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The Wokalup beef cattle selection experiment

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The aim of the Department of Agriculture's long-term beef cattle selection experiment at Wokalup is to examine the effects of selection for faster-growing cattle on biological traits that may influence the productivity of a commercial beef herd.

Selection lines were established from Hereford and multibreed cattle in 1977. Twelve years of selection have produced an increase in growth rate to weaning of about 120 g per day in both lines. About 40 per cent of this increase is the result of permanent genetic improvement.

Animals in the selection lines now grow faster and reach target weights more rapidly than did their ancestors in 1977. However, they are not necessarily using feed more efficiently, nor do they necessarily produce better quality meat or develop into more fertile adults.

We plan to compare these characteristics in cattle from the selection lines with cattle that have been grown from frozen embryos, stored since selection was first started.

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The Wokalup selection experiment

In 1972, the Department of Agriculture began to buy cattle for a selection experiment at its Wokalup Research Station, 150 km south of Perth. The aim of this experiment, which is not due to finish until 1995, is to examine the effects of selection for increased pre-weaning growth rate on traits influencing the net productivity, or efficiency, of a commercial beef cattle herd.

Weight gain from birth to weaning is an important selection criterion in beef breeding herds. However, the economic consequences of selection are uncertain, because we do not know how faster pre-weaning growth affects such things as feeding efficiency, carcass quality and fertility in cattle. (See 'The consequences of selection for increased pre-weaning growth rate' on page 56.)

Two contrasting types of cattle are used in the Wokalup selection experiment: straight-bred Herefords and four-way cross multibreds, produced by mating Charolais x Brahman bulls with Friesian x Angus or Friesian x Hereford cows. These types were chosen to examine the effects of selection within the extremes of genetic variation available in Australia.

The Herefords represent the traditional British straight breed, with a narrow genetic base and a long history of subjective improvement. The multibreds represent the many new, broadly based synthetic types established by crossing two or more traditional breeds. We are primarily interested in the effects of selection within each breed type, not in comparisons between them.
Selection lines for increased pre-weaning growth rate were established from 300 cows and 12 bulls of each breed type in 1977. Each line is run separately as 12 single-sire breeding groups of 20 to 30 females at Wokalup.

The pastures of subterranean clover and annual ryegrass produce abundant green feed from July to October and adequate dry feed until March-April. Supplements of hay and grain are fed through late autumn and early winter. Cows are joined in winter over a 65-day period and calve in autumn. Calves are weaned in December.

In each selection line, population size is maintained at about 300 cows and 12 bulls, with about 60 new females and 10 new males introduced each year. Replacement heifers and bulls are selected on pre-weaning growth rate. Before 1986, the selection criterion was individual weight gain, calculated from our own records and adjusted for age of dam. In 1985, the Wokalup herds were enrolled in Breedplan, and from 1986 onwards the selection criterion has been an index calculated from estimated breeding values (EBVs) for pre-weaning growth. (See 'The consequences of selection ...' on page 56 for an explanation of EBVs.)

In 1987, 1988 and 1989, multiple ovulation and embryo transfer (MOET) technology was used to increase the rate of genetic change in the selection lines. (See box 'Multiple ovulation and embryo transfer [MOET]' ) In these three years, about 45 calves in each selection line were born as a result of embryos transferred from the top cows.

Response to selection
The changes in pre-weaning growth rate in the Hereford and multibreed selection lines since the experiment started are shown in Figure 1.

**Table 1. Weaning weight (averaged over sexes, and adjusted for date of birth of calf and age of dam) in Hereford and multibreed selection lines from 1978 to 1989**

<table>
<thead>
<tr>
<th>Year</th>
<th>Hereford</th>
<th>Multibreed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>218.9</td>
<td>258.1</td>
</tr>
<tr>
<td>1979</td>
<td>221.0</td>
<td>248.9</td>
</tr>
<tr>
<td>1980</td>
<td>233.2</td>
<td>260.2</td>
</tr>
<tr>
<td>1981</td>
<td>219.1</td>
<td>244.9</td>
</tr>
<tr>
<td>1982</td>
<td>229.2</td>
<td>258.3</td>
</tr>
<tr>
<td>1983</td>
<td>238.1</td>
<td>274.7</td>
</tr>
<tr>
<td>1984</td>
<td>242.6</td>
<td>268.0</td>
</tr>
<tr>
<td>1985</td>
<td>240.1</td>
<td>271.7</td>
</tr>
<tr>
<td>1986</td>
<td>234.8</td>
<td>261.9</td>
</tr>
<tr>
<td>1987</td>
<td>239.1</td>
<td>271.2</td>
</tr>
<tr>
<td>1988</td>
<td>246.3</td>
<td>285.1</td>
</tr>
<tr>
<td>1989</td>
<td>249.0</td>
<td>282.1</td>
</tr>
</tbody>
</table>

