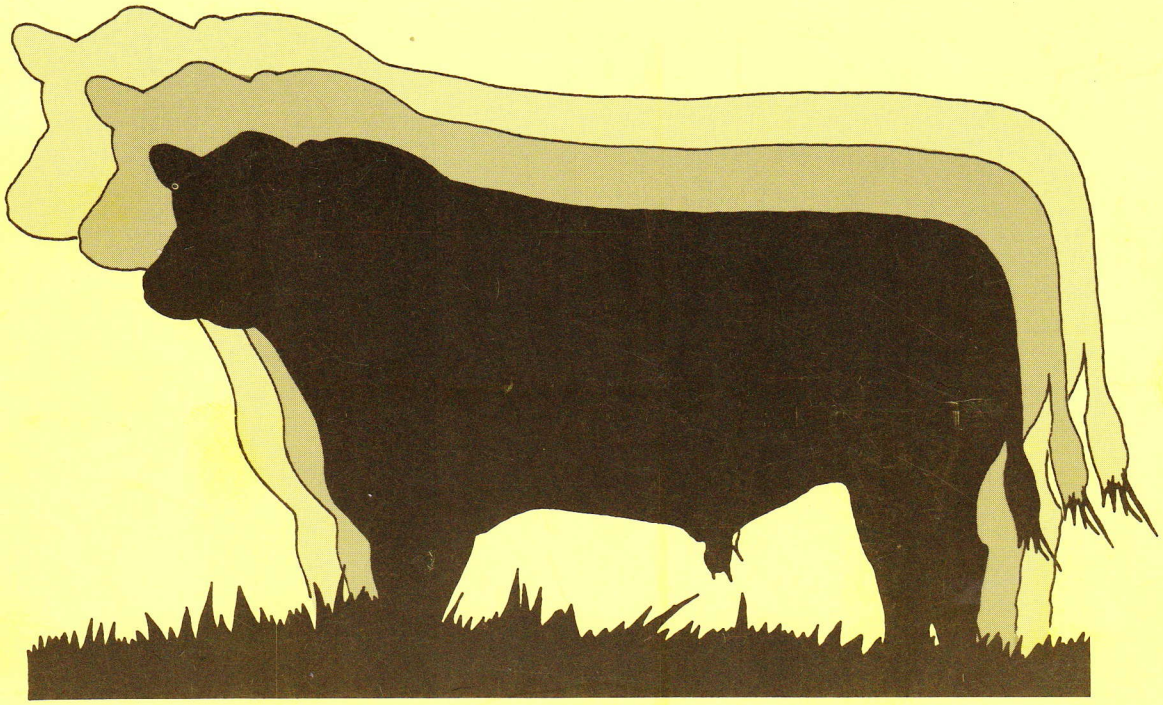
IMPLICATIONS OF SELECTION FOR GROWTH

- *Trangie Cattle Project*



Agricultural Research Centre, Trangie
12th September, 1990

AUSTRALIAN
MEAT AND LIVESTOCK
RESEARCH DEVELOPMENT
CORPORATION

NSW Agriculture & Fisheries

IMPLICATIONS OF SELECTION

FOR GROWTH

- THE TRANGIE CATTLE PROJECT

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NSW Agriculture & Fisheries
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SUMMARY

* Three closed lines of Angus cattle were established in 1974 to investigate the effect of selection for growth rate on beef herd profitability.

* Fifteen years of selection for either increased or decreased yearling growth rate resulted in a divergence in growth rate of over 30 percent between the High and Low selection lines. A Control line was maintained to provide a base for the measurement of direct and indirect genetic responses.

* Selection for increased (or decreased) yearling growth rate resulted in increases (or decreases) in weight and size at all ages. This included changes in mature cow size and weight. Data collected from Trangie and Glen Innes indicated that the responses in growth rate are consistent across different environments.

* Cross-mothering and milk production studies indicated that about 80 percent of the response in weaning weight of calves could be attributed to changes in the calf's genetic potential for growth, and about 20 percent to changes in the maternal ability of cows.

* Selection for increased growth rate resulted in a slight improvement in the reproductive performance of heifers and cows. Selection for decreased growth rate was associated with a decline in overall reproductive performance.

* High line steers reached target market weights faster, and had slightly leaner carcases at the same slaughter weight than Control line steers. At a standard age, High line steers produced heavier carcases, with no significant changes in the proportions of fat, muscle or bone.

* Studies conducted in the automated feedlot indicated that selection for increased growth rate was accompanied by slightly increased feed costs per head for cows and their calves. High line cows and calves were slightly more efficient in the use of feed than Control line cows and calves. Low line cows and calves were slightly less efficient. Further feed intake and efficiency studies are currently being conducted on pasture at Glen Innes and Hamilton.

* The feed costs and efficiency of growing steers are still being determined in feedlot and pasture studies. Early results have not shown any differences between the selection lines in the efficiency of feed use of steers at one year of age.

* Economic analyses of the results collected to date show that the High line returned more profit per cow and more profit per unit of feed consumed than the Control line when compared across a range of production systems. The Low line produced less profit than the Control line.

1. INTRODUCTION

A unique research project has been conducted at the Agricultural Research Centre during the past 15 years to examine the implications of selection for growth rate on beef herd profitability.

The results provide important information to help beef producers determine the correct emphasis to place on growth rate in their breeding programs.

The profitability of a beef herd depends on its "turn-off" rate, the value of market animals, and the costs of replacement, maintenance and growth of breeding and market animals. The most important decision in the design of a breeding program is determining which components of production offer the greatest opportunity for genetic improvement in herd profitability.

The development of BREEDPLAN has provided beef producers with a powerful tool to achieve genetic change in their herds through the implementation of simple genetic selection programs. However, before breeders can make effective use of BREEDPLAN for the selection of breeding stock, they must first determine suitable breeding objectives for their particular production systems and markets.

The Trangie project provides important biological and economic information required for the establishment of appropriate breeding objectives for individual producers. The project has also provided data for the further development of BREEDPLAN to provide for a wider range of traits in the genetic evaluation of beef cattle.

During the last two decades beef producers have placed increased emphasis on selection for growth rate and size. Growth rate is easy to measure, it responds to genetic selection and is closely related to the value of individual animals. However, whilst it is known that selection for increased growth rate will result in faster growing animals which are heavier at all ages, little is known on the likely associated changes in other important components of herd profitability. In particular, a serious limitation of selection for increased growth rate is the associated increase in mature cow size, and hence in the feed costs of the breeding herd.

The Trangie project was designed to provide information on the effects of selection for growth on each of the major components of herd profitability. This has included the investigation of the responses in reproductive performance; maternal ability; herd feed requirements; carcase yield and quality; and structural soundness. Knowledge of the changes to these components has provided the necessary information to conduct a detailed economic analysis of the impact of selection for growth on overall herd profitability.

2. DESIGN OF THE TRANGIE PROJECT

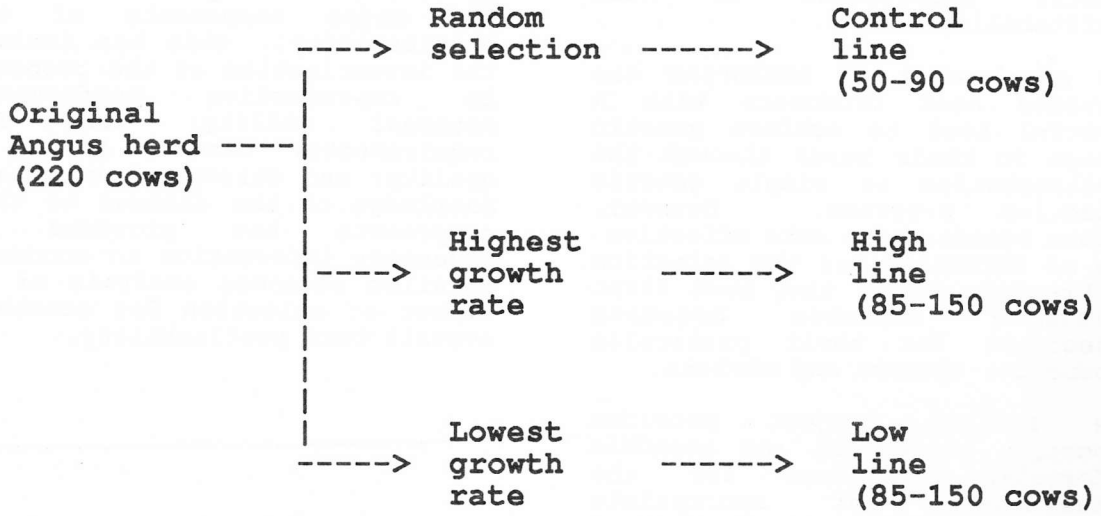
The current phase of the Trangie project began in 1974 with the establishment of three closed selection lines from the Angus herd at the Agricultural Research Centre.

Of the 220 breeding cows in the herd in 1974 a group of 50 were randomly chosen to form a Control line. Of those remaining, 85 cows were allocated to the High line and 85 to the Low line, based on their individual growth performance between birth and yearling age.

This unique design was chosen to provide a rapid divergence in growth rate between the High and Low selection lines, with the Control line providing a base for the measurement of selection responses.

Since 1974 the three lines have remained completely closed. All replacement bulls and heifers for the High and Low lines were selected solely on their yearling gain (adjusted for age of dam).

The Control line was maintained with all replacements chosen at random. Animals from each line were run together throughout the year, except during mating.



Selection based on average daily weight gain from birth to yearling age (adjusted for age of dam)

During 1974 to 1982 the High and Low selection lines were each maintained with approximately 85 breeding females and 5 sires used per year. The Control line had approximately 50 breeding females and 10 sires used per year.

From 1983 to 1988 the herd was expanded in size by retaining all potential breeding females to enable the establishment of satellite herds at Glen Innes and Hamilton. This enabled the study of the persistence of selection responses across environments.

The current breeding herd at Trangie consists of approximately 120 breeding cows in each of the High and Low lines and about 100 breeding cows in the Control line. Across all locations (Trangie, Glen Innes and Hamilton) there are currently over 900 breeding cows involved in the project.

Replacement bulls and heifers were joined at 14 months of age throughout the selection program. The bulls were used for only one breeding season and the cows were culled only if they failed to calve in two consecutive years. Prior to 1982 cows were sold at 7 years of age to ensure a rapid generation turnover.

Allocation of cows to bulls within selection lines was completely at random, except for the avoidance of matings between half-sibs or bulls with their dam. This has minimised inbreeding.

A comprehensive performance recording program has provided a large amount of data for the evaluation of selection responses.

Comparison with other studies

There have been several beef cattle experiments conducted throughout the world during the past 40 years to investigate the responses to selection for growth and weight traits. These have been mainly conducted in U.S.A., Canada, U.K. and New Zealand, and have involved a range of breeds (e.g. Angus, Hereford, Shorthorn, Zebu crosses).

Until recently, very few studies included a Control population as a baseline for the measurement of selection responses over time. The Trangie experiment is the only one that has used both a High and a Low line to obtain rapid genetic divergence in the selected trait. With some exceptions, most other experiments have used actual weight at a given age (e.g. weaning weight or yearling weight) as the major selection criteria rather than growth rate.

The number of generations of selection applied in a breeding program is the result of the average age of parents in the herd and the number of years over which selection was conducted. The average number of generations of selection across all beef cattle experiments is less than 3. Since 1974 almost 5 generations of selection were conducted for both the High and Low lines at Trangie.

In all experiments, the majority of the selection pressure could be attributed to selection of replacement sires. Averaged across all studies, sire selection accounted for 70 to 85 percent of the total selection pressure. In the Trangie experiment, sire selection accounted for an average of 83 percent of the total selection pressure in the High line and Low lines.

