CONTRACT REVIEW

THE CONSEQUENCES OF SELECTION FOR GROWTH RATE IN BEEF CATTLE

P.F. PARNELL

NSW Agriculture, Agricultural Research Cenrtc, PMB 19, Trangie, N.S.W. 2823

During the last 2 decades beef producers in Australia have placed considerable 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. Whilst it is known that selection for increased growth rate will result in faster growing animals which are heavier and larger at all ages, the associated changes in other components of herd profitability are less certain. After reviewing the available evidence Barlow (1984) concluded that when the breeding objective was defined at the herd level there was little justification for selecting for growth rate to improve the efficiency of meat production in maternal breeds under favourable environments. He suggested that a major limitation of selection for growth rate was that any increases in gross efficiency among growing stock appeared to be more than offset by higher maintenance requirements of breeding females.

The studies described in this review were designed to provide information on the effects of selection for growth rate on each of the major components of herd profitability. The experiment commenced at Trangie, NSW in 1974 with the establishment of divergent growth rate selection lines to investigate responses in growth rate, turn-off weight, size, reproductive performance, maternal ability, carcase composition, herd feed requirements and overall herd profitability. The studies were subsequently expanded at Glen Innes, NSW and Hamilton, Vic to enable further evaluation of the responses in production efficiency across a range of nutritional environments. This contract reviews the results obtained at each of these locations, and briefly compares the results with evidence from other studies.

THE TRANGIE EXPERIMENT - RESPONSES IN GROWTH RATE, SIZE, MATERNAL ABILITY, REPRODUCTIVE PERFORMANCE, CARCASE COMPOSITION, FEED REQUIREMENTS AND HERD PROFITABILITY

P.F. PARNELL, R.M. HERD, D. PERRY and B. BOOTLE

NSW Agriculture, Agricultural Research Centre, PMB 19, Trangie, N.S.W. 2823

The Trangie growth rate selection experiment commenced in 1974 with the establishment of 3 closed lines of Angus cattle at the Agricultural Research Centre. Of the 220 cows in the herd, a group of 50 were randomly chosen to form a Control (C) line. Of the remaining cows, 85 were allocated to the High (H) line and 85 to the Low (L) line, based on their individual yearling growth performance. This design was chosen to provide a rapid divergence in growth rate between the H and L lines, with the C line providing a base for the measurement of selection responses (Barlow 1979). From 1974 to 1992 the 3 lines remained closed with no introduction of outside genetic material. All replacement bulls and heifers for the H and L lines were selected solely on their own growth performance from birth to yearling age (adjusted for age of dam). The C line was maintained with all replacements chosen at random. Replacement bulls and heifers were joined at 14 months of age, and bulls were used for only 1 breeding season. Cows were culled only if they failed to calve in 2 consecutive years. Animals from each line were run together throughout the year, except during mating. From 1974 to 1982 the H and L lines were each maintained with approximately 85 breeding females and 5 sires used per year. The C 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. Sires used each year at Trangie were subsequently used at Glen Innes and Hamilton to maintain genetic links between each location. Figure 1 shows the responses in various production traits measured at Trangie in the H and L lines, relative to the C line.

Responses in growth and size

The average difference between the H and L lines in yearling growth rate after 15 years of selection was over 25 %. The average response in weight gain to yearling age was 2.11 kg/year (about 0.87% per year) in the H line and 2.54 kg/year (about 1.05% per year) in the L line. These responses corresponded to realised heritabilities of 0.37 ± 0.09 and 0.38 ± 0.09 in the H and L lines, respectively. The actual responses obtained in any particular year fluctuated from the overall pattern of responses in each line due to genetic sampling effects. The direct responses in growth rate in each line were associated with correlated responses in size and weight of calves at all ages. On average, the H line calves were larger and heavier at all ages than the C line calves, and the L line calves were smaller and lighter. The H line heifers had larger pelvic areas than C line heifers and L line heifers had smaller pelvic areas. Mature H line cows were larger and heavier than C line cows and L line cows were smaller and lighter. The responses in cow weight and size lagged behind the responses observed in calves because they were the result of fewer years of selection.

