Growth and carcass composition of angus steers raised together from birth and managed on two post-weaning nutritional treatments

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ABSTRACT

Two groups of 33 Angus steers aged 270 days and weighing 179 ± 2.1 kg were allocated after weaning to 2 pasture regimes designed for high (H) and low (L) mean Liveweight. When the treatments finished after 138 days liveweights were 242 ± 3.7 kg (H) and 218 ± 3.7 kg (L). Both H and L groups were then grazed together on pasture until slaughter at 30 months of age. At slaughter fat depth at the 12th rib, weight of kidney and channel fat, ribeye area, and the trimmed fat, bone and lean (90% visual lean) were measured from the right side of the carcass. Carcass weight was the same for both treatment groups (258 ± 2.5 kg).

The L group had faster liveweight gain than the H group for 283 days after treatment, but not thereafter. Steers from the L treatment had more kidney and channel fat ($P<0.02$). A significant ($P<0.01$) regression coefficient of 0.05 ± 0.019 for carcass weight on kidney and channel fat weight existed for steers in the H group, but not the L group. Rate of live weight gain before weaning was significantly ($P<0.01$) related to the weight of trimmed bone and lean at slaughter. Differences between animals in live weight gain at the end of the treatment period affected the weight of kidney and channel fat in the L group ($P<0.01$), and the weight of trimmed fat in the L group ($P<0.05$). These results are discussed in context of effects of growth rate on tissue development in cattle.

Keywords: cattle; growth; body composition.

INTRODUCTION

An understanding of how different growth rates at different stages of an animal's life affect current and subsequent body composition is of value to an industry which seeks to consistently produce carcases that comply with market specifications of weight, fatness, yield and more recently meat quality. It is recognised in other species that prior growth affects the relative composition of lean and fat tissues, depending on the timing and extent of growth retardation and the rate of growth achieved during realimentation (Wilson, 1960; Widdowsen, 1977). In cattle the timing and extent of undernutrition and the length of time that the animal spends in the compensatory phase has been shown have variable effects on carcase composition. Increases or decreases fatness and retail yield and an increase variance in growth rate all noted (O'Donavan, 1984; Ryan, 1990; Carstens, 1995). These effects have implications for the control of product yield and quality. This paper discusses a modification of the multivariate analysis of variance that can evaluate the effects of the growth path on the body composition of cattle at slaughter. The results of this analysis are discussed with regard to current knowledge of cattle growth.

MATERIALS AND METHODS

Sixty six Angus steers born in the spring of 1978 at Tuapaka, Massey University's hill country farm were weaned on 13 March 1979 and moved to 'Bests' another University farm where they were grazed on pasture. On 24 May, 1979 when the steers averaged 270 (range 228 to 320) days of age and weighed 179 ± 2.1 kg two groups of 33 animals were randomly selected. One group designated high nutritional plane (H) was offered an abundance of pasture over the winter in order to achieve maximum growth rates during this period. The other group designated low nutritional plane (L), were restricted in the amount of pasture offered to achieve lower live weight gains than the H group. No objective measurements of pasture availability were made. Decisions on the grazing pressure of the L group were made subjectively, but took into account the live weight change of this group relative to the H group.

Nutritional treatments continued for 138 days until 17 September, 1979, (age 386 days) when both groups were combined and grazed together at the highest possible nutrition available at pasture. At this time the H group weighed 242 ± 3.7 kg (treatment LWG 0.54 kg/day), and the L group weighed 218 ± 3.7 kg (treatment LWG 0.34 kg/day).

The steers were slaughtered on the 24 and 30 of March 1981 and 6 April 1981 at the Feilding Abattoir. Animals from each treatment were randomly chosen for slaughter on each day. Variables measured at slaughter were dressing out percentage, fat depth at the 12th rib, kidney and channel fat weight and eye muscle area. The right side of each carcass was dissected to measure trimmed fat weight and bone weight. The weight of carcass lean was obtained by difference from the right side weight.

Statistical Methods

The liveweight change of the steers was analysed by multivariate profile analysis described by Morrison (1990). The parallel hypothesis was used to decide if the average liveweight change of the steers in each nutritional treat-

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ment differed between given weighing dates.

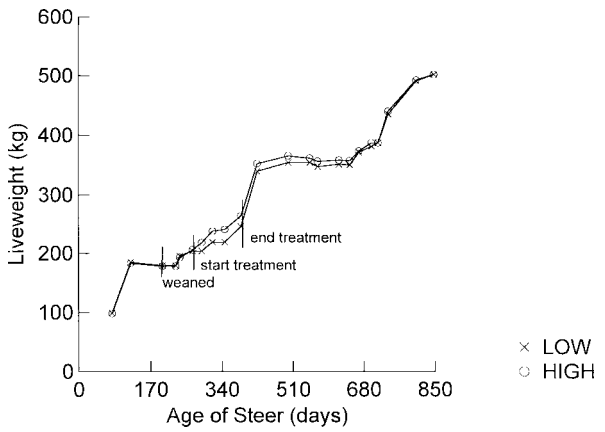
To identify the time of the animal growth path which most affected the components of body composition the following technique was used.