3. RESPONSES TO SELECTION

3.1 Growth and size

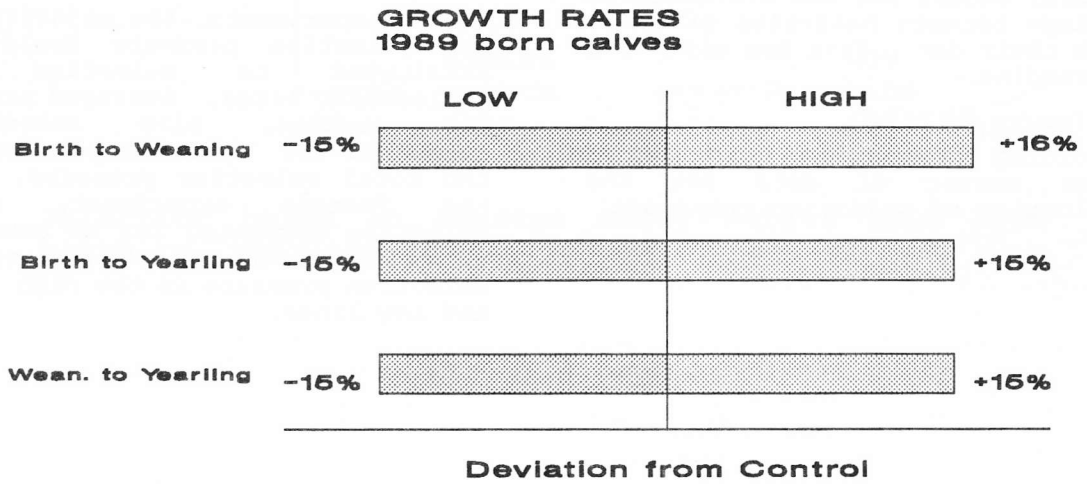
The unique design of the Trangie project has resulted in a rapid divergence in growth rate between the selection lines. For calves born in 1989 the average difference between the High and Low lines in the selected character (adjusted yearling gain) was 30 percent, and the average difference between the High and Control lines was 15 percent. The divergence between the High and Low lines represents the expected response following 25 to 30 years of single trait selection in a conventional within-herd selection program.

The average rate of response in yearling growth rate for the High and Low selection lines was about 1 percent per year. The actual responses obtained in any year fluctuated from the overall pattern of responses in each line. This occurs in any breeding program due to genetic sampling effects.

The responses in growth rate compare favourably with the results reported for other studies of selection in beef cattle. The maximum possible rate of genetic change in growth rate in a closed herd is about 1.4 percent per year. However, the average rate of selection response reported for yearling weight is about 0.8 percent per year. Early results of a large study currently being conducted in Nebraska, USA indicate that current Angus and Hereford sires used in the USA are about 12 percent superior in genetic potential for yearling weight than sires used 20 years ago.

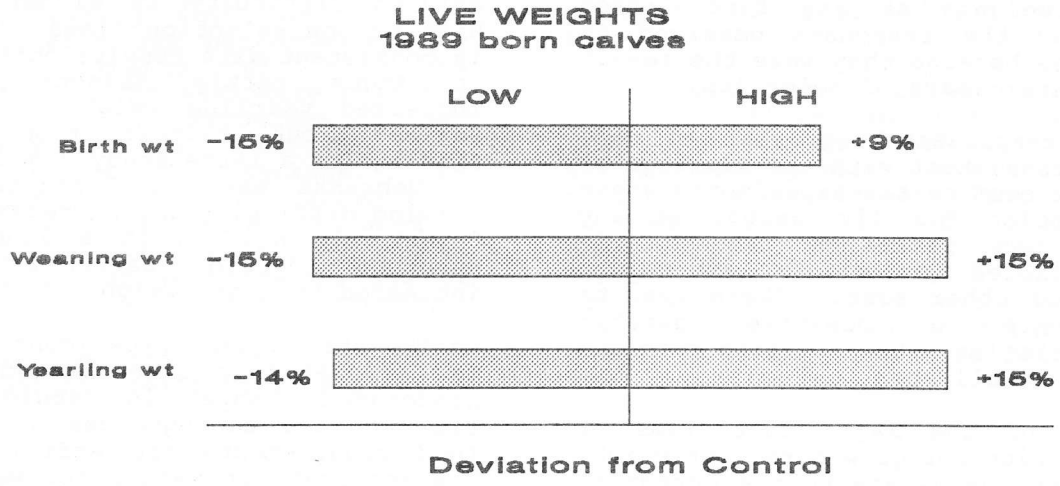
The rates of genetic change achieved from single-trait selection experiments are higher than those generally realised in industry herds. This is due largely to the consideration of a number of production traits in most practical breeding programs.

The responses achieved at Trangie were solely the result of selection within closed lines, with no introductions of outside stock. Many industry herds can potentially achieve greater rates of genetic change by selecting replacement sires from outside sources.

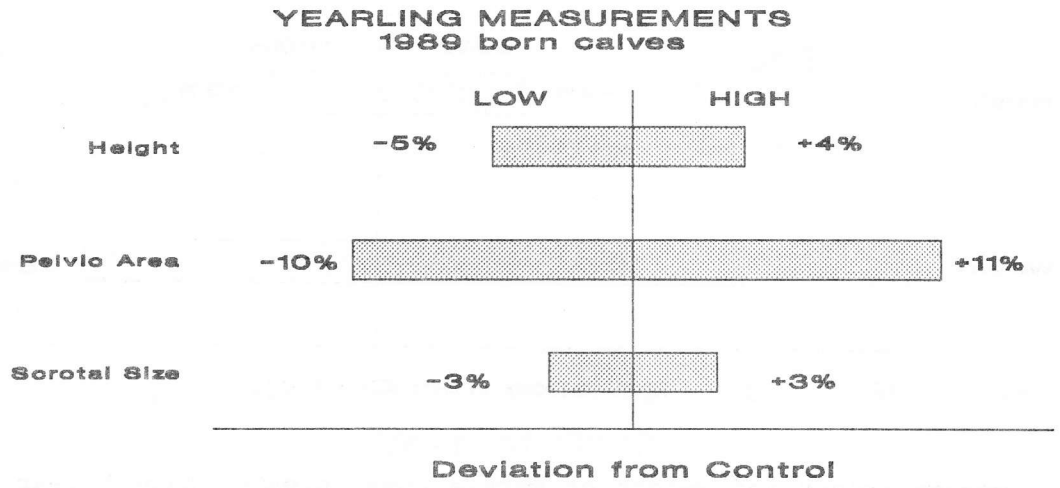


Average growth rates of 1989 born calves in the High and Low selection lines, expressed as percentage deviation from the average of calves in the unselected Control line

The responses in growth rate in the selection lines were associated with responses in size and weight of calves at all ages. On average, the High line calves were larger and heavier at all ages than the Control line calves, and the Low line calves were smaller and lighter.



Average weights of 1989 born calves in the High and Low selection lines, expressed as percentage deviation from the average of calves in the unselected Control line



Average yearling measurements of 1989 born calves in the High and Low selection lines, expressed as percentage deviation from the average of calves in the unselected Control line

Selection for increased growth rate has resulted in an increase in the average size and weight of mature cows in the High line. There was a corresponding reduction in the size and weight of cows in the Low line.

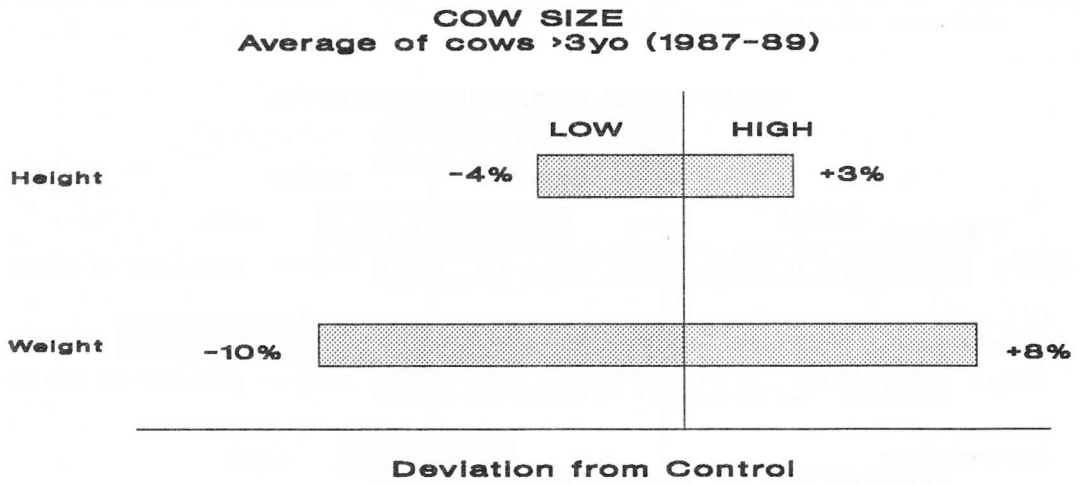
The selection responses in mature cow weights at any time lagged behind the responses observed in calves because they were the result of fewer years of selection.

The responses in growth and size are consistent with the findings of other beef cattle experiments where selection for live-weight at any age has generally resulted in associated changes in live-weight at all other ages. These results indicate a positive genetic association between growth rate and size at all ages.

Some of the major criticisms of selection for growth rate or weight at any age relate to the potential consequences of the associated changes in birth weight and in mature cow weight. Increases in calf birth weight resulting from selection for growth have been observed in most studies, however the associated changes in calving difficulty have varied.

As shown in section 3.3 of this booklet, there was no increase in calving difficulty in either the High or Low selection lines. This is consistent with results obtained in Angus cattle selected for increased yearling weight in New Zealand, but differs from the findings of a large study conducted in Nebraska where the degree of calving difficulty was increased in 2-year old heifers in a line of Hereford cattle selected for increased yearling weight.

Unlike the Trangie experiment very few studies have investigated the associated changes in mature cow size and its consequences on herd feed requirements and efficiency. The responses in mature cow weight described above are consistent with the fragmentary evidence that is available from other studies.



Average height and weight of mature cows (greater than 3 year old) in the High and Low selection lines during 1987-89, expressed as percentage deviation from the average of cows in the unselected Control line

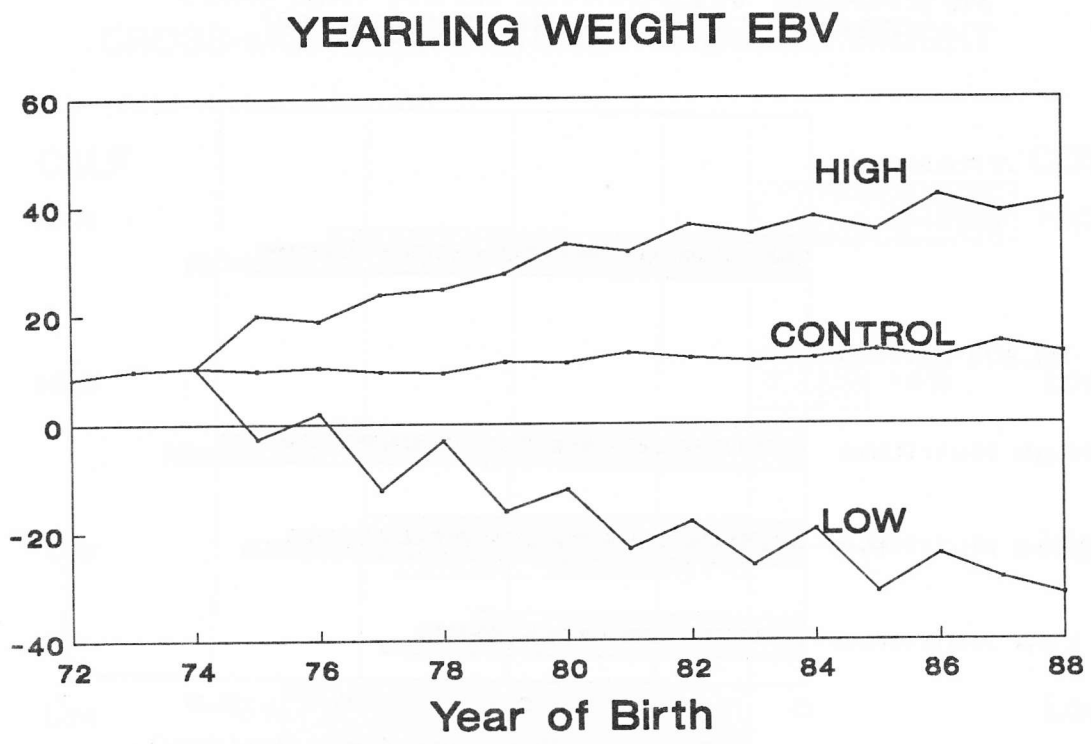
Estimated Breeding Values

Pedigree and growth performance records were used to compute Estimated Breeding Values (EBVs) for animals in each selection line. These values were the best assessment of each animal's genetic merit, taking into account the individual's own performance plus the performance of all its relatives. The EBVs were computed using a similar procedure as used for the National Beef Recording Scheme's BREEDPLAN package. The procedure adjusted for known non-genetic factors that contributed to an animals performance (e.g. age of the animal at measurement, age of its dam, and year/season effects).

