THE EFFECT OF DIVERGENT SELECTION FOR YEARLING GROWTH RATE ON GROWTH AT PASTURE AND FINAL SIZE OF ANGUS STEERS

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SUMMARY

Following 14 years of divergent selection for daily gain from birth to yearling age, 12 steers from the high-line (fast gain) and 10 from the low-line (slow gain) were grown on pasture for four years. High-line steers were heavier, taller, longer and had a greater girth ($P<0.005$) than low-line steers at birth and at every 3-monthly measurement period. The 1.39-fold divergence in yearling liveweight was accompanied by a nearly proportional increase (1.29) in asymptotic mature liveweight. Despite the difference in mature size attained, there was no significant difference in the rate of maturation of weight, length, height or girth. At the same age there were no differences ($P>0.05$) between the two selection lines in fat depth over the rib or the rump. When slaughtered at four years of age the carcases of high-line steers were heavier ($P<0.01$) but there were no differences ($P>0.05$) in dressing percentage or subcutaneous fat depth on the carcase.
Keywords: Cattle, growth curves, selection, size, maturity.

INTRODUCTION

Growth rate receives considerable emphasis in most beef cattle improvement schemes. Selection experiments have shown that growth rate to, or liveweight at a given age, is moderately heritable, responds to selection, and is positively correlated with liveweights at other ages, including maturity (Barlow 1984). Selection to change the shape of the growth curve might be able to restrict the correlated increase in mature size. However, when examined over a range of genotypes, there is a remarkable uniformity in the pattern of growth in relationship to mature liveweight attained (Taylor 1980a). This study was of the growth to maturity on pasture of steers from divergent growth-rate selection lines. It examines whether selection has changed their pattern of growth beyond that explained by the correlated response in mature size.

MATERIALS AND METHODS

The steers came from lines of Angus cattle established in 1974 at the Agricultural Research Centre, Trangie. These lines were selected for either fast (high-line) or slow (low-line) daily gain from birth to one year of age (Parnell *et al.* 1994). Twenty-two steers (12 high-line and 10 low-line) born in July 1988 were used. They were sampled from each line after the available animals had been stratified by sire and date of birth. They were weaned at six months of age and were used when one-year-old in feeding trials that necessitated feeding of a pelleted ration for two months. The steers were grown on improved pastures, forage crops and irrigated pastures and were generally allotted the best available pasture to enable them to grow rapidly. Low temperature and frost during winters (June to August) generally reduced feed availability during these months.

The steers were weighed at birth, three, six and 12 months of age, and then every three months until four years of age. They were weighed after a 4-hour fast when 3-months old and thereafter after an overnight fast. Except at three months of age, each animals' height at the shoulder, girth around the chest, and length from point of shoulder to pin bone (ischium) were also measured. Fat depths over the 12/13 rib were measured ultrasonically from one year of age. Measurement of fat depth over the P8 site on the rump began three months later. By three years nine months of age liveweight, height, length and girth appeared to plateau, although no plateau in fat deposition was apparent. They were grown to four years of age and then slaughtered.

At slaughter the steers were weighed without fasting. They were slaughtered in a commercial abattoir where accredited assessors recorded the hot carcase weight, fat depth over the rump, and rump profile. The latter scored from "a" to "e" with more rounded, heavily muscled carcases given an "a" and lightly muscled carcases given an "e".

Statistical analyses. The modified Gompertz curve used by Archer *et al.* (1997) for height was used to model the size measurements of weight, length, height and girth of individual steers from birth to maturity. The curve was fixed through size measured at birth and growth was described using two parameters representing asymptotic mature size (A) and the rate of maturation (K) of the size measurement.

Differences in the patterns of growth of animals from the two selection lines might simply reflect the difference in mature sizes attained. Liveweight, height, length and girth were genetically size-scaled for their differences in mature size by calculating the degree of maturity (u) and metabolic age (ma) for steer at each measurement time. Degree of maturity was calculated by dividing the periodic measurements for each steer by its previously calculated asymptotic mature measurement, and ma as (age+280 days of gestation-3.5)/(mature liveweight)$^{0.27}$(Taylor 1980a). Using u allows comparisons of the rate of growth to, or attainment of maturity, independent of mature size, and ma makes a complimentary allowance for the expected longer time large animals take to mature.

The genetic size-scaled measurements taken from weaning onward for each steer were modelled using the Brody curve: $u = 1 - e^{-k(ma-t)}$, where k = scaled rate of maturation. This curve has previously been shown to give a good description of postweaning growth (Taylor 1980b). The Gompertz and Brody curves were fitted using the Non-Linear Regression Procedure of SAS (1989).

The significance of the differences between the means for the two selection lines for the six traits measured on each steer at 3-monthly intervals, for the measurements taken at slaughter, and for the estimates of curve parameters (A, K and k), was tested using the Student-Newman-Keuls test available within the General Linear Models Procedure of SAS (1989).

RESULTS

Steers from the high-line steers were heavier, longer, higher and had a greater girth, that is were thicker, than steers from the low-line at birth and at every measurement time to four years of age ($P<0.005$, Table 1). The divergence in liveweight at one year of age (1.39-fold) was accompanied by a nearly proportional increase in asymptotic mature weight (A; 1.29). Proportional increases in the other three size measurements were less: 1.12, 1.11 and 1.08 for length, height and girth respectively. There were no significant ($P>0.05$) differences between the two selection lines in the depth of fat over the rib or of fat over the rump at any measurement period.

