, Hamilton, New Zealand

SUMMARY
Direct responses and some correlated responses to selection for age at puberty in heifers were estimated in an Angus herd established in 1984/85. Lines were selected for early or late age at first behavioural oestrus (AFO) alongside an unselected Control, and evaluated up to 2004. Breeding values for AFO were calculated for both sexes and used for selection, from data on AFO and age-adjusted scrotal circumference or size (SS) evaluated monthly from 7 to 13 months; no liveweight selection criteria were included. Realised heritabilities for standardised AFO and single-record SS were 0.27 ± 0.03 and 0.41 ± 0.04, respectively, with a genetic correlation of -0.25 ± 0.09 between them. The direct response in AFO (difference between the ‘early’ and ‘late’ lines) was 62 days, 16% of the mean, and the correlated response in mean SS was 3.1 cm, 12% of the mean. There was no selection-line difference in weaning weight and only a 2.7% difference between the lines in yearling live weight (P < 0.05). The ‘early’ and ‘late’ selection lines differed in yearling-heifer pregnancy rate by 29 percentage points (P < 0.001), and there was a trend for an associated pregnancy-rate difference in mixed-aged cows between lines (91.8 vs 86.1%, respectively; P < 0.10). There was a significantly greater incidence of subfertile yearling bulls in the ‘late’ than in the Control or ‘early’ lines (P < 0.001).

Keywords: Cattle, puberty, selection, pregnancy.

INTRODUCTION
It is now well accepted that pubertal traits in beef cattle are heritable. There are frequent reports with heritability estimates for scrotal circumference or size (SS), although fewer for age at puberty (first behavioural oestrus, AFO). Morris et al. (1993a) reviewed three large New Zealand studies, and average heritability estimates were 0.34 for AFO (or 0.40 for AFO when standardised), and the AAABG website on genetic parameter estimates (http://www.gparm.csiro.au/) contains an average heritability of 0.45 for SS at fixed age (25 estimates). Although several single-generation selection studies have been carried out with pubertal traits in beef cattle, it is believed that AgResearch’s project to apply long-term selection for higher or lower AFO is the only one of its kind. The selection experiment began in 1984/85, and the objective of this paper is to report results to 2004.

MATERIALS AND METHODS
Background and management. Earlier phases of the puberty selection experiment with Angus cattle were described in a previous Conference paper (Morris and Wilson 1995) but, briefly, the foundation stock in 1984/85 came from a prior experiment (1962-81) selecting for weight and weight-gain traits (Carter et al. 1990); there were then 3 years of re-randomisation. Alongside an unselected Control line, three puberty lines were set up, selected for increased age at puberty in heifers (AGE+ line), reduced age at puberty in heifers (AGE- line), or increased scrotal circumference, with the last two lines being merged at the 1992 matings (forming a new AGE- line, with continued early puberty selection in heifers). Calves were tagged and recorded to dam within 24 h of birth.
Selection Index and Genetic Profiling

The lines grazed on pastures which were predominantly a mix of ryegrass and white clover, with some supplementation in periods of feed shortage (silage and hay but no concentrates). All lines grazed together except at single-sire mating time. All lines of breeding females (including yearling heifers) began mating at the same time each year, for an 8-week period, with chinball-harnessed bulls. Each selected or Control sire was joined with an age-balanced sample of females from his own line. All the Control-line bulls were yearlings whereas, in order to make best use of elite selection-line sires, about half of the bulls in each selection line were yearlings whilst the other half were older bulls (mainly 2-year-olds). Generally 4 to 5 bulls were mated per line, and about 120 females were joined per line each year until 1991, and 60-80 per line from 1992 onwards. Female culling policy was generally to retain all open yearlings, and to cull open cows; then some additional cows were disposed of as culls-for-age, to avoid increases in herd numbers. In three birth years (1993-1995), however, all females were retained for their first four joinings.