EBVs were expressed as kilograms of live-weight, relative to a fixed base equivalent to the average of the first 200 animals recorded in the herd (during 1963-64).

Pedigree records extending back as far as 1929 were used to determine genetic relationships among animals.

The divergence between the selection lines in the annual trends in average EBVs for birth weight, weaning weight and yearling weight were consistent with those measured directly from the average performance of the three selection lines. The average EBVs in the original herd in 1974 were greater than zero due to prior selection placed on growth and size between 1963 and 1973.



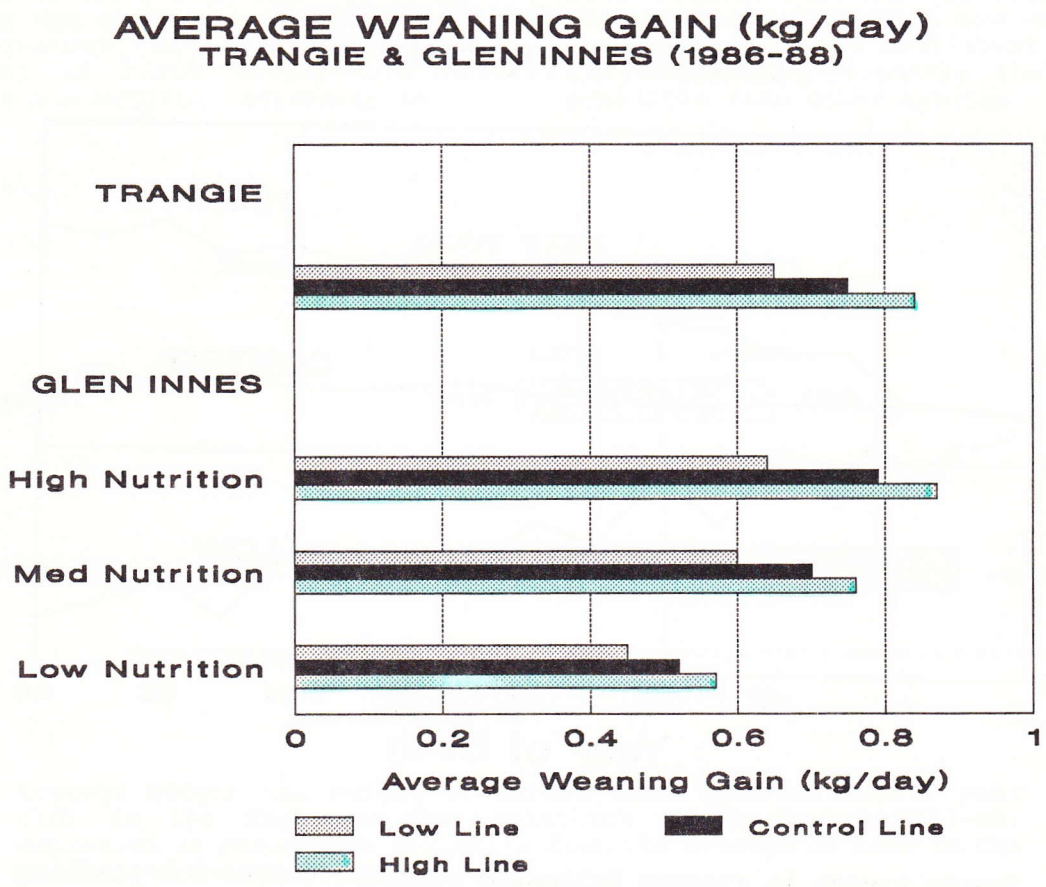
Yearly trends in average Estimated Breeding Values for yearling weight among calves in each selection line

Selection responses across environments

The expansion of the selection lines to "satellite" herds at Glen Innes and Hamilton will provide information of the persistence of selection responses across a range of environments. Previous studies have indicated that the relative performance of different breeds and crosses can vary substantially across wide extremes of environment. Little is known of the potential importance of this phenomena to within-breed selection.

Sires used each year at Trangie are subsequently used at Glen Innes and Hamilton to maintain the genetic differences between the selection lines at each location. At Glen Innes, cows and calves from each line have been divided into groups run at three widely different levels of pasture availability. These groups represent good, medium and poor levels of nutrition. The cattle at Hamilton are divided into groups run on pasture plots at different set stocking rates.

Analyses of data collected so far from calves sired by bulls from each selection line at Trangie and Glen Innes indicate that the responses to selection in growth to weaning are consistent across the environments. This suggests that similar genes are determining the differences in growth performance of the lines in each environment.



Average growth rates to weaning (kg/day) for calves sired by bulls from each selection line used at Trangie and Glen Innes

3.2 Maternal ability

The observed changes in weaning weight which resulted from selection for growth rate could be partly attributed to responses in the genetic potential of calves for growth and partly to responses in the maternal ability of their dams.

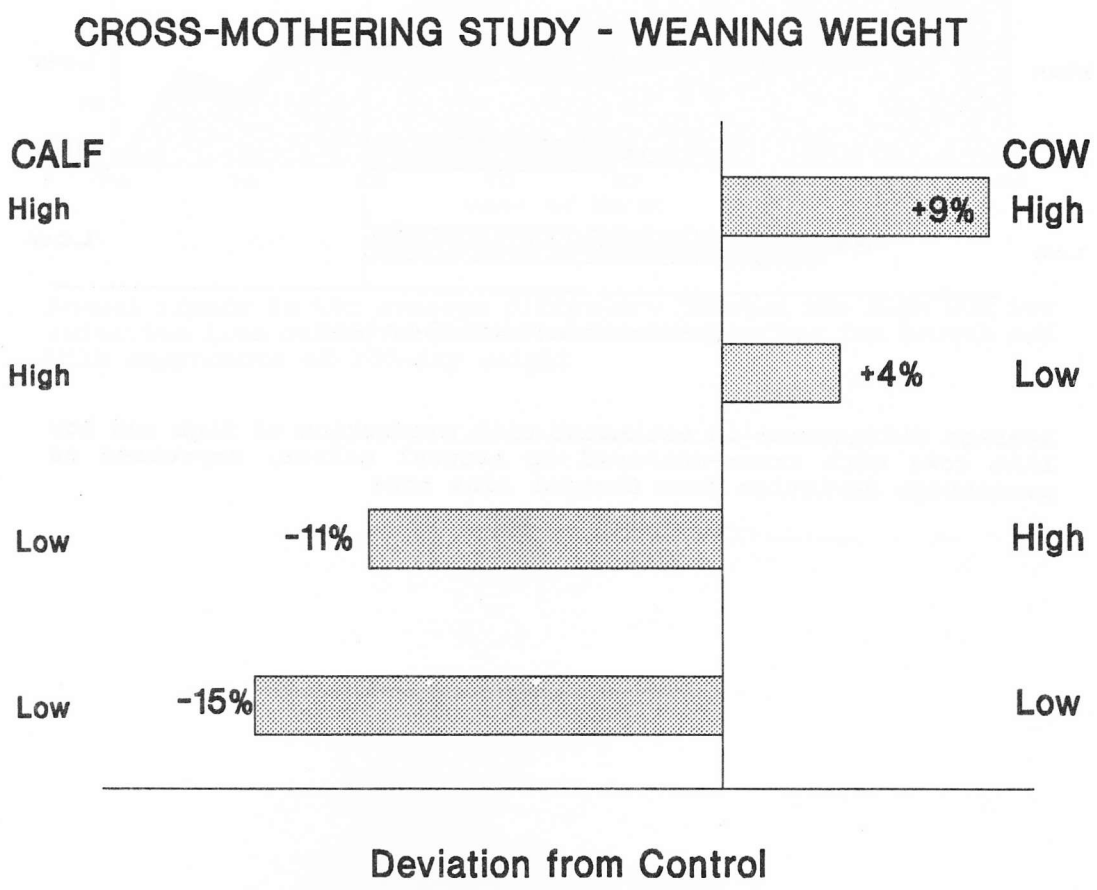
A combination of cross-mothering and milk production studies were conducted to examine the relative importance of the responses in growth potential and maternal ability as they affected weaning weight.

Cross-mothering study

The changes in calf growth potential and cow milk production were measured by cross-mothering samples of High line and Low line calves between cows from each line.

The growth of these cross-mothered calves was then compared with that of their naturally-mothered contemporaries. The milk production of cows was also estimated at strategic intervals during lactation using the calf weigh-suckle-weigh technique.

High line calves reared by their natural High line dams were heavier at weaning than Low line calves reared by their natural Low line dams. When cross-mothered to Low line cows the High line calves were slightly lighter at weaning than naturally reared High line calves. Conversely, when Low line calves were cross-mothered to High line dams they were slightly heavier than naturally-reared Low line calves.



Average differences in weaning weight of calves cross-mothered between the High and Low selection lines, expressed as percentage deviation from naturally-reared Control line calves

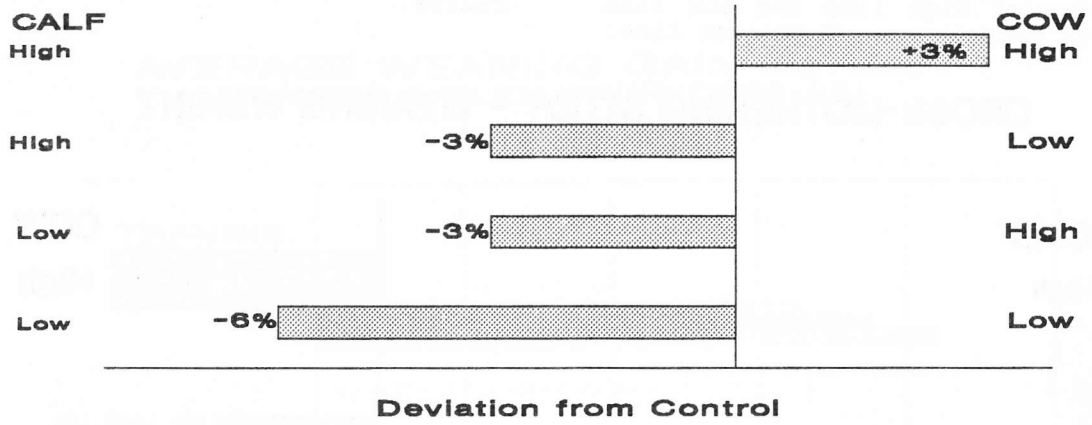
The results of the cross-mothering study indicated that 82 percent of the difference in weaning weight between the High line and Low line calves was due to difference in their genetic potential for growth. The other 18 percent was due to differences in the maternal ability of their dams.