Responses in maternal performance

The changes in weaning weight resulting 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. The relative changes in calf growth potential and cow milk production were measured by cross-mothering samples of H and L line calves between cows from each line. The growth of these cross-mothered calves was then compared with that of their naturally-mothered contemporaries (Herd 1990). The milk production of cows was also estimated at strategic intervals during lactation using the calf "weigh-suckle-weigh" technique. When cross-mothered to L line cows, the H line calves were lighter at weaning (-5%) than naturally reared H line calves. Conversely, when L line calves were cross-mothered to H dams they were heavier (+4%) than naturally-reared L line calves. The results indicated that 82% of the difference in weaning weight between the H and L line calves was due to difference in their genetic potential for growth. The other 18% was due to differences in the maternal ability of their dams. The differences in maternal ability could be explained by differences in estimated milk production between the selection lines. The H line cows produced slightly more milk than C line cows, and L line cows produced less milk.

Responses in reproductive performance

Selection for increased growth rate reduced the average age of first observed oestrus in H line heifers relative to C line heifers, and delayed the average age of first oestrus in L line heifers. The average yearling scrotal size of H line bull calves was larger than C line bull calves, whilst L line bull calves had a smaller average yearling scrotal size. The average gestation length, and the average number of days from start of the joining period to calving (days to calving), were not significantly different between the lines. The average calving percentage was slightly higher, for first-calf H line heifers, relative to C line heifers, and slightly lower for L line heifers. There was no significant difference in calving rate for mature cows in the H and C lines, but a significant decline in L line cows. The incidence of calving difficulties was lower among heifers in both the H and L lines (about 10% average), than in the C line (about 15%).

Responses in carcase composition

Studies were conducted on samples of steers from each selection line slaughtered at a range of ages from birth to maturity. The H line steers had heavier carcases than C line steers at any particular slaughter age, and L line steers had lighter carcases. However, there were no significant differences between the lines in the percentage of carcase fat, muscle or bone at the same age. The H line steers reached a given carcase weight faster and tended to be leaner than C line steers, whilst L line steers took longer to reach any particular carcase weight and tended to be fatter. This was a consequence of the differences in age and stage of maturity of the lines at any carcase weight.

Responses in herd feed requirements and efficiency

Studies were conducted in an automated facility at Trangie to examine the differences between the lines in feed consumption and efficiency of cows and calves, and growing steers. These studies involved the recording of the intake of a pelleted roughage ration for individual animals sampled from each line. The total feed intake of cows was recorded from early pregnancy, through calving and lactation until weaning, along with the growth rates and feed intakes of each calf. The H line cows and calves consumed slightly more feed than C line cows and calves, and L line cows and calves consumed less feed. However, when calf weaning weights and changes in cow liveweights were considered, the H cows and calves were more efficient than C line cows and calves in converting feed energy into calf growth; and L line cows and calves were less efficient. There was considerable variation in the efficiency between individual cows within each of the selection lines. Some cows consumed up to 50% less feed per kg of calf weaned than other cows of similar size from the same selection line. Studies on mature, nonpregnant, non-lactating cows indicated that the differences in individual cow efficiency were likely to be due mainly to individual variation in maintenance feed requirements, and were significantly influenced by differences in body composition (Herd 1992).