Measurements. Date at first behavioural oestrus was monitored by staff about twice-weekly in heifers from 8 to 17 months of age, with the assistance of paint marks from chinball-harnessed vasectomised bulls (except during the mating period from 14 to 16 months of age, when entire bulls were used); AFO was calculated from this date and the date of birth. SS was measured with a flexible tape on all bulls every month, from 7 to 13 months age; the repeatability of SS was high (0.71 ± 0.01). All heifers and cows were pregnancy-tested per rectum about 5 weeks after the service sires were removed from mating groups. Cow and calf weights were recorded routinely.

Data analyses. For line comparisons, all traits were subjected to analyses of variance (SAS 1995), except for bull fertility traits where chi-square analyses were used. The fixed effects tested were birth-year blocks (3 blocks, each of three years), year of birth within block, and line. The AFO data were transformed to an underlying scale (SFO) with a standard deviation of unity, as if AFO was an ordered categorical response (Gianola 1981), so that it was possible to rank bulls for selection, even when they had female relatives which had not yet reached oestrus (e.g., potential bulls for yearling mating). Line means presented here were part of a larger data set including contemporary back-crosses. For genetic parameter estimates for AFO, SFO and SS, restricted maximum likelihood (REML) procedures (Gilmour 1997) were employed, with an animal model and a full relationship matrix. The REML models for SS and mixed-aged cow pregnancy-rate included repeated-animal terms. The reproductive data summarised here were from the 1994-2004 years, for nine birth-years of cow data (i.e., all animals born in 1993-2001 and present in the breeding herd between 1994/95 to 2003/04). Subfertile bulls were defined as those with < 60% females from their mating group diagnosed pregnant after the mating period. Cows in subfertile bull groups were generally not culled; their pregnancy data were discarded in summarising single-year traits.

RESULTS
Realised heritabilities for SFO and single-record SS were 0.27 ± 0.03 and 0.41 ± 0.04, respectively, with a genetic correlation of -0.25 ± 0.09 between them. The phenotypic standard deviations were 52 days for AFO (before standardisation), and 2.57 cm for single-record SS.

Table 1 compares the AGE- and AGE+ lines over the last four birth years (for calf and yearling data) and nine birth years for cow data. A 62-day (16%) difference in AFO was achieved between the two
herds; the Control line mean was slightly closer to that of the AGE- line (Control minus AGE- line = 23 ± 9 days). There was a corresponding increase in average SS in the AGE- line over the AGE+ line by 3.1 ± 0.4 cm (12%); the female and male traits were roughly equivalent in terms of phenotypic standard deviations of line difference (1.2 sigma). There was no significant selection-line difference in weaning weight (5 months of age), but a small difference in yearling weight (7.3 ± 3.0 kg greater in the AGE- line; representing only 2.7% of the mean; P < 0.05).

Two out of 24 yearling bulls from the AGE- line were found to be subfertile (mating years 1994/95 to 2003/04), along with 2/33 in the Control line and 10/20 in the AGE+ line (P < 0.001). Setting aside the cow or heifer records in these subfertile groups (and 4/36 other bull mating groups where there were subfertile older bulls), the pregnancy rates in yearlings were 29 ± 8 percentage points larger in the AGE- than AGE+ line (P < 0.001), whilst pregnancy-rate differences between lines of older cows approached significance (P < 0.10), with a 5.7 ± 3.2 percentage-point higher mean in the AGE- line than in the AGE+ line. There was no significant line effect on calving rate (per cow pregnant) or on calf survival rate to weaning (per calf born).