Milk production

The differences in maternal ability between cows in each selection line were explained by differences in estimated milk production. High line cows produced more milk than Control line cows and Low line cows produced less milk.

The milk production studies also indicated that the differences in growth potential between the selection lines could be largely attributed to differences in the appetites of calves. When reared by High line cows, the Low line calves did not increase their milk consumption to the level of naturally-reared High line calves. In contrast, cross-mothered High line calves were able to increase the level of milk production from Low line cows. This suggests that the High line calves had a greater appetite than Low line calves.

CROSS-MOTHERING STUDY - MILK PRODUCTION

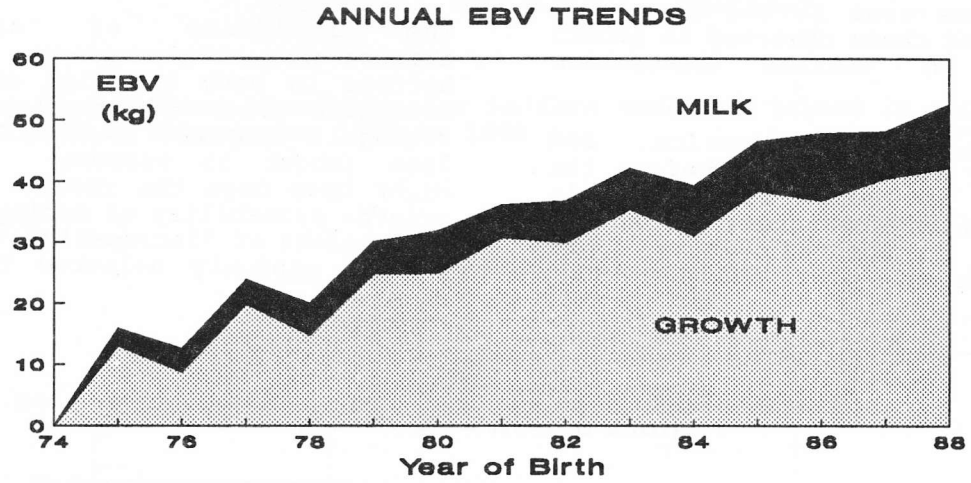


Average differences in estimated milk production of High and Low line cows with cross-mothered or natural calves, expressed as percentage deviation from Control line cows

200-day weight EBVs

In BREEDPLAN the EBVs for 200-day weight are partitioned into 200-day growth and 200-day milk components. The cross-mothering experiment provided a unique opportunity to test the accuracy of BREEDPLAN'S determination of these components.

The analysis of the 200-day weights collected in the Trangie herd showed an average difference between the current High line and Low line calves in 200-day growth EBVs of 40kg. The difference in EBVs for 200-day milk was 10kg. This corresponded closely with the relative responses in growth potential and maternal ability measured in the cross-mothering experiment. The results confirmed that the partitioning of 200-day weight EBVs into growth and milk components in BREEDPLAN was appropriate.



Annual trends in the average difference between the High and Low selection line calves in Estimated Breeding Values for Growth and Milk components of 200-day weight

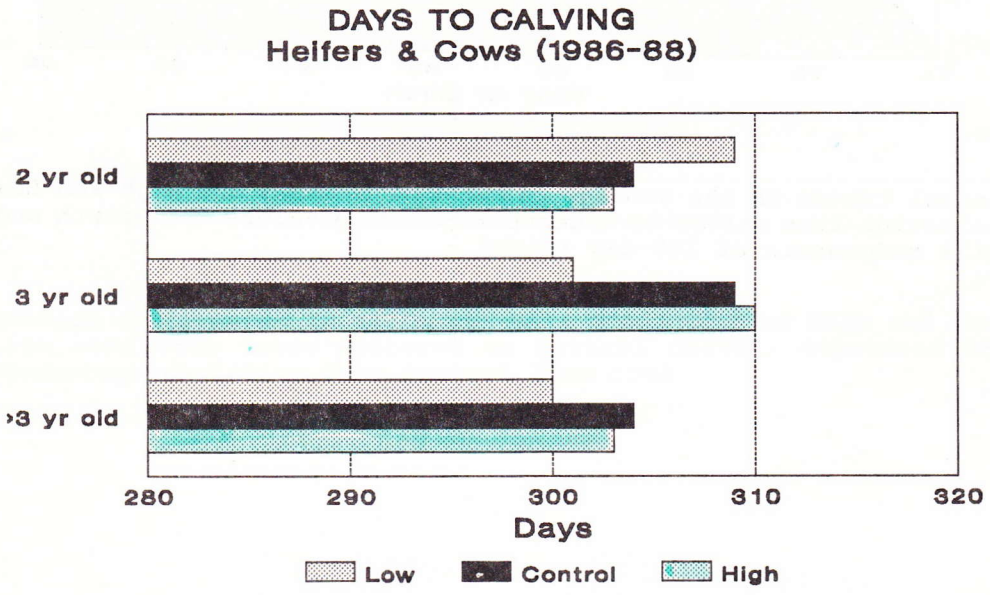
3.3 Reproduction

Because of the importance of turn-off rate to overall herd profitability it was essential to determine the impact of selection for growth on components of reproductive performance. The evaluation of responses in reproduction is difficult because of the limited degree of genetic variability in its key components and the irregular nature of the expression of these components. In addition, the responses in reproductive performance of heifers and mature cows at any time will lag behind those observed in growth traits in current generation calves.

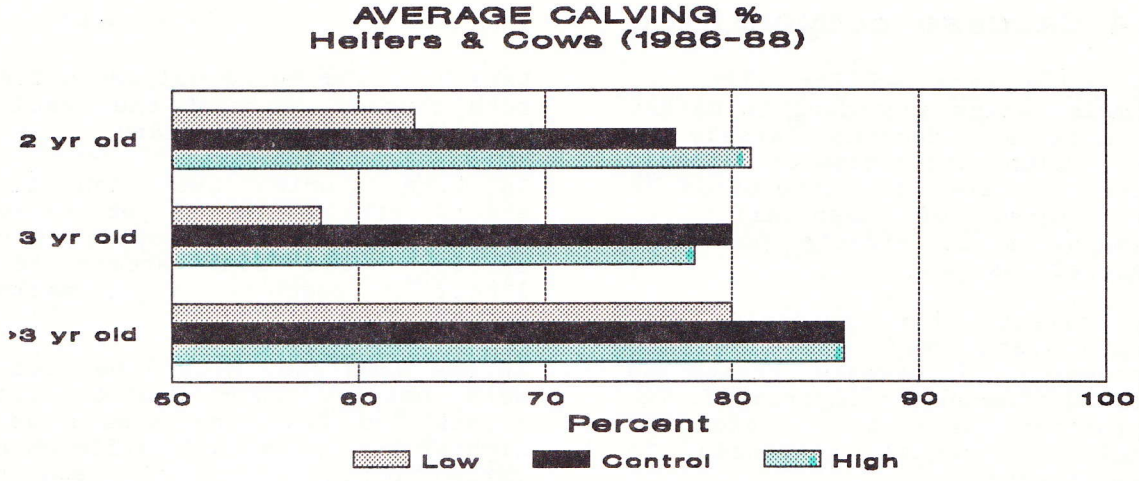
Further data collection and analyses are necessary before the nature of the responses in reproduction are accurately known. Results presented here are therefore only preliminary.

Data collected to date on the average number of days from mating to calving, and on average overall calving percentages, show that High line heifers had a slightly improved reproductive performance compared to Control line heifers. There was no significant difference in these indicators of reproductive performance for mature cows in the High and Control lines. In contrast, the net reproductive performance has declined in Low line heifers and mature cows.

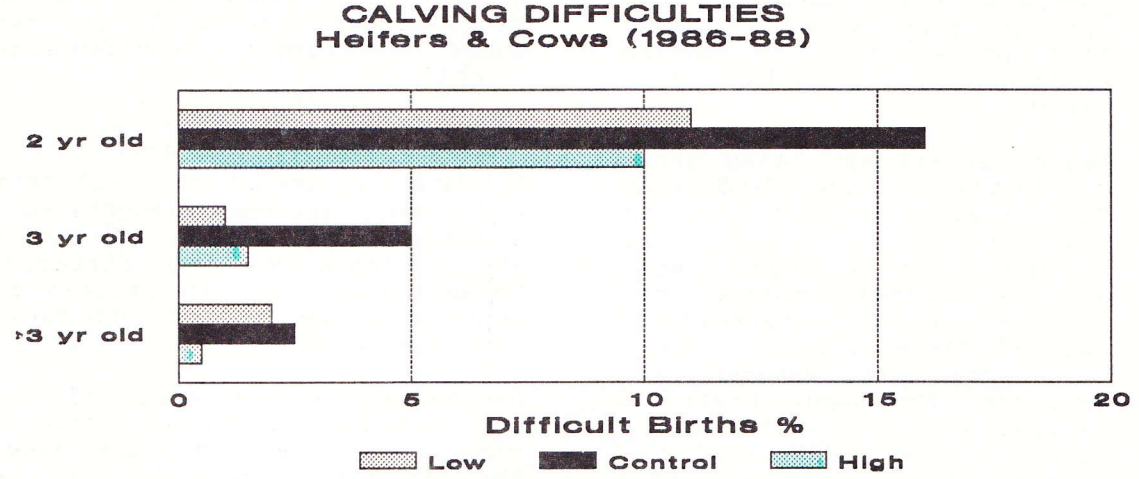
The incidence of calving difficulties was lower among heifers in both the High and Low selection lines (about 10 percent average), compared to the Control line (about 15 percent). This might have been the result of the greater probability of mating bulls and heifers of "incompatible" sizes in the randomly selected Control line.



Average interval from the first day of joining to the day of calving for heifers and cows in each selection line



Average calving percentage for heifers and cows joined in each selection line during 1986 to 1988



Average percentage of difficult calvings for heifers and cows joined in each selection line during 1986 to 1988

Observations using teaser bulls showed that there was substantial variation in the age of puberty of heifers within the selection lines. On average, the High line heifers tended to exhibit first oestrus at a slightly younger age than Control line heifers. Low line heifers were slightly older at first oestrus.

On average, High line bull calves had larger scrotal sizes at yearling age compared to Control line calves. Low line calves had a smaller average scrotal size. Studies of libido and semen quality of yearling bulls showed no differences between the three lines.

3.4 Carcase composition

The price received for slaughter animals varies according to market criteria and depends largely on their weight and degree of fatness. Processors are also interested in the degree of muscularity of animals as it affects potential yield of lean meat.

Any effect that selection for growth rate may have on the expression of carcase traits is clearly of economic importance. Two approaches have been taken to examine potential responses in these traits.

* Groups of two year old steers from each selection line were grown out on pasture on the New England tablelands and subsequently slaughtered in a commercial abattoir. Carcase weight, fat depth and eye muscle area were measured, and the carcases were boned-out into primal cuts to obtain estimates of saleable meat yield.

* Weaner steers are being grown out in the automated feedlot at Trangie at a constant level of nutrition. They are slaughtered at a range of ages and the carcases dissected into subcutaneous fat, intermuscular fat, muscle and bone. These components are weighed and expressed as a percentage of carcase weight. This gives a more precise measure of the fatness, muscularity and lean meat yield than is possible to obtain in a commercial abattoir.