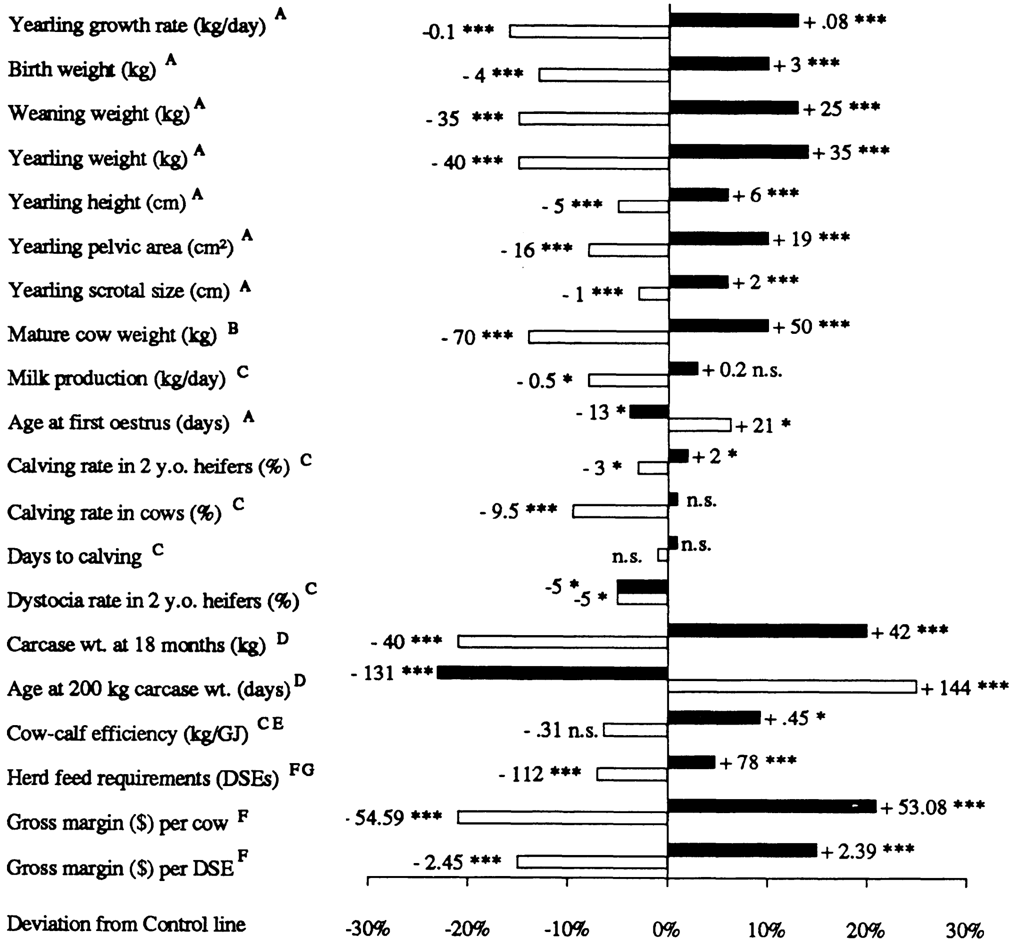

Figure 1. Summary of responses measured at Trangie in the high (closed bars) and low (open bars) growth rate selection lines, relative to the unselected control line

[A]Calves born in 1989-91; [B]Cows calving in 1989-91; [C]Samples of cows measured between 1986-88;
[D]Steers sampled from calves born in 1986-87;
[E]Cow-calf efficiency = kg calf weaned per GJ of feed energy consumed by cow and calf;
[F]Assuming a self-replacing 100 cow herd turning off slaughter animals at 18 months of age;
[G]DSE (dry sheep equivalent) is the amount of feed required by a 50 kg wether for 1 year.
Significance of difference from control line: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; n.s. $P > 0.05$.

Steers from each line were evaluated at Trangie for post-weaning gross feed conversion efficiency. The H line steers consumed less feed per kg liveweight to reach any particular target liveweight than C line steers, and L line steers consumed more feed per kg liveweight. The superior gross feed conversion efficiency of the H line steers was largely due to their faster growth rate resulting in the need to maintain each kg of body weight for a shorter time. A study of H and L line yearling steers showed that H line steers required less feed than L line steers to maintain each kg liveweight, but no difference was found between the lines in the efficiency of feed use for liveweight gain (Herd *et al.* 1991).

Responses in overall herd profitability

The selection responses observed for each line were included in an economic analysis to determine the responses in overall herd profitability for a representative beef production system. Gross margins (GM) were calculated as the total income less the variable costs, and did not account for capital costs, interest charges or the costs of land ownership and labour. The feed requirements for each line were based on the differences in body weight and feed conversion efficiency, with allowances for growth rate, pregnancy and lactation. For a self-replacing herd turning off slaughter progeny at 18 months of age the H line returned a higher GM/cow and consumed more feed than the C line. The L line returned a lower GM/cow and consumed less feed than the C line herd. A 95 cow H line herd consumed a similar amount of feed as a 100 cow C line herd, but returned about $3,750 more profit per year (+15.1%). A 107 cow L line herd also consumed a similar amount of feed as a 100 cow C line herd, but returned $4,045 less profit per year (-15.5%). The reduction in the incidence of calving difficulties in the H and L line heifers relative to the C line heifers had a positive effect on the GMs for both the H and L line herds. Changes in turn-off weights and feed conversion efficiency had positive effects on the GMs for the H line herd and negative effects on the GMs for the L line herd. The reduction in calving rate also had a negative effect on the GMs obtained from the L line herd.

THE GLEN INNES EXPERIMENT - PRODUCTION EFFICIENCY, MARKET SUITABILITY AND PROFITABILITY OF CATTLE SELECTED FOR GROWTH

R. W. DICKER[A] and R.J. FARQUHARSON[B]

[A]NSW Agriculture, Agricultural Research and Advisory Station, PMB, Glen Innes, N.S.W. 2370
[B]NSW Agriculture. Agricultural Research and Advisory Station, PMB, Grafton, N.S.W. 2460.