Table 1. Means[A] ($\pm$ se) for measurements at birth, 1 year of age and growth curve parameters for steers from lines selected from either fast (high-line; no. = 12) or slow (low-line; no. = 10) growth from birth to 1 year of age

Line	Birth	1-year-old	Asymptotic mature size (A)	Rate of maturation ($K \times 10^4$)	Scaled rate of maturation ($k \times 10^3$)
Weight (kg)					
High	34.7 ± 0.9^a	288 ± 8^a	765 ± 12^a	29.0 ± 0.4^a	10.9 ± 0.2^a
Low	25.0 ± 1.2^b	208 ± 9^b	591 ± 28^b	27.8 ± 0.5^a	9.6 ± 0.2^b
Length (cm)					
High	66.2 ± 0.5^a	133 ± 2^a	178 ± 1^a	33.5 ± 0.7^a	15.5 ± 0.4^a
Low	57.9 ± 1.4^b	115 ± 2^b	159 ± 2^b	33.1 ± 0.9^a	13.1 ± 0.3^b
Height (cm)					
High	64.8 ± 0.8^a	104 ± 1^a	135 ± 1^a	29.6 ± 0.7^a	13.8 ± 0.2^a
Low	57.6 ± 1.5^b	94 ± 1^b	121 ± 2^b	30.4 ± 0.9^a	13.0 ± 0.4^a
Girth (cm)					
High	72.0 ± 0.9^a	154 ± 2^a	233 ± 2^a	27.1 ± 0.6^a	11.9 ± 0.2^a
Low	62.5 ± 1.1^b	139 ± 2^b	215 ± 4^b	27.4 ± 0.9^a	10.8 ± 0.2^b

[A] Means with the same superscript do not differ ($P>0.05$).

Despite the difference between the lines in mature size attained, there was no significant difference in the rate of maturation (K) of weight, length, height or girth (Table 1). That is, the high-line steers reached mature size at the same age as the low-line steers. Scaling for difference in asymptotic mature size revealed that the high-line steers had a faster scaled rate of maturation (k) of weight, length and girth, but not height, than the low-line steers. That is, the high-line steers grew more quickly relative to their mature weight, length and girth than the low-line steers.

When weighed "full" before slaughter the high-line steers were 1.31 times heavier than the low-line steers (731 $\pm$ 13 and 557 $\pm$ 30 kg; $P<0.001$). After slaughter their carcases were 1.34 times heavier (404 $\pm$ 7 and 301 $\pm$ 15 kgs; $P<0.001$). There was no difference between the two lines of cattle in dressing percentage (55.3 $\pm$ 0.4 and 54.2 $\pm$ 1.0 %; $P>0.05$), in depth of fat over the rump

(21.1 ± 1.8 and 26.3 ± 3.5 mm; P>0.05) or in rump profile, with two high-line carcases being given a score of "b" and all other carcases being scored "c".

DISCUSSION

The results of this study on steers showed that 14 years (four generations) of divergent selection for growth led to correlated increases in weight, length, height and girth at all ages through to maturity. Archer *et al.* (1997) reported a similar conclusion for weight and height of cows from the same selection lines. Olthoff *et al.* (1990) and Morris *et al.* (1992) also reported that the correlated response in mature size to be almost proportional to the direct response to selection for high yearling weight in beef Shorthorn cattle, and high yearling liveweight or high 18-month liveweight in Angus cattle.

In beef cattle generally, size at any one age has a high genetic correlation with size at any other age (Taylor and Craig 1965). For this reason selecting animals for large or small size will result in relatively large concomitant changes at all other ages, as reported above. The higher the inter-age genetic correlations, the less easily can size at one age be modified without affecting size at other ages, and hence the less is the "genetic flexibility" of the mean growth curve (Taylor and Craig 1965). In this study the genetic size-scaling of growth in weight, length and girth revealed a small left-shift in the standardised growth curve for the high-line steers. Selection for growth from birth to one year of age increased the (scaled) rate of growth. This corresponds with the lack of significant responses in (unscaled) rate of maturation in weight, length, height and girth expected to accompany the increase in mature size.

Phenotypically there was no evidence for an increase in time to reach mature weight, length, height or girth. The lack of significant responses in (unscaled) rates of maturation in the steers in this study and in cows in the study reported by Archer *et al.* (1997), suggest no change in the temporal pattern of maturation despite attainment of larger size. This conclusion is supported by the lack of difference between these selection lines in subcutaneous fat (this study) and body composition of steers at constant age (Parnell *et al.* 1994). A corollary is that high-line steers would attain a specified market liveweight and fat depth at a younger age than low-line steers.

The increase in size of steers from the High-line was not accompanied by an increase in subcutaneous fat depth. As high-line steers were consistently heavier than the low-line steers this suggested there was no increase in total fat as a proportion of bodyweight in the high-line animals. This is supported by the lack of difference between the lines in dressing percentage of the mature steers and the lack of difference between these selection lines in body composition of steers at constant age (Parnell *et al.* 1994).

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