1. The liveweight change data for each animal was divided into a pre-treatment (birth to 24 May 1979), treatment (24 May 1979 to 17 September 1979) and post-treatment (17 September 1979 to 6 April 1981) phase and cubic spline polynomials (Wold 1974) were fitted to the liveweight data of each steer. Spline knot points were placed at the beginning and end of the treatment period.
2. The cubic spline polynomial coefficients for each animal $\mathbf{S} = (s_1\ s_2\ s_3\ s_4)$ were regressed on the residuals of the body composition variables after correction for treatment and killing date.
3. The hypothesis sum of squares matrix **H** and the error sum of squares matrix E were used to find the value of t (time) for the vector **a** representing the first differential (growth rate) of the spline polynomial which maximises the F ratio. Here **a'** = $(3t^2\ 2t\ 1\ 0)$ and
$$F = \frac{a'Ha}{a'Ea}$$
4. The linear function of the spline polynomial coefficients **a'S** was tested for significance using the multivariate analysis of variance, establishing the significance of the relationship between the body composition variables and the time identified by 3 above.

RESULTS

The average liveweight change of each of the nutritional groups of steers is shown in Fig. 1. Over the post treatment period from17 September 1979 to 9 January 1980 the L group had higher ($P < 0.01$) liveweight gain than the H group. At all other post treatment times there were no differences in the rate of liveweight change between the treatment groups. Liveweight differences between the treatments were not statistically significant after 9 May 1980. Average liveweight at slaughter was 485 ± 6.5 kg for both nutritional groups. Liveweights differed between slaughter days, with steers killed on 6 April 1981 being lighter (P<0.01) than steers killed earlier (466 v 495 kg).

FIGURE 1: Average liveweight through time of steers on each of the nutritional treatment groups.



Least squares means for each of the carcass components is given in Table 1. While the trend was for L steers to be fatter, kidney and channel fat weight was the only variable to show a significant difference (P<0.02) between the nutritional treatments. Animals killed at the end of the trial on 6 April had less trimmed fat ($P < 0.01$) than animals killed on the 2 preceding dates.

TABLE 1: Least squares means and standard errors for the effect of the nutritional treatment on each of the carcass components measured.

Response Variable	H nutritional treatment	L nutritional treatment	Regression on carcass weight
Fat depth at the 12th rib (mm)	8.8 ± 0.52	9.5 ± 0.56	0.04 ± 0.017*
Kidney and channel fat (kg)	4.1 ± 0.29*	5.0 ± 0.29*	H: 0.02 ± 0.019 L: 0.05 ± 0.019**
Trimmed fat (kg)	28.8 ± 0.76	29.6 ± 0.80	0.24 ± 0.028***
Trimmed bone (kg)	59.0 ± 0.56	59.0 ± 0.62	0.14 ± 0.026***
Trimmed muscle (kg)	162.2 ± 0.68	162.2 ± 0.76	0.52 ± 0.072***

Note. Asterisks denote variables which are significantly different between treatments, or regression coefficients significantly different from zero.

* P < 0.05; ** P < 0.01; ***P < 0.001

Age of the dam affected the weight of trimmed bone, steers from 2 and 3 year old dams had less ($P < 0.02$) bone (28.7 kg) than steers from older dams (30.2 kg). There was no affect on any of the carcass traits due to steer age.

The regression on the weight of the carcass given in Table 1 showed that steers with heavier carcasses were fatter and had more bone and muscle than steers with lighter carcasses. The kidney and channel fat weight showed a difference between nutritional treatments in the regression on carcass weight. Within the H treatment group there was no significant relationship between kidney and channel fat weight and the carcass weight of the steer. Within the L nutritional treatment group a highly significant

TABLE 2: The times of growth and regression coefficient of growth rate on response in the pre-treatment, treatment and post-treatment phases which had the greatest affect on the body composition of the steers at slaughter.

Response	Pre-treatment	Treatment	Post-treatment
Fat depth at the 12th rib	no response	no response	no response
Kidney and channel fat	no response	376 days of age ** (H only) b = 0.04 ± 0.015	no response
Trimmed fat	no response	372 days of age* (L only) b = 0.24 ± 0.106	no response
Trimmed bone	169 days of age** b = 0.14 (0.026	no response	no response
Trimmed muscle	171 days of age*** b = 0.52 ± 0.072	no response	796 days of age (P<0.1) b = 0.04 ± 0.020

*P<0.05, **P<0.01, ***P<0.001

relationship was observed ($P < 0.01$).