The H, L and C lines were evaluated at Glen Innes, NSW to determine growth and reproductive rates, estimate pasture intakes, calculate gross feed conversion efficiencies, determine market suitabilities, obtain measures of total herd productivity and calculate relative herd profitabilities across a range of different environments. Breeding herds comprising the 3 lines were grazed at high, medium (industry average) or low levels of nutrition. These nutrition levels were set by strategic management of pasture quality and stocking rate, and supplementary feeding to maintain large differences in cow condition throughout the year. Measurements of total herd productivity included cow liveweight, calving percentage, weaning percentage, weaning weight, steer growth and carcase yield. All differences between the lines and nutrition levels quoted below were significant at the $P < 0.05$ level. Interactions between line and nutritional level were minor.

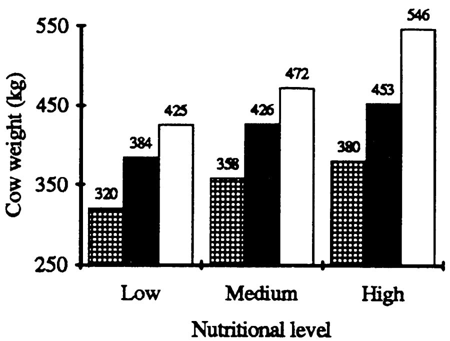

Figure 2. Average annual weights (kg) of breeding cows from the low (cross hatch bars), control (closed bars) and high (open bars) lines at low, medium and high levels of nutrition

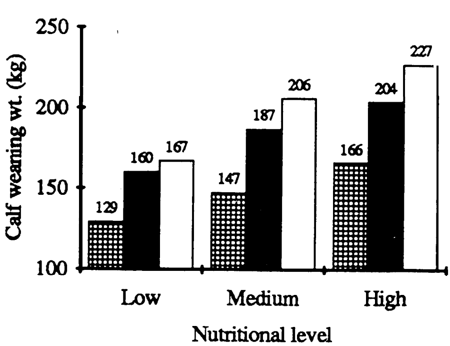

Figure 3. Average weaning weights (kg) of calves from the low (cross hatch bars), control (closed bars) and high (open bars) lines at low, medium and high levels of nutrition

Cow liveweights and calving rates

Average annual liveweights of breeding cows of each line and nutrition level over 6 years are shown in Figure 2. Large differences were maintained between nutrition levels. Differences between lines were greatest at high nutrition. Mean calving rates for each line did not differ. Calving rates at high and medium nutrition (91% and 89%, respectively) were similar and greater than rates at low nutrition (82%).

Growth responses

Average weaning weights of calves (adjusted for sex, 230 day calf age and dam age) of each line and nutrition level are shown in Figure 3. Over the 3 environments H line weaners were 9-13% heavier, and L line weaners were 12-19% lighter, than C line weaners.

Cow intakes and efficiencies

Total pasture dry matter intakes of breeding cows were estimated for a 230 day period from post-calving to post-weaning in 2 consecutive years using "Captec Chrome" intra-ruminal controlled release devices (NuFarm Ltd, Laverton, Vic). Gross feed conversion efficiencies were then calculated as the ratio of calf weaning weight to total pasture dry matter intake of the cow. Mean cow and calf weights at weaning, total dry matter intakes of cows and gross feed conversion efficiencies (adjusted to average cow weight change) of lines for 2 years, adjusted for effects of nutrition level, are shown in Table 1.

The H line cows had 10% heavier calves, and the L line cows had 14% lighter calves, than C line cows. However, H line cows ate 11% more pasture, and L line cows ate 9% less pasture, than the C line cows. Consequently, there were no differences in gross feed conversion efficiency between the lines.

Table 1. Means (± SE) of cow and calf weights at weaning, total pasture dry matter intake of cows from post-calving to post-weaning and gross feed conversion efficiency of each line pooled across 2 years and adjusted for effects of nutrition level

	Low line	Control line	High line
Cow weight at weaning (kg)	349 (5)^c	387 (5)^b	420 (4)^a
Calf weaning weight (kg)	172 (3)^c	199 (4)^b	219 (3)^a
Total dry matter intake (kg)	1971 (32)^c	2172 (38)^b	2409 (29)^a
Gross feed conversion efficiency (kg calf/1000 kg dry matter intake)	88.6 (1.8)	93.1 (2.1)	92.2 (1.6)

Values with unlike superscripts in same row are different, $P < 0.05$.