Data is still being collected from both sources, so that the results given here are preliminary.

In both studies the High line steers attained a target market weight earlier than Control line steers. Low line steers took longer to reach a target market weight.

At the same age, High line steers were heavier than Control line steers and Low line steers were lighter. The actual differences varied depending on the age of comparison.

There was no difference between the selection lines in dressing percentage. The relative differences between the selection lines in live-weight and carcase weight at the same age were similar within any group of animals, although not necessarily the same under different environmental conditions.

Abattoir results

To date two groups of 22-23 month old steers have been slaughtered in a commercial abattoir. For these steers there was no difference between the lines in carcase fat depth at either the 12/13th rib or the P8 site.

Average eye muscle area, adjusted for carcase weight, was slightly smaller in the High line steers than in the Control line or Low line steers. However there was no difference between the selection lines in the yield of primal cuts, or in visual muscle score taken prior to slaughter.

Dissection data

Steers from the Trangie feedlot have been slaughtered at strategic intervals from birth to maturity, and their carcases dissected into muscle, fat and bone. The pattern of growth of tissues within the carcase can then be seen over the life of the animal and carcase composition estimated for any age or target market weight.

At the same age there was no significant differences in the steers from the different selection lines in the percentage of subcutaneous fat, intermuscular fat, muscle or bone. Hence, the percentage lean meat yield was the same for all lines.

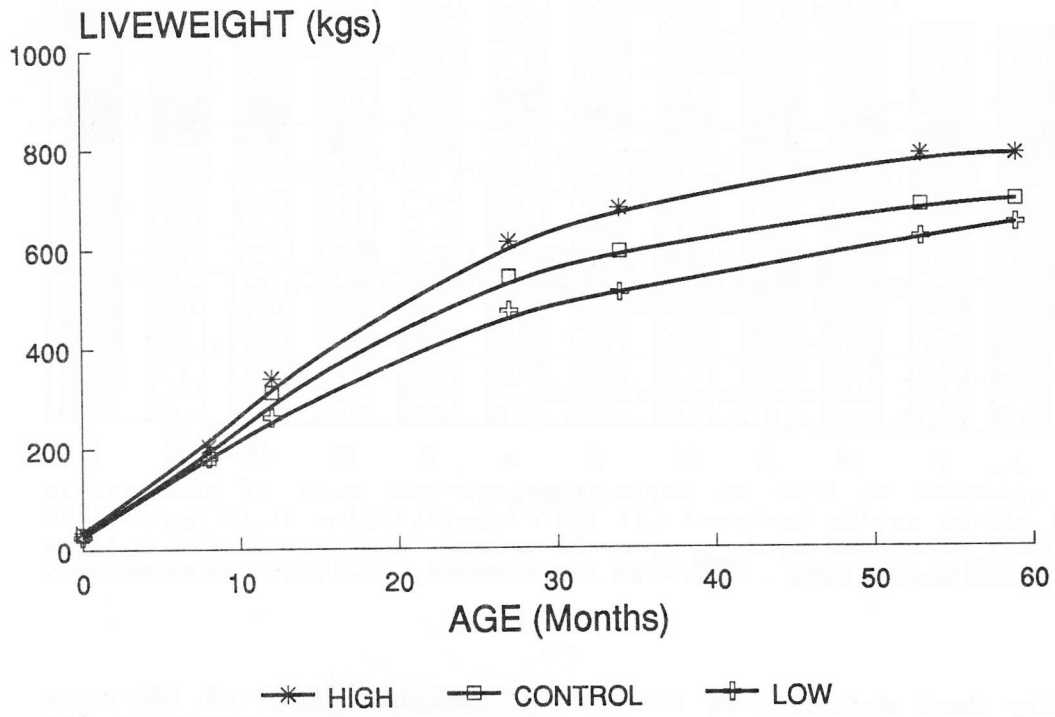
At the same weight there was a trend for the High line steers to be slightly leaner than the Control line steers, which in turn were slightly leaner than the Low line steers. At a carcase weight of 250 kilograms there was only a 2 percent difference in percentage subcutaneous fat and a 2 mm difference in P8 fat depth between the High line and Low line steers.

There was no difference between the selection lines in the percentage of muscle and bone within carcases.

Summary

Preliminary results indicate that when slaughtered at a standard age the High line steers had higher carcase weights, and higher kilogram yields of lean meat than Control or Low line steers. There was no significant change in dressing percentage, fatness, or percentage yield of lean meat yield. High line steers were slightly less muscular at the same age, but this trend was not enough to be of commercial significance.

High line steers reached target slaughter weights faster and had slightly leaner carcases at the same slaughter weight. There was no difference between the lines in dressing percentage or lean meat yield at the same slaughter weight.



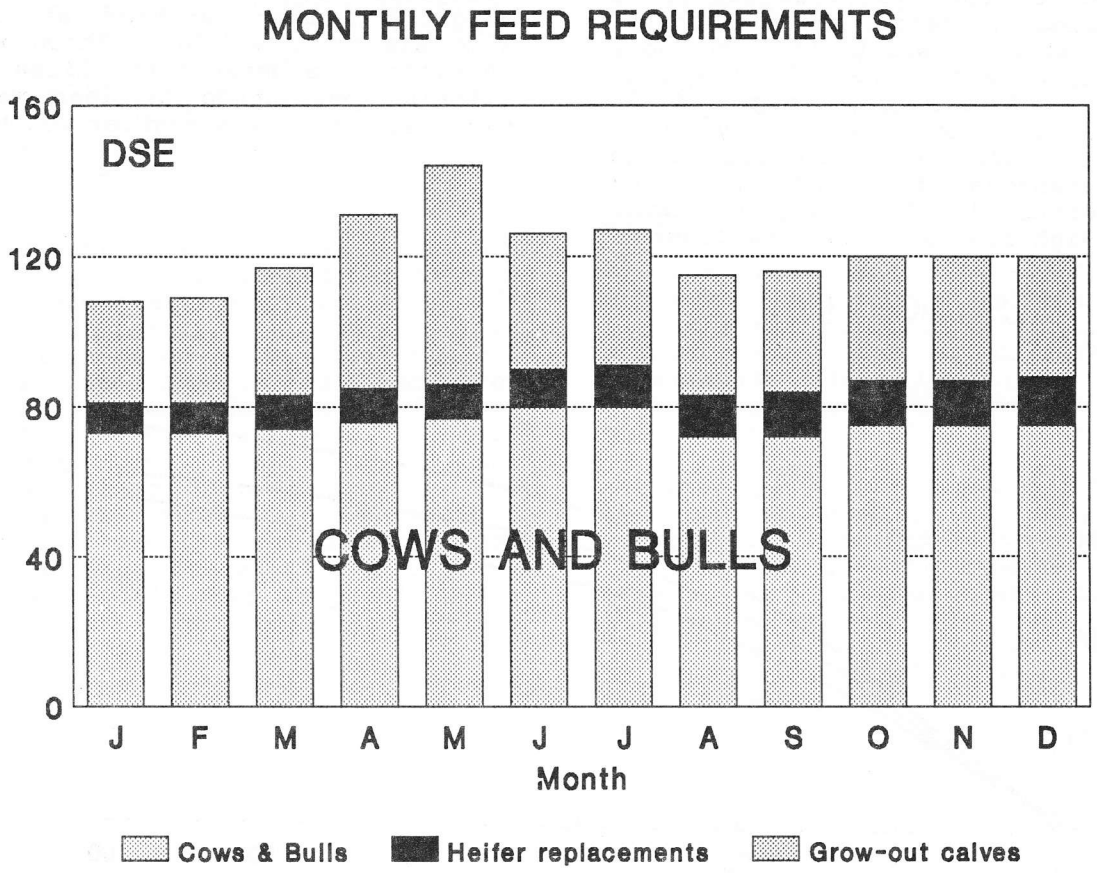
Schedule of slaughters for steers raised in the Trangie feedlot

3.5 Herd feed requirements & efficiency

An important limitation of faster growth rate as a breeding objective is the associated increase in mature cow size and hence in the feed costs of the breeding herd. This is particularly important in pasture based enterprises where cow maintenance and replacement costs can contribute up to 50-80 percent of the total herd feed costs.

For example, in a self-replacing herd of 100 Control line cows, with calves turned-off at 12 months of age, the feed eaten by cows and their heifer replacements is 71 percent of the total feed consumed by the herd.

If the calves are sold at weaning then the total herd feed requirement declines, but the proportion consumed by the cows and their replacements increases to 78 percent of the total. Retaining the calves to 24 months of age increases total herd feed requirements. The proportion of the herd's feed now consumed by the cows and their replacements would still be 54 percent of the total feed cost.



Monthly feed requirements for a self replacing herd of 100 cows turning off calves at 12 months of age. Feed requirements for pregnancy and lactation are included in calf feed requirements.

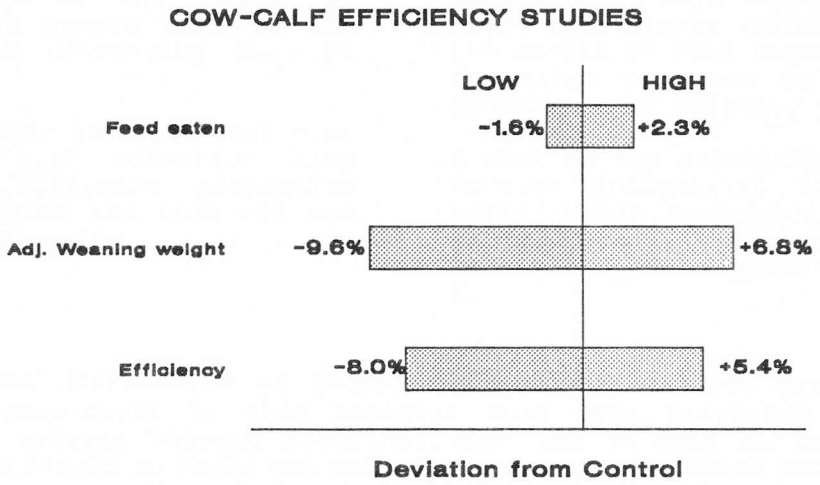
Unless selection for growth rate results in an increase in the efficiency of feed use then the associated increase in mature cow weight could elevate the total herd feed costs to the extent that the number of cows in the herd has to be reduced. This results in the marketing of fewer calves.

Studies have been conducted in the automated feedlot over a number of years to examine the differences between the selection lines in feed consumption and efficiency of cows and calves, and growing steers. Further studies of the feed intake and efficiency of cows maintained at different levels of pasture availability are being conducted at Glen Innes. In addition, direct measures of the profitability per hectare obtained from each selection line are being determined in stocking rate experiments at Hamilton, Victoria.

Cow/calf efficiency

The cow/calf efficiency study in the Trangie feedlot involved the recording of total feed intake of cows from when they entered the feedlot prior to calving until they left following weaning. Feed intake of calves was measured from birth to weaning.

Cows and calves from the High line ate slightly more feed than those from the Control line or Low line. However, the High line calves were heavier at weaning, and the High line cows and calves were more efficient in converting feed energy into calf growth. There was a large variation in the efficiency between individual cows in each of the selection lines.



Differences in feed consumption, weight of calf at weaning, and efficiency (calf weight/feed eaten) for cows and calves in the High and Low selection lines, expressed as percentage deviation from the Control line

Steer efficiency

A detailed study is currently underway in the automated feedlot to determine the feed requirements of steers from each selection line as they grow from birth to maturity. When completed this study will provide data to enable comparisons of the efficiency of growth of steers to any specified age or market weight, or to the same degree of carcase maturity.