Table 1. Summary of line comparisons for pubertal traits and some correlated traits (calf crops born in 2000-2003; cow data recorded in 1994/95 to 2003/04)

<table>
<thead>
<tr>
<th>Trait</th>
<th>Number of records</th>
<th>Overall mean</th>
<th>RSD</th>
<th>AGE+ minus AGE-</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at puberty (days)</td>
<td>356</td>
<td>391.8</td>
<td>48.3</td>
<td>62.3</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Standardised oestrous day</td>
<td>375</td>
<td>-0.01</td>
<td>0.87</td>
<td>1.10</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Average scrotal circumf. (cm)</td>
<td>387</td>
<td>26.5</td>
<td>2.2</td>
<td>-3.1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Weaning weight (kg)</td>
<td>821</td>
<td>162</td>
<td>16.7</td>
<td>1.9</td>
<td>NS</td>
</tr>
<tr>
<td>Yearling weight (kg)</td>
<td>767</td>
<td>268</td>
<td>23.6</td>
<td>-7.3</td>
<td>P &lt; 0.05</td>
</tr>
<tr>
<td>Pregnancy rate: yrlng hfrs (%)</td>
<td>629</td>
<td>73.9</td>
<td>42.0</td>
<td>-29.3</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>: older cows (%)</td>
<td>1502</td>
<td>89.0</td>
<td>31.2</td>
<td>-5.7</td>
<td>P &lt; 0.10</td>
</tr>
<tr>
<td>Joinings in the breeding herd</td>
<td>742</td>
<td>3.41</td>
<td>1.45</td>
<td>-0.35</td>
<td>P &lt; 0.01</td>
</tr>
<tr>
<td>– with exclusions 742</td>
<td>2.87</td>
<td>1.42</td>
<td>-0.80</td>
<td>P &lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Calvings per ‘lifetime’</td>
<td>742</td>
<td>2.44</td>
<td>1.71</td>
<td>-0.72</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Calves weaned per ‘lifetime’</td>
<td>742</td>
<td>2.18</td>
<td>1.63</td>
<td>-0.64</td>
<td>P &lt; 0.001</td>
</tr>
</tbody>
</table>

A Means and RSDs for the first five traits were from the selection lines, Control line and back-crosses.  
B The average of monthly measurements per bull (7 - 13 months of age).  
C Averages of the 742 heifers recorded, but excluding their records when in sub-fertile bull groups.

Table 1 also shows the cow-lifetime data for reproductive traits (last 4 rows), indicating large significant line differences. All four traits were significant, showing from 10 to 30% greater lifetime calf production (relative to the mean) from AGE- than AGE+ cows, in spite of significant line x year of birth interactions (P < 0.001 in all cases).
DISCUSSION
Genetic selection was successful in achieving a 62-day (16%) direct response in AFO in heifers so far, and a 12% response in SS between lines. This divergence was achieved without using a live weight index-selection approach. Indeed, the genetic correlations between SFO and weaning or yearling weights in this herd were close to zero (0.07 ± 0.15 (weaning direct), -0.11 ± 0.09 (weaning maternal) and -0.22 ± 0.09 (yearling); Morris et al. 2000).

Previous studies by our group have highlighted that lifetime cow performance differences are probably genetic in nature, among and within breeds (Morris et al. 1987, 1993b). There were significant line differences in the cows’ lifetime survival in the present herd (Table 1), which represent correlated responses within the management constraints imposed. The cow line differences in numbers of pregnancies per lifetime were apparently greater if bull fertility effects were removed. Although a line difference in yearling-heifer pregnancy rate might be expected in this experiment, finding a trend towards pregnancy rates associated with line in older cows is important, and it needs to be tested in an industry data set. However, these results were consistent with findings on mixed-aged cow pregnancy rates from another research herd in New Zealand where SFO and SS were studied (Morris and Cullen 1994). With this negative genetic correlation between SFO in females and SS in bulls (at least in a Bos taurus breed), the more practical way to apply it in industry would probably be to measure SS and to use breeding values for SS in a selection-index. Recording schemes such as Breedplan now include SS, and this experiment may help to clarify some of the spin-offs from puberty selection.

ACKNOWLEDGEMENTS
We thank the Station managers and stockmen on the Waikeria and then Tokanui Stations for care of animals and for extensive data collection over many years, and we thank research associates John Hunter and John Wilson at Ruakura. The project was funded from 1990 by the New Zealand Foundation for Research, Science and Technology.

REFERENCES