Market suitabilities

Weaner steers were evaluated under commercial conditions in grow-outs on pasture at high nutrition with co-operating beef producers. In a normal year all steers were suitable for the domestic market at about 23 months of age. Liveweights of finished steers of each line and pre-weaning nutrition level are shown in Figure 4. Over the 3 pre-weaning nutrition environments, H line steers were 10-14% heavier, and L line steers were 1620% lighter, than C steers. Post-weaning liveweight gains of H line steers were an average 11% higher than C line steers. All steers from low pre-weaning nutrition had greater gains than those from other levels. When slaughtered at the same age, carcases of all lines had similar fat cover (7-10 mm at the 12/13th rib), dressing percentages (54%), wholesale meat yields (73%) and quality characteristics.

Profitabilities

Gross margins per unit of feed required were calculated to compare the profitabilitv of lines at each nutrition level for an enterprise breeding and grass finishing 2 year old steers. The feed unit used was the dry sheep equivalent (DSE, the feed required by a 50 kg wether for 1 year). Gross margins per DSE for each line and nutrition level are shown in Figure 5. The H line was more profitable than other lines at all nutrition levels despite its higher feed requirement. Increases in gross margin per DSE for the H line over the C line were 9%, 8% and 8% at high, medium and low nutrition levels, respectively. Corresponding decreases for the L line from the C line were 24%, 15% and 13%. These differences were largely due to the different turnoff weights for each line.

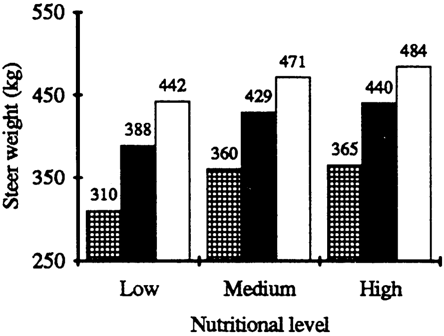

Figure 4. Average finished liveweights (kg) of steers from the low (cross hatch bars), control (closed bars) and high (open bars) lines at low, medium and high pre-weaning nutrition levels grown out on pasture at high nutrition

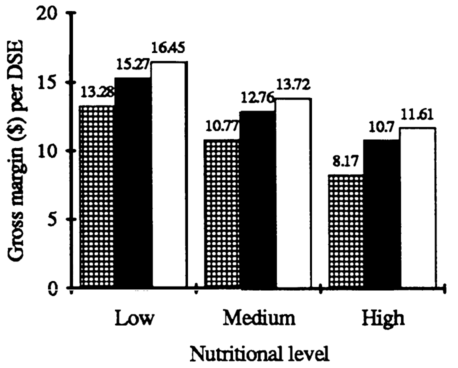

Figure 5. Gross margins ($) per DSE (the feed required by a 50 kg wether for 1 year) for the low (cross hatch bars), control (closed bars) and high (open bars) growth rate lines at low, medium and high levels of nutrition

THE PER HECTARE PRODUCTIVITY AND EFFICIENCY OF BEEF COWS SELECTED FOR DIFFERENT RATES OF GROWTH

J. F. GRAHAM

Dept of Agriculture, Pastoral and Veterinary Institute, Private Bag 105, Hamilton, Vic. 3300

At Hamilton, Vic, the productivity of the H, L, and C lines was compared when each line was stocked at either 0.8, 1.2, 1.6 or 2.0 cows/ha, over a 4 year period. The design was a randomised control block, with 4 animals/plot with each plot replicated. Each year bulls from each of the selection lines that had previously been used firstly at Trangie and then at Glen Innes, were joined to females at Hamilton. Within years, the average age of the females in each line by stocking rate treatment was similar, and each year older cows were replaced by heifers. After calving, plots were maintained with 100% calves at foot. Calving in autumn, joining commenced in the first week of June, for a 9 week period, and calves were weaned when around 10 months of age.

Table 2. The influence of line and stocking rate on cow and calf liveweight (kg) at weaning

	Stocking rate (cows/ha)				
	0.8	1.2	1.6	2.0	Mean
Low	462/228	464/217	422/197	398/190	437/208
Control	530/263	505/255	483/243	473/243	498/251
High	576/290	527/274	510/263	461/237	518/266
Mean	523/260	500/249	472/234	444/224	484/242

Cow liveweight LSD (P = 0.05): stocking rate = 22.3; Line = 19.3.
Calf liveweight LSD (P = 0.05): stocking rate = 11.4; Line = 13.1.

Table 2 shows cow and calf liveweights at weaning. Both line and stocking rate significantly ($P < 0.05$) influenced calf weaning weight (adjusted to 280 days of age using standardised adjustments for age of dam, sex and age of calf) and cow liveweight at weaning.