The results of a smaller study of the efficiency of High line and Low line yearling steers have been analysed. At the same age there was little difference between steers from the High and Low selection lines in the amount of feed required per kilogram of weight gain. However, due to their faster growth rate, the High line steers would require fewer days of feeding to reach a given target market weight.

Results of other studies

There are few reports of other experiments where the effects of selection for growth rate on the efficiency of feed use have been studied. Separate studies on responses in the feed efficiency of bulls and steers in lines of Hereford cattle selected for either weaning weight or yearling weight in the USA have shown conflicting results.

Summary

Selection for increased growth rate was accompanied by a small improvement in the efficiency of feed use by cows and their calves.

Further studies will determine if selection for growth rate changes the efficiency of the growth of steers to specified market weights, ages or degrees of carcase maturity. Early results have not found any change in the efficiency of feed use of steers at one year of age.

4. RESPONSES IN HERD PROFITABILITY

The key objective of the Trangie project was to determine the effect of selection for growth rate on herd profitability. In order to determine this, performance data collected during the project was used to compare the expected economic returns from each selection line under a range of beef production systems.

A series of gross margin budgets were used to compare the differences between the costs and returns associated with each beef production system. A gross margin is the total income from an enterprise less the variable costs attributed to that enterprise. It does not account for capital costs such as the interest charges on the purchase of livestock, machinery or buildings. Nor does it include the costs of land ownership or labour.

The difference between the selection lines in the gross margin per unit of feed consumed provided an indication of the effect of selection for growth rate on the efficiency of converting feed to profit.

The gross margin analyses were conducted for each selection line under five different production systems in which the turn-off age of calves was varied.

These production systems were:

1. Self-replacing herd turning off 7 month old progeny,
2. Self-replacing herd turning off 12 month old progeny,
3. Self-replacing herd turning off 18 month old progeny,
4. Self-replacing herd turning off 18 month old heifers and 24 month old steers, and
5. Self-replacing herd turning off 24 month old progeny.

Each enterprise was based on a 100 cow herd.

In order to compare the relative efficiency of the three selection lines at converting feed to profit it was necessary to calculate the annual feed requirements for each line under each of the five production systems. The feed requirements were expressed as Dry Stock Equivalents (DSEs). A DSE is the amount of feed required by a 50 kg wether per year to maintain a constant body weight.

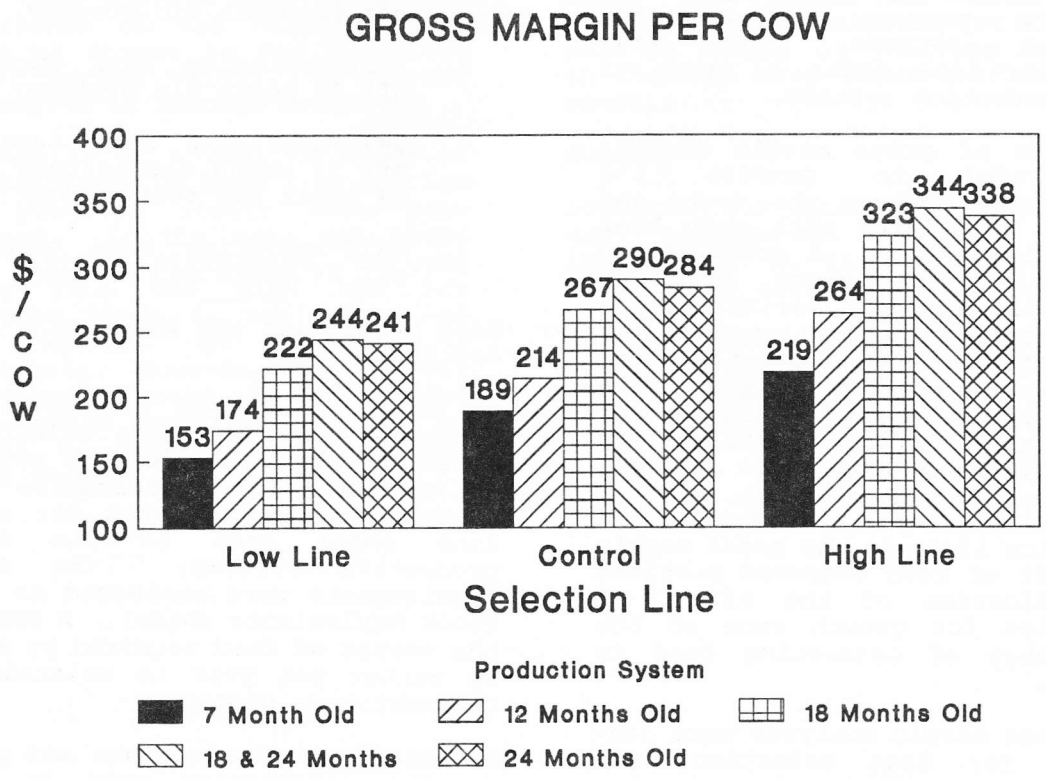
A list of the assumptions and production information used in the gross margin budgets is contained in Appendix 1. An example gross margin budget is shown in Appendix 2.

N.B. The differences in profit between the various production systems considered in this analysis were very sensitive to the relative returns between different ages and weights at turn-off. Producers should do their own calculations to decide which production system is more efficient for their individual situation.

Gross margin per cow

For each selection line the production system with the highest gross margin per cow was that involving the sale of 18 month old heifers and 24 month old steers.

The High line returned the highest gross margin per cow in all production systems.



Gross margin per cow ($/cow) for each selection line and production system

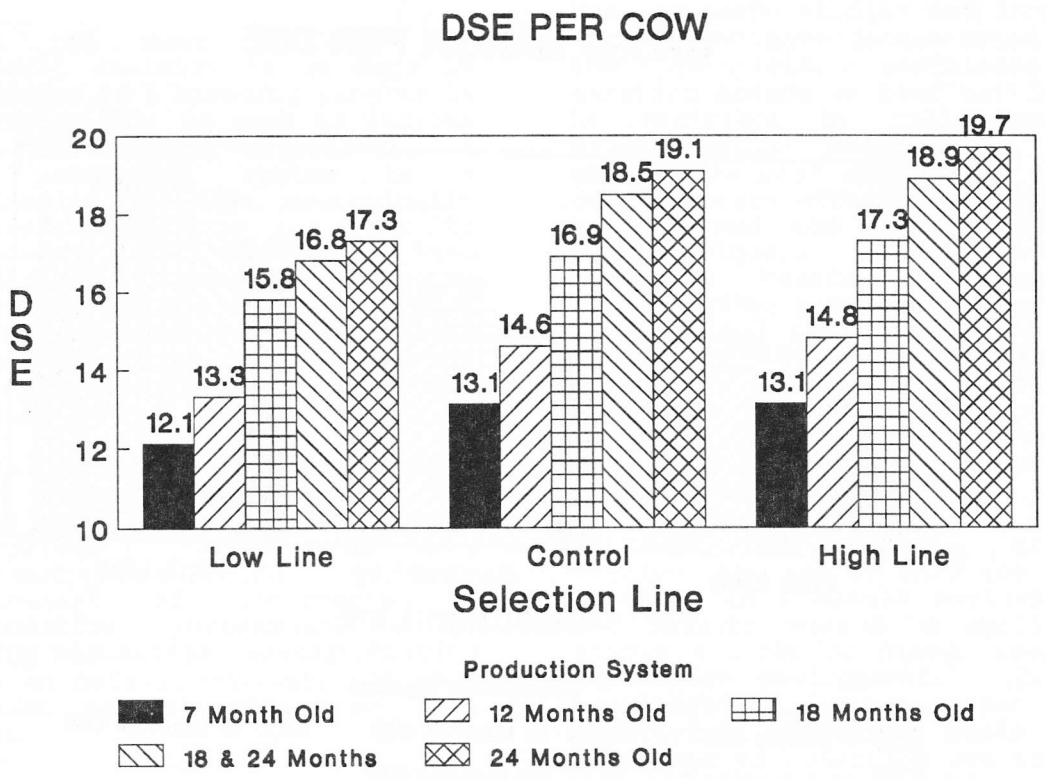
Feed requirements per cow

The feed requirements per cow for each selection line were calculated using the Metabolisable Energy Requirements System. This system is based on the body weight of animals, with allowances for growth rate, pregnancy, lactation, exercise and efficiency of feed conversion.

Live-weights and growth rates used in the estimation of feed requirements were based on the experimental data collected from each selection line. Allowances for pregnancy, lactation and exercise were assumed to be constant (per kg body weight) across each selection line.

The efficiency of feed use for each line was obtained from the cow/calf efficiency studies.

The High line required more feed than the Control line and Low line but the differences between the lines were not as large as the relative weight differences of the cattle would lead us to expect. This was due to the better efficiency of feed use in the High line.



Feed requirements (DSEs per cow) for each selection line and production system

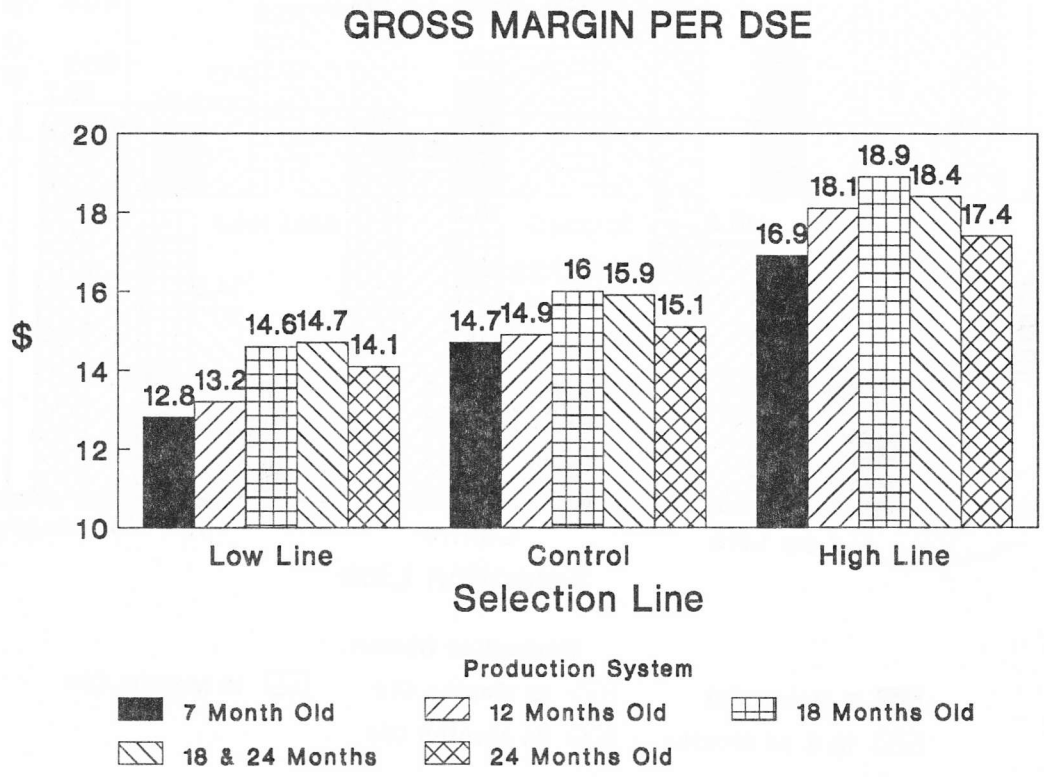
Gross margin per unit of feed

The High line returned more profit per DSE in all production systems examined. This means they were more efficient in converting feed to profit.

The most profitable production system for both the Control line and the High line was that which involved selling both heifers and steers at 18 months of age. The most profitable production system for the Low line involved selling heifers at 18 months of age and retaining steers until 24 months of age. This was because the Low line cattle took longer to reach required market weights.