**Multiple ovulation and embryo transfer (MOET)**

With multiple ovulation, hormonal treatment is used to induce superovulation (release of more than the normal single ovum or egg) in donor cows. The donor cow is then mated, either naturally or using artificial insemination, and the resulting embryos collected (usually) by non-surgical flushing. The embryos are transferred to recipient cows whose reproductive cycles have been synchronised to that of the donor. The embryos may be transferred fresh or frozen for later use.

The major advantage of MOET in breeding herds is that it mostly increases the rate of genetic gain by increasing the reproductive capacity of genetically superior females. The rate of genetic improvement or response to selection in a herd is directly proportional to the intensity of selection (percentage of the population selected) and inversely proportional to the generation interval (average age of parents at the birth of their selected offspring).

With MOET, genetically superior females can contribute many offspring to the next generation, thus increasing the intensity of selection on females and effectively reducing the generation interval.
Growth rate of calves in both lines has increased by about 10 g per day every year, averaged over the 12 years of selection. This increased growth rate has resulted in heavier weaning weights in both lines (Table 1).

The increases in growth rate and weaning weight in the selection lines are not all the result of genetic changes. Environmental changes, particularly in herd structure and management practices, have also contributed to more rapid calf growth over the years.

Our best estimates of genetic gain in the growth rate of calves in the selected herds suggest an increase in both lines of about four grams per day every year. That is, about 40 per cent of the increase in growth rate and weaning weight shown in Figure 1 and Table 1 can be regarded as permanent genetic improvement. These estimates are based on changes in estimated breeding values for pre-weaning growth.

Figure 1 and Table 1 show that the multibreds are a larger, faster-growing type than the Herefords. This is a reflection of both the breed composition of the multibreed population, which includes large, late-maturing dairying and European beef breeds, and heterosis, the increased vigour that arises from crossing inbred lines.

There is no evidence from Figure 1 and Table 1 of any differences between the Hereford and multibreed lines in their response to selection. This is surprising. From theoretical considerations, we expected the multibreds, with their broader genetic base, to respond more rapidly. (See box ‘Response to selection in straight breeds and multibreds’.)

Effects of selection

The Wokalup selection experiment is now entering its final phase, where the effects of selection for increased pre-weaning growth rate on important biological traits will be evaluated. This will involve a comparison between Hereford and multibreed cattle from the two selection lines, and from two control lines. Cattle from the control lines are being grown from frozen embryos that have been stored from the foundation herds.

Cattle from the selection lines will be compared with their respective controls for:

- growth traits, such as daily weight gain, birth weight, weaning weight and mature weight;
- carcass traits, such as fat depth, marbling and bone:muscle ratio; and
- fertility traits, such as scrotal circumference, serving capacity, calving ease and pregnancy rate.

These comparisons will provide us with information on how selection for increased pre-weaning growth rate in beef cattle will
All cattle are individually tagged and regularly measured for a range of traits. Phil Moyle (left) and Bob Jones from Wokalup Research Station with some Hereford and multibreed calves.

influence total herd efficiency in early-maturing and late-maturing breeds under our agricultural conditions.

The selection and control lines also will be compared for physiological, biochemical and molecular traits which underlie differences in growth, carcass structure and fertility. These are traits such as appetite, feeding efficiency, level of basal metabolism, activity of metabolic enzymes, production of hormones involved in growth and reproduction, and base structure of deoxyribonucleic acid (DNA), the material of which all genes are composed.

Comparisons of this sort involve basic biological research. They are unlikely to provide us with immediate solutions to the problem of undesirable correlated responses to selection for increased growth rate. They will, however, enable us to understand better the sequence of events inside the growing animal, which lead to the phenotypic changes we recognise as differences in growth traits, carcass traits and fertility traits.