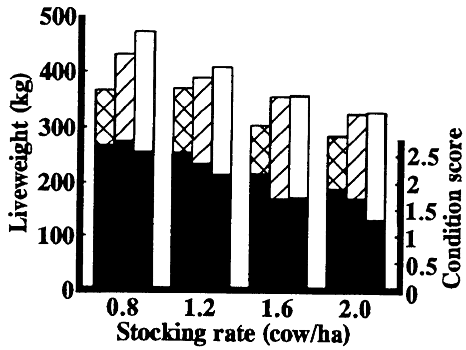

Figure 6. Cow liveweight and condition score (closed bars) at the end of mating, of low (cross hatch bars), control (diagonal hatch bars) and high (open bars) growth rate lines at 4 stocking rates

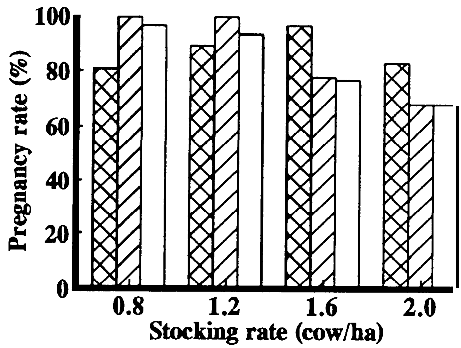

Figure 7. Pregnancy rates of the low (cross hatch bars), control (diagonal hatch bars) and high (open bars) growth rate lines at 4 stocking rates (4 year average)

Figure 6 shows that condition score and liveweight of cows at the end of mating (normally the end of the winter feed shortage period) was also significantly influenced ($P < 0.001$) by both line (condition score LSD = 0.15, liveweight LSD = 17.4) and stocking rate (condition score LSD = 0.17, liveweight LSD = 20.11). Because of the lower condition score and lower relative liveweight of the H and C line cows at the high stocking rate over winter, compared to the L line cows at the same stocking rate, the pregnancy rates of those cows were adversely affected compared to the L line cows (Figure 7). Stocking rate (LSD = 10.52, $P = 0.004$), but not line, significantly influenced pregnancy rates. However, there does seem to be an interaction between line and stocking rate; as stocking rate increased, the pregnancy rates of both the H and C line cows tended to decrease (LSD = 18.2, $P = 0.055$) compared to the L line cows.

Figure 8 shows the productivity (weaned calf liveweight produced per ha) of the 3 lines, calculated using pregnancy rates as shown in Figure 7 and compared with productivity using pregnancy rates of 100%. Both line (LSD = 16.44) and stocking rate (LSD = 18.99) influenced per ha productivity ($P = 0.001$) when pregnancy rates of 100% were used, and the significant stocking rate by line interaction (LSD = 32.9, $P = 0.043$) indicates that the productivity of the H line cows stocked at 2.0/ha had been reduced in comparison to the C and L line cows. When actual pregnancy rates were included, the influence of line failed to be significant ($P = 0.105$) because the productivity of the C and H line cows was substantially reduced, compared to that of the L line cows at the higher stocking rates.

The efficiency of production of the 3 lines (the per ha production from a given cow liveweight/ha) is shown in Figure 9. This was assessed by comparing the relationship between the liveweight of weaned calf/ha (kg/ha) and cow liveweight/ha at weaning (kg/ha), without considering pregnancy rate. Each point on the graph represents the average of 16 cows for each treatment replicate. There was no significant difference in this measure of efficiency between the H and C lines, but the slope of the regression of the L line, which was significantly lower than the other 2 lines ($P<0.05$), indicated that as grazing pressure increased the L line became less efficient compared to the other 2 lines. When actual pregnancy rates were included in the regression analysis the difference in efficiency between the lines was no longer evident, and the relationship became curvilinear. When pregnancy rates were included, the maximum output was 330kg calf weaned/ha, with a grazing pressure of 850 kg of cow liveweight/ha. This occurred with L line cattle stocked at 2.0 cows/ha, and H line cattle at 1.6/ha.

The Hamilton results show that growth rate selection increases the size of cows, and thus increases grazing pressure. However, apart from the H line cows stocked at 2.0 cows/ha, growth rate selection tended to increase production/ha at all stocking rates when cow fertility was ignored. When fertility was taken into account, the advantage of growth rate selection particularly at the higher stocking rates was reduced (Figure 8).