Summary

The economic analysis showed that the overall profit per unit of feed was greatest for the High line, despite a necessary reduction in the number of cows in the herd relative to the Control line. For example, a 98 cow High line herd, turning off progeny at 18 months of age, would eat about the same amount of feed as a 100 cow Control line herd, but would return $4,800 more per year. This, when combined with the expected labour savings of running fewer animals, makes selection for increased growth rate profitable.



Gross margin per unit of feed ($/DSE) for each selection line and production system

5. IMPLICATIONS FOR INDUSTRY BREEDING PROGRAMS

The economic analyses of results from the Trangie project indicated that selection for increased growth rate would result in more profit per cow and more profit per unit of feed consumed across a range of production systems. However, this result does not necessarily suggest that industry breeding programs should emphasise selection for increased growth rate. The potential increase in profit resulting from selection for increased growth rate must be considered in context with other opportunities for improving profitability through genetic selection.

Often the most critical and difficult decision to be made in the design of a breeding program is specifying what we want to improve (i.e. the breeding objective). A beef production system is a combination of many economically important traits. In order to maximise current and future herd profits the breeding objective should account for all inputs, such as feed, husbandry and marketing costs, as well as for all outputs, such as income from sale of progeny and cull cows.

Growth rate and size will make a major contribution to both the income and the costs in a beef enterprise. However, in many circumstances the genetic improvement of components of reproductive performance (e.g. calving percentage, average calving day), or carcase quality, can have an even greater effect on herd profit.

Ideally, genetic selection would be based on a combination of all the important components of the production system. Unfortunately, in reality many of these components are currently difficult, or impossible, to measure on individual animals. The planned expansion of BREEDPLAN will eventually give breeders a wider range of traits to consider as potential selection criteria to achieve their breeding objectives (e.g. growth and size traits, reproduction traits, carcase traits). Once this occurs, breeders will have to utilise information such as that obtained from the Trangie project to determine the relative emphasis to be placed on each trait.

Many research studies and industry experiences have demonstrated that the commercial usefulness of existing breeds of beef cattle can be maximised by their use in crossbreeding programs. This enables the best utilisation of the complementary effects of different breeds, and the exploitation of hybrid vigour. Selection among available breeds for use in crossbreeding programs may provide near optimal performance for many production systems and market situations. However, continued long-term genetic improvement inevitably depends on the use of selection in the straightbred bull breeding herds.

Although the Trangie project involved the use of only one breed selected in a single environment, the results should be applicable across a range of breed types and production environments. Current knowledge indicates that the underlying genetic basis for responses to selection are similar for all breeds and environments. Notable exceptions to this general rule have only been observed in comparisons between extreme breed types and production environments.

A1. Gross Margin Assumptions.

		low	Control	High
1. Herd Information				
1.	Average Calving Rate	74.7 %	83.7 %	84.0 %
2.	Adult Mortality rate	3.17 %	5.17 %	3.5 %
3.	Calf Mortality Rate	8.0 %	8.5 %	6.0 %
4.	Bulls (% of cows)	3.0 %	3.0 %	3.0 %
5.	Cow Age at First Calf	2 years	2 years	2 years
6.	Cow Age When Culled	8 years	8 years	8 years
7.	Calves Weaned at (age)	7 months	7 months	7 months
8.	Heifer Weaning Weight	145 kg	180 kg	196 kg
9.	Steer Weaning Weight	168 kg	198 kg	218 kg
10.	Calf Birth Weight - Male	25 kg	30 kg	33 kg
11.	Calf Birth Weight - Female	23 kg	29 kg	31 kg
2. Production and Sale Information				
12.	Month Cows Joined		September	
13.	CFA Cow Weight	439 kg	476 kg	535 kg
14.	Steer Sale Weight - 7 months old	168 kg	198 kg	218 kg
15.	Steer Sale Weight - 12 months old	210 kg	250 kg	300 kg
16.	Steer Sale Weight - 18 months old	300 kg	340 kg	390 kg
17.	Steer Sale Weight - 24 months old	380 kg	430 kg	480 kg
18.	Heifer Sale Weight - 7 months old	145 kg	180 kg	196 kg
19.	Heifer Sale Weight - 12 months old	195 kg	235 kg	260 kg
20.	Heifer Sale Weight - 18 months old	280 kg	345 kg	380 kg
21.	Heifer Sale Weight - 24 months old	295 kg	360 kg	400 kg
22.	CFA Bull Weight	530 kg	600 kg	630 kg
23.	CFA Bull Age		5 years	
3. Beef Sale Price Information		($/kg)	($/kg)	($/kg)
24.	Steer Sale Price - 7 months old	$1.55	$1.53	$1.51
25.	Steer Sale Price - 12 months old	$1.45	$1.43	$1.41
26.	Steer Sale Price - 18 months old	$1.39	$1.37	$1.35
27.	Steer Sale Price - 24 months old	$1.30	$1.27	$1.24
28.	Heifer Sale Price - 7 months old	$1.51	$1.49	$1.47
29.	Heifer Sale Price - 12 months old	$1.43	$1.41	$1.39
30.	Heifer Sale Price - 18 months old	$1.31	$1.29	$1.27
31.	Heifer Sale Price - 24 months old	$1.20	$1.17	$1.15
32.	CFA Cow Price	$0.99	$0.99	$0.99
33.	CFA Bull Price	$1.10	$1.10	$1.10

A2. Example Beef Gross Margin Budget.

Enterprise Name: 12 Months Old
Selection Line: High Growth Rate
Enterprise Units: 100 cows

Region: Central West
Date: 17-Aug-90

A. Income:

				Our Budget	Your Budget
a: Sale cattle					
39	steers	$423	/head	$16,646.04	
22	cull heifers	$361	/head	$8,020.58	
13	c.f.a. cows	$530	/head	$6,858.69	
1	c.f.a. bull/s	$693	/head	$693.00	
b: Other					
	A. Total Income			$32,218.32	

B. Annual Operation Expenses:

					Our Budget	Your Budget
a: Replacement stock						
1	bull	@	$2,500		$2,500.00	
b: Husbandry operations						
Operation	Number	Stock class	Number of doses	Cost per head		
1.Vaccination:	100	cows	1	$0.29	$28.58	
Coopers 5 in 1	3	bulls	1	$0.36	$1.07	
	17	repl. heif.	1	$0.15	$2.48	
	85	calves	4	$0.09	$28.90	
2. Drenching:	100	cows	0	$1.45	$0.00	
Systamex-Rumen In	3	bulls	0	$1.81	$0.00	
	17	repl. heif.	1	$0.75	$12.57	
	85	calves	1	$0.43	$36.60	
3. Lice Control	100	cows	3	$1.67	$500.15	
Tiguvon-Spot On	3	bulls	3	$2.08	$18.75	
	17	repl. heif.	3	$0.86	$43.41	
	85	calves	3	$0.50	$126.42	
c. Other Costs:		eartags @	$0.91	/cow	$91.30	
		raddle ink @	$0.52	/cow	$51.56	
		causmag @	$0.08	/cow	$8.44	
		cal mag @	$0.26	/cow	$26.13	
		harnesses @	$0.55	/cow	$54.75	
d. Pasture Protection Board Rates (levied on DSE equivalents)						
1478	DSE units	@	$0.122	/DSE	$180.26	
e. Veterinary costs	$250	per annum	(ave. costs)		$250.00	
f. Vibrio vaccination for bulls		10	ml/year @	$3.50 /ml	$104.94	
g. Sale costs						
4% charged on sale cattle					$1,288.73	
75 sale cattle @	$1.60	/head saleyard charge			$120.79	
	B. Total Operation Expenses:				$5,475.83	

				Your Budget
		Gross Margin (A - B)	$26,742.48	
		Gross Margin/cow	$264.44	
Herd LSM's	17730	Gross Margin/LSM	$1.51	
Herd DSE's	1478	Gross Margin/DSE	$18.10	

Beef Cattle Budgets – Production Information

Enterprise Name:	12 Months Old	Region:	Central West
Selection Line:	High Growth Rate	Date:	17–Aug–90
Enterprise Units:	100 cows	Time:	9:02 AM

1. Livestock Trading:

a: Sale Livestock

Number	Class	Month Sold	Weight (kg)	Price ($/kg)	Price ($/head)	Age (mths or yrs)
39	steers	July	300	$1.41	$423.00	12
22	cull heifers	July	260	$1.39	$361.40	12
13	cfa cows	January	535	$0.99	$529.65	8
1	cfa bull	January	630	$1.10	$693.00	5

b: Purchase Livestock

Number	Class	Month Purchased	Weight (kg)	Price ($/kg)	Price ($/head)	Age (mths or yrs)
1	repl. bull	March	504	NA	2500	2

2. Herd Information:

Target herd size (number of cows + – 2%)		100
Average body weight of mature cows (in kgs)		535
Average calving rate		84.02%
Average weaning weight	– steers (kgs)	218
	– heifers (kgs)	196
Average weaning age	– steers (in months)	7
	– heifers (in months)	7
Mortality rate	– adult cattle (per annum)	3.50%
	– calves	6.00%
Bulls	– as a percentage of cows	3%
Cows	– age at first calf (years)	2
Cows	– age when culled (years)	8

3. Herd Structure:

Cow Age	Number of Cows	Calves	Weaners/ Vealers	Yearlings	Herd Output
2	16		40 heifers	39 heifers	17 replacement heifers retained
3	15				
4	15	85			22 heifers sold @ 12 months old
5	14				
6	14		40 steers	39 steers	39 steers sold @ 12 months old
7	13				
8	13				13 cfa cows sold @ 8 years old
					1 cfa bull sold @ 5 years old

Beef Cattle Budgets – Metabolisable Energy Requirements.

Enterprise Name: 12 Months Region: Central West Time: 9:43 AM
Selection Line: High Growth Rate Date: 17-Aug

Operations:	January	February	March	April	May	June	July	August	September	October	November	December
Joining									Joining			
Calving						Calving						
Weaning	Weaning											
Cow Status			Calf in 3	Calf in 2	Calf in 1	Lactating	Lactating	Lactating	Lactating	Lactating	Lactating	Lactating
Table Of M.E Requirements – Wet Cows (including those 3< months from partuition)												
Number	0	0	85	85	85	85	85	84	84	83	83	82
weight	471	471	475	479	479	502	502	445	445	482	482	482
FM Mj			34.64	34.91	34.91	36.29	36.29	32.83	32.83	35.06	35.06	35.06
Exercise			1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Efficiency			1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
Cow Status			1.10	1.30	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
ME Mj/day			76.81	91.50	105.57	117.06	117.06	105.90	105.90	113.09	113.09	113.09
L.S.M./head			9.30	11.08	12.79	14.18	14.18	12.83	12.83	13.70	13.70	13.70
Table Of M.E Requirements – Dry Cows												
Number	101	101	16	16	16	16	17	17	17	18	18	19
weight	471	471	475	479	479	502	502	445	445	482	482	482
FM Mj	34.42	34.42	34.64	34.91	34.91	36.29	36.29	32.83	32.83	35.06	35.06	35.06
Exercise	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Efficiency	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
ME Mj/day	69.38	69.38	69.83	70.38	70.38	73.16	73.16	66.19	66.19	70.68	70.68	70.68
LSM/head	8.40	8.40	8.46	8.52	8.52	8.86	8.86	8.02	8.02	8.56	8.56	8.56
Table Of M.E Requirements – Male Calves												
Number	40	40	40	40	39	0	0	0	0	0	0	0
weight	234	251	267	284	300	0	0	0	0	0	0	0
FM Mj	19.97	20.97	21.97	22.97	23.97							
Exercise	1.60	1.60	1.60	1.60	1.60							
Efficiency	1.26	1.26	1.26	1.26	1.26							
ME main	40.26	42.27	44.29	46.31	48.32							
Wght Gain	0.54	0.54	0.54	0.54	0.54							
Retention	6.88	7.08	7.28	7.47	7.67							
Eff. Gain	0.66	0.66	0.66	0.66	0.66							
ME Gain	10.44	10.74	11.04	11.35	11.65							
ME Mj/day	50.70	53.02	55.33	57.65	59.97							
LSM/head	6.14	6.42	6.70	6.98	7.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Table Of M.E Requirements – Males > 12 months old.												
Number	0	0	0	0	0	0	0	0	0	0	0	0
weight	0	0	0	0	0	0	0	0	0	0	0	0
FM Mj												
Exercise												
Efficiency												
ME main												
Wght Gain												
Retention												
Eff. Gain												
ME Gain												
ME Mj/day												
LSM/head	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Table Of M.E Requirements – Female Calves												
Number	40	40	40	40	39	0	0	0	0	0	0	0
weight	209	222	234	247	260	0	0	0	0	0	0	0
FM Mj	18.41	19.19	19.97	20.75	21.53							
Exercise	1.60	1.60	1.60	1.60	1.60							
Efficiency	1.26	1.26	1.26	1.26	1.26							
ME main	37.11	38.68	40.26	41.83	43.40							
Wt. Gain	0.42	0.42	0.42	0.42	0.42							
Retention	4.92	5.03	5.15	5.27	5.38							
Eff. Gain	0.66	0.66	0.66	0.66	0.66							
ME Gain	7.47	7.64	7.82	7.99	8.17							
ME Mj/day	44.57	46.32	48.07	49.82	51.58							
LSM/head	5.40	5.61	5.82	6.03	6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table Of M.E Requirements – Females > 12 months old, not in breeding herd.