The times of animal growth which most affected the body composition of the steers at slaughter are given in Table 2. The weight of trimmed bone at slaughter was significantly ($P<0.01$) affected by the differences in animal growth rates at about 12 February 1979 when the steers averaged 170 days of age, faster growth rate being associated with heavier bone weight at slaughter (regression 0.14 ± 0.026 kg bone per kg per day). A similar association between trimmed muscle weight at slaughter and differences in the growth rates of the steers on 14 February 1979 occurred ($P<0.001$) (regression 0.52 ± 0.072 kg muscle per kg per day).

The response of the kidney and channel fat weight and the trimmed fat weight at slaughter to variation in growth path depended on the nutritional treatment. Kidney and channel fat weight at slaughter only responded to variation in growth rate in the H treatment with a maximum response on 7 September, 1979 ($P<0.01$) (regression 0.04 ± 0.015 kg fat per kg per day), just before the end of winter. But there was no effect due to growth path at this time in the steers on the L treatment. In contrast, the trimmed fat weight at slaughter only responded to the growth path at this time in steers on the L treatment ($P<0.05$) (regression 0.24 ± 0.106 kg fat per kg per day). Thus the H treatment kidney was associated with differences in channel fat weight due to differences in growth path of the steers, while on the L treatment trimmed fat weight was associated with differences in the growth paths of the steers.

DISCUSSION

This study shows that variation in growth rate during an animal's life is statistically associated with differences in carcass composition at slaughter. It presents a statistical method by which these effects may be evaluated between and within treatment. The results suggest that these tools may be useful for developing procedures to understand and control variation in commercial carcass composition attributes.

Growth in the spring (post-treatment phase) when the steers were one year old increased the fatness of these animals, especially the amount of kidney and channel fat. That is animals that had higher rates of gain (compensatory growth) during this period after a winter restriction had higher proportions of fat in these depots at slaughter 18 months later. The sensitivity of kidney and channel fat to nutritional changes during the period of experimentation is further illustrated by the interaction of carcass weight and nutritional treatment for this variable when animals from the two slaughter groups were killed at the same age. Steers in the L group had higher weights of kidney and channel fat at higher carcase weights whilst for steers from the H group no relationship was observed between growth rate during this period and kidney and channel fat. This indicates that animals that experienced a high degree of restriction (the L group) did deposit proportionally more fat relative to live weight gain during a compensatory growth period. Several authors have also noted this response (Berge, 1991; Schadereit *et al*., 1995; Ball, 1996).

Analysis of the liveweight change curves of individual steers when considered independently of the carcass weight showed that the bone weight at slaughter was significantly ($P<0.01$) affected by liveweight change before weaning. This is consistent with other observations that bone is an early developing tissue and responsive to feed levels at this stage of development (Kamalzadeh *et al*., 1998). There was also a significant ($P<0.001$) effect of liveweight change (independent of carcass weight) on the weight of trimmed muscle at this time (before weaning), and also on 1 November 1980 ($P<0.05$) when the steers were just over two years of age. In cattle functional hyperplasia (satellite cell incorporation) of muscle continues until at least 300 kg liveweight (DiMarco *et al*.,1987). These results suggest that nutritional levels at specific phases of animal growth can have clear effects on muscle development and hence final retail yield (Kreienbring *et al*. 1994; Oddy, 1997). There was no specific liveweight change independent of carcass weight close to slaughter for any of the response variables. The amount of liveweight change, and the variance of liveweight change, at these times could not be distinguished from the amount and variance of liveweight change at other times during the growth of the animals.

Nutritional treatment affected the relationship between individual animal live weight gain and deposition of adipose tissue within fat depots. Variation in growth among the H steers in the spring just before the treatments finished (7 September, 1979) had a significant ($P<0.01$) effect on the weight of kidney and channel fat at slaughter, steers which gained more liveweight having greater kidney and channel fat weight at slaughter. There was no significant effect of live weight gain on kidney and channel fat weight at slaughter among the L animals. However, a significant ($P<0.05$) effect of liveweight change on the trimmed fat weight at slaughter occurred at this time (3 September, 1979) among the L animals, but there was no significant effect for the H animals. This suggests that nutrition by growth path interactions influenced the partition of fat between carcass fat and kidney and channel fat. From these results it is clear that growth paths followed by individual animals will affect the ability of the producer to supply to fatness and weight specifications.

In summary, the present study demonstrates that variation in some carcass measurements at slaughter are statistically associated with overall nutritional treatment and more specifically with variation in the rate and pattern of previous growth. This is explicable in terms of the differential development of tissues.

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