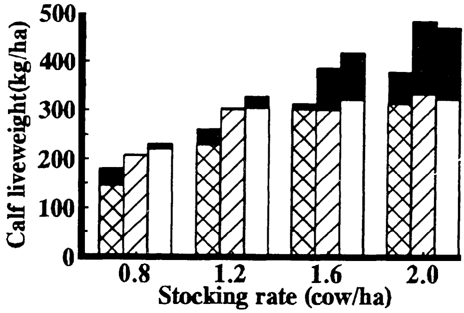

Figure 8. Calf weaning weight (kg/ha), calculated using 100% pregnancy rates (solid bars), or using the actual pregnancy rates of the low (cross hatch), control (diagonal hatch) and high (open bars), at 4 stocking rates

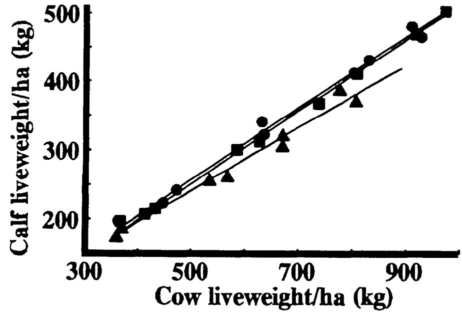

Figure 9. Production of calf weight/ha from cow weight/ha (using pregnancy rates of 100%) of the low (triangle, $y = 9.9 + 0.46\pm0.010x$), control (square, $y = -13.6 + 0.53\pm0.015x$) and high (circle, $y = -6.0 + 0.53\pm0.017x$) lines

Whilst selection for growth increased productivity of cows when compared at similar stocking rates. when compared at similar grazing pressure (a similar cow liveweight/ha) there was no difference between the H and C lines, and differences between these 2 lines and the L line only became evident when grazing pressure was increased to extreme levels, and then only when pregnancy rates were ignored. The results show only marginal gains in efficiency, (in terms of liveweight production/ha from a given cow liveweight/ha) and it is apparent that whilst selection for growth rate certainly gives a response to that selection criteria, it will not provide a comparable response in efficiency. Other selection criteria need to be established to enable the industry to select animals for increased efficiency.

PERSISTENCE OF GROWTH RATE SELECTION RESPONSES IN DIFFERENT ENVIRONMENTS

P.F. PARNELL[A], R. DICKER[B] and J. GRAHAM[C]

[A]NSW Agriculture, Agricultural Research Centre. PMB 19, Trangie, N.S.W. 2823
[B]NSW Agriculture, Agricultural Research and Advisory Station, PMB, Glen Innes, N.S.W. 2370
[C]Dept of Agriculture, Pastoral and Veterinary Institute, Private Bag 105, Hamilton. Vic. 3300

Data on the growth performance of H, C and L line calves at Trangie and at each of the nutritional environments at Glen Innes and Hamilton were used to investigate whether the responses to selection observed at Trangie were transferred to the other environments. Previous studies have indicated that the relative performance of genotypes can vary across wide extremes in environment, and that genes controlling performance in 1 environment may only partly be the same as those controlling performance in another environment. Figure 10 shows the average adjusted weaning weights of calves for each selection line at each environment, plotted against the mean adjusted weaning weight of all lines at each environment. Adjustments were made for the effects of year, calf sex, calf age at weaning (within location) and cow age. Calves were weaned at about 200 days of age at Trangie, 230 days of age at Glen Innes and 280 days of age at Hamilton. The slopes of the regression of average adjusted weaning weight on environment for each selection line were not significantly different, indicating no significant genotype by environment interaction. This suggests that the observed selection responses in weaning weight for each line were generally consistent across a wide range of nutritional environments.

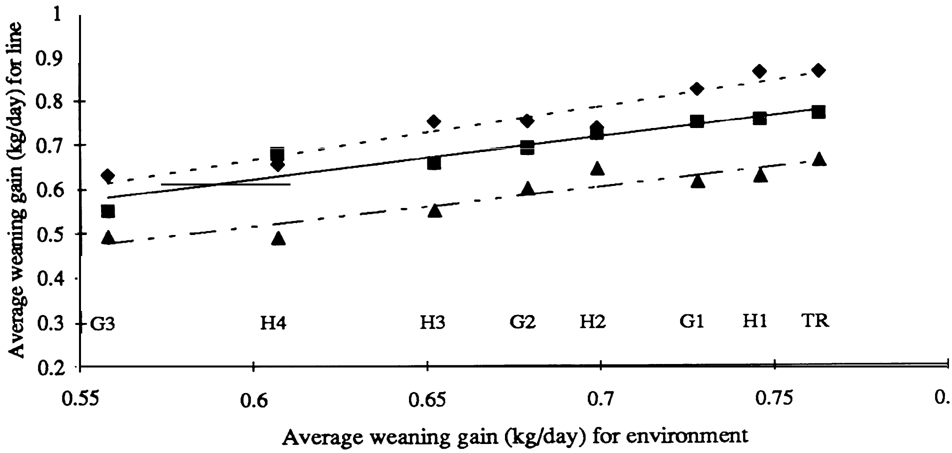

Figure 10. Average pre-weaning gains (adjusted for effects of calf age, calf sex and cow age) of calves in the High (diamonds), Control (squares) and Low (triangles) growth selection lines at Trangie, Glen Innes and Hamilton