Number	0	0	0	0	0	0	0	0	0	0	0	0
weight	0	0	0	0	0	0	0	0	0	0	0	0
FM Mj												
Exercise												
Efficiency												
ME main												
Wt. Gain												
Retention												
Eff. Gain												
ME Gain												
ME Mj/day												
LSM/head	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table Of M.E Requirements – Heifer Replacements

Number	0	0	0	0	0	17	17	17	17	17	17	17
weight						277.71	295.43	313.14	330.86	348.57	366.29	384.00
FM Mj						22.61	23.69	24.77	25.85	26.93	28.01	29.09
Exercise						1.60	1.60	1.60	1.60	1.60	1.60	1.60
Efficiency						1.26	1.26	1.26	1.26	1.26	1.26	1.26
ME main						45.58	47.76	49.94	52.12	54.30	56.48	58.65
Wt. Gain						0.58	0.58	0.58	0.58	0.58	0.58	0.58
Retention						8.12	8.36	8.59	8.83	9.06	9.30	9.53
Eff. Gain						0.66	0.66	0.66	0.66	0.66	0.66	0.66
ME Gain						12.33	12.69	13.04	13.40	13.76	14.11	14.47
ME Mj/day						57.91	60.45	62.98	65.52	68.05	70.59	73.12
LSM/head	0.00	0.00	0.00	0.00	0.00	7.01	7.32	7.63	7.94	8.24	8.55	8.86

Table Of M.E Requirements – Bulls

Number	3	3	3	3	3	3	3	3	3	3	3	3
weight	630	630	630	630	630	630	630	630	630	630	630	630
FM Mj	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10	44.10
Exercise	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
Efficiency	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26
ME Mj/day	88.91	88.91	88.91	88.91	88.91	88.91	88.91	88.91	88.91	88.91	88.91	88.91
LSM/head	10.77	10.77	10.77	10.77	10.77	10.77	10.77	10.77	10.77	10.77	10.77	10.77

Table of Total Herd Requirements in LIVESTOCK MONTHS

Cows	850	850	927	1079	1224	1348	1346	1215	1213	1294	1291	1289
Calves	461	479	497	515	533	0	0	0	0	0	0	0
Heifers	0	0	0	0	0	118	123	128	132	137	142	146
Bulls	33	33	33	33	33	33	33	33	33	33	33	33
TOTAL	1343	1362	1457	1627	1790	1499	1501	1376	1378	1463	1466	1468
Year Total	17730											

Note:

A livestock month is the amount of energy required to maintain a 50 kg wether for one month. That is, one twelth of a Dry Stock Equivalent (DSE).

A3. HISTORY OF THE TRANGIE ANGUS HERD

The Angus herd at the Trangie Research Centre was established in 1929 to assist in providing a source of quality Angus cattle for the NSW cattle industry.

Foundation stock were purchased from the Glencarnock Stud, Brandon, Canada. The original importation included two bulls, one cow and calf, and seventeen heifers. The two bulls "Glencarnock Revolution" and "Brave Edward Glencarnock" were from the famous "Blackcap Revolution" family. "Blackcap Revolution" had remarkable success in the show ring, being Champion Bull at the famous Chicago International Show in 1923. His sire, "Earl Marshall", sired no less than nine champions of the Chicago International Shows (including "Blackcap Revolution").

The bull "Brave Edward Glencarnock" was by "Edward Glencarnock", a son of "Blackcap Revolution". During his life he sired several Sydney Royal Show champions, including the Trangie exhibits that won the prestigious Narrangullen Cup three times.

The cow "Glencarnock Eurotia 4th" was an outstanding import. Her progeny won many prizes at the Sydney Royal Show. These included the Champion bulls "Trangie Prism" and "Trangie Edward 4th", the Champion Cow "Trangie Eurotia 2nd" (twice), and several Reserve Champions. Another cow, "Blackcap Bixie 2nd", was imported in calf, carrying "Glencarnock Blackcap Eric" who became Champion Bull at Sydney in 1933.

In 1936, the bull "Revolution of Page 28th" was imported from the USA. He was also sired by "Blackcap Revolution" and had a brilliant record as a sire before coming to Australia. He was the sire of "Blackcap Bessie 23rd of Page", Grand Champion Female at Minnesota, North Dakota, Great Falls and Montana, and Champion Cow at the Chicago International in 1939. His prize-winning progeny at the Sydney Royal included "Trangie Susan", Junior Champion Heifer in 1941, and "Trangie Page 52nd", Reserve Champion Bull in 1944.

In 1941 the English-bred bull "Everside 2nd of Maisemore" was imported, and in 1947 the bull "Erison of Harviestoun" was purchased for 3000 guineas from the famous Dalmeny Stud in Scotland. Four heifers, also bred from the leading bloodlines at Dalmeny, were imported in 1948.

The bull "Eblinettee's General of Ada" and two heifers "Craven's Revolution Blackcap 7th" and "Lady Glencarnock 4th" were imported from Canada in 1947. In the same year, three heifers were imported from Andelot Stud, Maryland, USA.

The stud exhibited with considerable success at the Sydney Royal Show during the 1940s and 1950s. Four Champion Bull awards were gained between 1948 and 1956, including Supreme Champions "Trangie Anthony" and "Trangie Erison 46th" in 1954 and 1955, respectively. The herd was considered as a source of high quality Angus cattle and bulls were sold to breeders from many parts of Australia.

The last introduction from overseas was the bull "Pro Ben of Balfron", imported from Scotland in 1956. Between 1961 and 1964 bulls were purchased from the leading NSW studs "Wambanumba", "Glengowan", "Tulagi" and "Wallah". The herd has remained totally closed since 1964 with no further introductions of outside animals.

In 1963 the Australian Meat Research Committee provided financial support for a research project to consider the role of performance recording in the breeding program of the herd. Equal emphasis was given to weight gain and visual conformation score in the selection of replacement bulls and heifers. This policy continued until 1970, and provided a successful demonstration of the use of measured performance in a stud herd.

From 1971 to 1973 a trial was conducted in the herd to compare the progress made from selection based on measured weight gain with that achieved using visual appraisal. The herd was divided into two portions. One portion was selected as it had been from 1963, whilst the other was selected by a panel of experienced stud breeders using visual appraisal. It soon became apparent that the panel of stud breeders was also placing a great deal of emphasis on size and conformation in their selection of replacements. The results indicated that the stud breeders were attempting to increase the growth potential of animals, either with or without the use of measured performance.

In 1974 a new project was initiated to evaluate the effect of selection for growth rate on total herd profitability. The herd was divided into three closed lines: a High line, selected for increased yearling growth rate; a Low line, selected for decreased yearling growth rate; and a randomly selected Control line. This unique design has been maintained to the present day. The difference between the High and Low lines in yearling growth rate is now greater than 30 per cent, representing the expected response following 25-30 years in a conventional, within-herd selection program.

The current research program involves a detailed evaluation of responses in the key components of herd productivity (e.g. weight gain, feed intake, reproductive performance, milk production, carcase yield and quality, structural soundness). Funds are provided by the Australian Meat and Live-Stock Research and Development Corporation to facilitate this research. "Satellite" herds have been established at Glen Innes and Hamilton, Victoria to evaluate the responses across a range of environments.

Whilst the emphasis in the Trangie herd is now on research, a portion of the herd is still maintained as a registered Angus stud.

Summary

1929	Importation of foundation stock from "Glencarnock Stud", Brandon, Canada
1930-50	Further importations from Canada, USA & Scotland
1961-63	Introductions from NSW studs - "Wanbanumba", "Glengowan", "Tulagi", and "Wallah"
1963-73	Selection based on visual appraisal and performance recording
1974-90	Evaluation of the effect of selection for growth rate on herd profitability

A4. THE TRANGIE FEEDLOT - A COMPUTERISED FEEDING SYSTEM

To study the effects of selection for growth rate on herd feed costs a computerised feeding system was developed to measure the feed consumption of individual animals in each selection line.

The computerised feeding system was developed and built at the Research Centre. Animals are run in groups in a feedlot and fed a pelleted diet of consistent quality. The pellets are produced in the feedmill at the Research Centre.

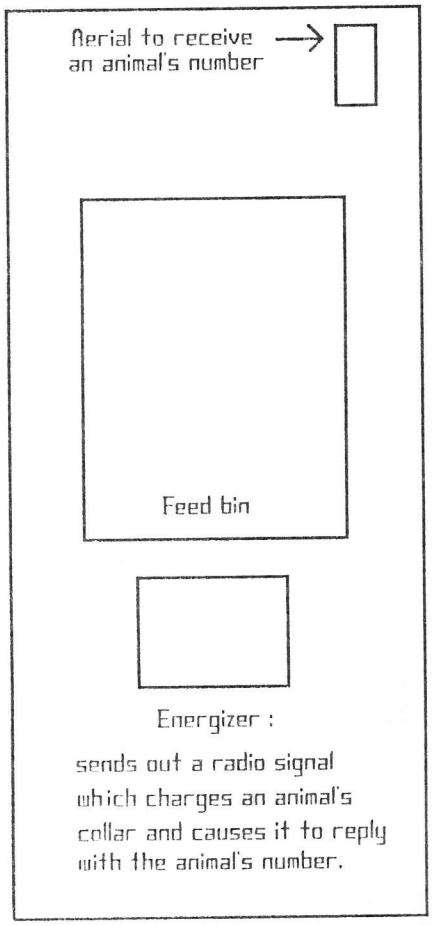
Each animal has access to feeding stalls 24 hours a day. A diagram of the front and back view of one of these stalls is shown below, identifying the main components and their functions.

Each animal wears a lightweight collar containing an individually encoded transponder. This identification number is recognised by a computer which controls both the feeding and the recording systems.

The amount of pellets fed and the amount remaining uneaten is weighed and recorded each time a new animal enters a stall. The amount of feed eaten is calculated for each animal on a daily basis.

The system gives us an accurate measure of the daily feed intake of each animal.

FRONT OF A FEEDER



BACK OF FEEDERS