In the long term, this may be the only way we can make broadly applicable, accurate predictions about the consequences of selecting cattle for faster growth.

Commercial beef herds buy all the bulls they use each generation, though they may breed their replacement females. Breeding herds breed their male and female replacements. Breeding herds are few, but control the rate of genetic improvement in the beef industry through the supply of bulls.

If commercial herds and the beef industry as a whole are to gain the permanent, long-term benefits of genetic improvement, it is important that replacement bulls in breeding herds are selected according to the interests of commercial producers. The overall breeding objective should therefore be the net productivity, or efficiency of a total commercial herd.

To break this overall objective into selection criteria, or measures that should be used as a basis for selection in practice, we need to:

• specify the production and marketing system in which we are involved;
• identify the principal sources of income and expenditure in this system; and
• decide which measurable biological traits influence income and expenditure.

In southern Australia, most commercially produced beef cattle are bred on the property and sold as baby beef or as yearlings or steers grown and finished on pasture. In such a production system, breeding animals comprise well over half the total herd. Income is therefore determined by the number of animals produced for slaughter, multiplied by their value. Expenditure is determined by the maintenance costs of both breeding and slaughter animals.

Biological traits that increase the number of calves produced each year, increase liveweight gain and carcass weight, improve carcass quality, decrease veterinary costs and decrease the amount of feed consumed, need to be improved if net productivity is to be improved. The question is: do the selection criteria used by cattle breeders now lead to genetic improvement in these traits?

Selection criteria
Selection criteria are many and varied. Although most breeders use subjective appraisal a little when selecting breeding stock, there has been an increasing emphasis over the past few decades on objective, performance-based selection.
selection for increased growth rate

In most developed countries, the principal objective selection criteria are one or more measures of weight gain or weight-for-age. In southern Australia, where many cattle are sold for slaughter as baby beef or yearlings, weaning weight or growth rate from birth to weaning are usually the criteria of choice.

The advantages of selecting cattle for increased pre-weaning growth rate or greater weaning weight are well recognised. Pre-weaning growth rate is moderately heritable and responds well to selection. It is simple to measure. With access to an advanced, computer-based national recording scheme such as Breedplan, breeders, and commercial producers through the bulls they buy, can rapidly obtain substantial genetic improvement in their herds.

Breedplan provides breeders with a prediction of genetic merit (called an estimated breeding value or EBV) for growth traits of each animal in the herd. This allows them to select accurately bulls that produce faster-growing progeny. Breedplan will soon also include EBVs for reproductive traits, such as calving ease, days to calving and scrotal size, and for carcass traits, such as eye muscle area and rump fat. However, pre-weaning growth rate is likely to remain the most widely used selection criterion for some time.

Effects of selection

What are the effects of selection for increased pre-weaning growth rate on biological traits that influence net productivity of a total commercial herd? The scientific evidence is conflicting (Figure 2).

It appears that such selection will lead to improvements in liveweight gain and carcass weight, but we cannot predict with certainty the effects on the many traits that influence the number of calves produced each year, carcass quality and maintenance costs. Without this knowledge it is difficult even to hazard a guess about the influence of selection on total herd efficiency.

There are several reasons for the conflicting results that have been obtained from previous studies. The studies used different methods to determine the effects of selection; some studies have predicted the effects of selection from genetic correlations between traits, while others have carried out selection experiments for increased pre-weaning gain. The studies also used different breeds of cattle, which may differ in their genetically correlated responses to growth. Finally, the studies were carried out in different environments, which may change correlated responses to growth even in the same breed.

Estimates

How can we obtain more reliable estimates of the effects of selection for increased pre-weaning growth rate? There are two possibilities.

We could run many separate selection experiments for various breeds of cattle in different environments, and measure correlated responses in all biological traits that may influence income and expenditure. This would be an expensive means of gathering information, but it would allow us to say with some certainty how selection for pre-weaning gain in a particular breed in a particular environment will influence total herd efficiency.

Alternatively, we could seek a more detailed understanding of the physiological, biochemical and molecular differences between fast- and slow-growing cattle. This would be a difficult undertaking because of the many interacting factors that underlie growth and development. It would, however, place us in a better position to make general predictions about the effects of selection over various breeds and different environments than our current limited estimates of phenotypic and genetic correlations between traits.

The Wokalup selection experiment was designed with both approaches in mind.