TR = Trangie	H 1 = Hamilton (0.8 cows/ha)
G1= Glen Innes (High nutrition)	H2 = Hamilton (1.2 cows/ha)
G2 = Glen Innes (Medium nutrition)	H3 = Hamilton (1.6 cows/ha)
G3 = Glen Innes (Low nutrition)	H4 = Hamilton (2.0 cows/ha)

DISCUSSION AND CONCLUSIONS

P. F. PARNELL

NSW Agriculture. Agricultural Research Centre. PMB 19, Trangie, N.S.W. 2823

Only a small number of designed experiments have been conducted to provide empirical evidence of the responses to selection. The Trangie Angus selection lines have been the only long-term divergent selection lines ever developed in beef cattle. The unique experimental design generated a divergence between the lines which represented the expected difference in growth rate achieved after 30-40 years of conventional within herd selection. The direct responses in yearling growth rate in each line of the Trangie lines were slightly greater than the average of 0.8% per year obtained in Angus, Hereford and Shorthorn lines selected for increased yearling weight in North America (reviewed by Mrode 1988), and similar to the responses obtained in Angus and Hereford yearling weight selection lines in New Zealand (Carter *et* al. 1990; Baker *et al.* 1991). The realised heritabilities obtained in the Trangie lines were also consistent with those obtained for yearling weight in the North American and New Zealand selection experiments (ie. 0.35 to 0.4).

The correlated responses in weight and size at all ages in the Trangie lines correspond with the evidence from other selection studies, and confirm the existence of positive genetic correlations between liveweight at all ages. The maternal component of the responses in weaning weight in the Trangie lines was greater than that observed in the Angus and Hereford yearling weight selection lines in New Zealand, but similar to the maternal responses obtained in Hereford weaning and yearling weight selection lines in Nebraska (R.M. Koch, pers. comm.) The lack of significant correlated responses in body composition at any slaughter age in the Trangie selection line animals corresponds with the limited evidence available from other selection experiments (Mrode 1988). The improvement in reproductive performance of first calf H line heifers (i e. reduced age at puberty, higher calving rates and lower dystocia rates) is generally consistent with the zero or slightly positive responses obtained in other studies, with the major exception being an experiment conducted in Nebraska where heifer dystocia rates increased in Hereford lines selected for increased weaning or yearling weight (Koch *et al.* 1982). However, the environment and management system in the Nebraska experiment was very different to those at Trangie and the base level of dystocia was substantially higher. The pelvic area in Trangie H line heifers tended to increase at a greater rate than the birth weight of their calves, possibly contributing to the observed reduction in dystocia. Apart from the Nebraska study, there is no other evidence of increased levels of dystocia as a consequence of within-herd selection for increased growth performance in beef cattle.

The responses in postweaning gross feed conversion efficiency measured at Trangie and estimated at Glen Innes correspond with evidence from North American studies (Koch *et al.* 1932). The responses in cow-calf efficiency measured at Trangie were consistent with preliminary findings from pasture intake studies in New Zealand Angus selection lines (C. Morris, pers. comm.). However, the lack of line differences in cow efficiency based on pasture intake estimates across different nutritional levels at Glen Innes cast some uncertainty about the true responses in cow efficiency. There was a large variation in feed intake and efficiency between cows within each line at Trangie and Glen Innes, independent of differences in cow weight and size. The consistency of differences in adjusted pre-weaning growth rates between calves from each selection line at Trangie, at the different nutritional treatments at Glen Innes, and at the different stocking rates at Hamilton indicated that selection responses in growth can be confidently transferred across a wide range of nutritional environments. Only when managed at extreme stocking rates at Hamilton did the per hectare productivity of the H line cows and calves fall in comparison to the C and L line animals.

In conclusion, the results of this comprehensive study indicate that selection for increased growth rate will lead to increased profitability. The extent of the economic response in any particular situation will depend on the market demands for carcase weight and size, and on the cost of available feed resources for breeding and finishing cattle.

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