How growth affects carcase and meat quality attributes

Meat and Livestock Australia
Locked Bag 991
North Sydney NSW 2059
Ph: 02 9463 9228
Fax: 02 9463 9100
Email: hoddy@mla.com.au

Hutton Oddy

Session 3a ~ Presented by Peter Dundon

Introduction

A common assumption made when discussing performance of feedlot cattle and feedlot nutrition is, that what is fed in the feed yard has the biggest bearing on animal performance and, in turn, profitability. This is not so. Potential growth, ultimate body composition (hence yield and marbling) and objective measures of toughness of the meat are influenced at least as much by what and how much the cattle eat before they get to the feed yard, as what they eat in it. Hence it is vitally important to **"**set up**"** animals for optimum feedlot performance at pasture before they go into a feedlot. This paper presents an outline of the theory and some aspects of the practice of growing cattle to target weights and fatness to "set up" feeder steers for the domestic and B3 market. The principles also link growth pattern to meat quality characteristics.

A simple theory of growth

Growth is an increase in size, set by the genes inherited by an animal, and the manner in which they interact with the environment. Most commonly the effect of environment is expressed through nutrient supply.

Bone growth precedes muscle growth. Fattening occurs later in life, usually after the point at which bone growth ceases, and muscle growth slows. When nutrient supply is insufficient to match the potential pattern of growth set by the genetics, the animal adapts by modifying the relative rate of deposition of bone, muscle and fat. The extent to which adaptation to a shortfall in nutrient supply occurs depends on the relative stage of maturity, which the animal has achieved before nutrient deprivation, and the severity of that deprivation. If a serious setback occurs early in an animal's life, the long-term effects are greater than if a setback occurs later in life.

These concepts are perhaps more easily seen in the accompanying figures. In the first (Figure 3a-1), the pattern of protein and fat deposition in "well grown" cattle is depicted. "Well grown" refers to no significant nutrient deprivation during the life of an animal. Protein gain slowly decreases as an animal grows, and fat gain increases slowly at first, then more quickly after a certain point at which fattening is thought to commence. Cattle with large frame sizes or more muscle tend to fatten later than depicted, and those with smaller frame sizes or less muscle tend to fatten earlier.

Feed restriction always decreases the rate of protein and fat gain (Figure 3a-2). If feed restriction happens early in life say before 250 kg and for a period of at least 2 months with a growth rate of <0.4 kg/d then, on refeeding, protein mass may not catch up to the expected amount for the animals genotype, but fat gain may commence prematurely. Thus at the same carcase weight, animals held back early in life, then subsequently well fed may grow slower and be fatter than their continuously well-fed brothers or sisters.

Feed restriction later in life, say after 250 kg, also reduces the rate of protein and fat gain (Figure 3a-3), but on refeeding protein mass usually catches up to that expected for the same genotype, but fat deposition may be delayed. Thus at the same carcase weight these animals may be leaner than continuously well fed siblings.

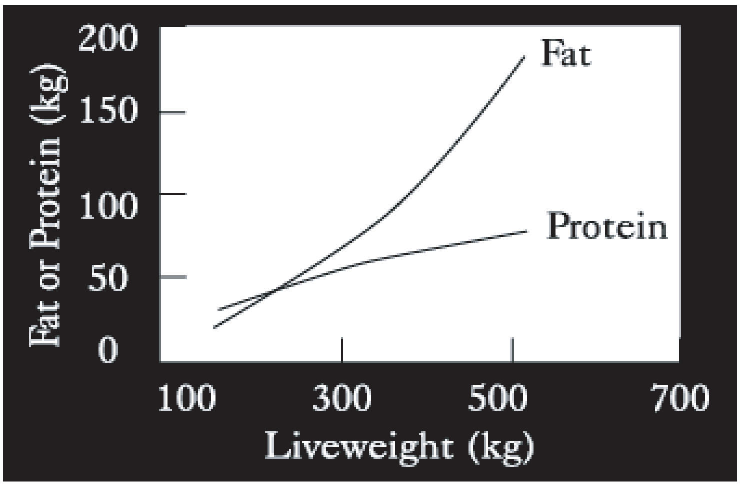

Figure 3a-1. The pattern of fat and protein deposition in continuously well fed beef cattle.

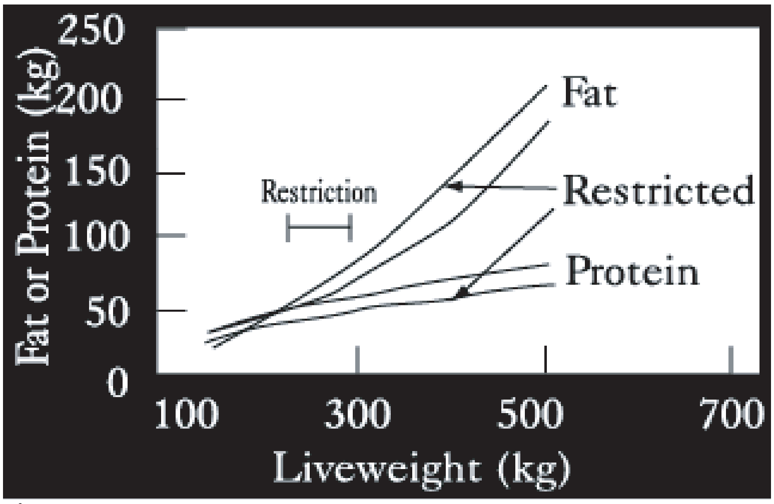

Figure 3a-2. The pattern of fat and protein deposition in early life restriction of feed, followed by unrestricted good quality feed.

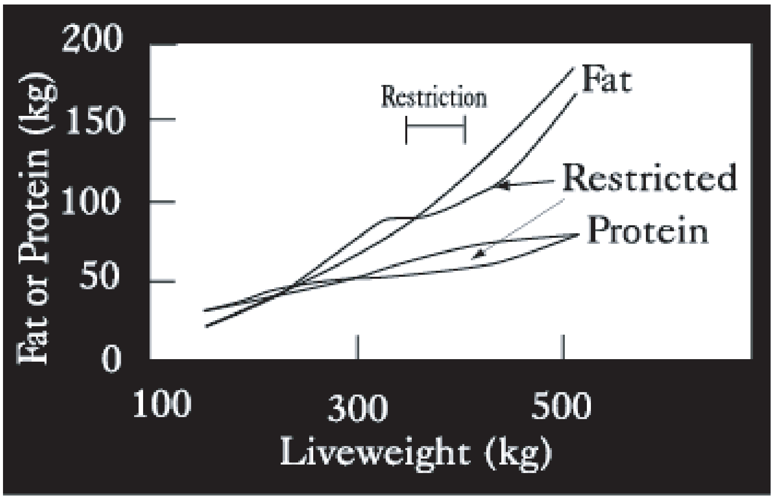

Figure 3a-3. The pattern of fat and protein deposition in initially well fed beef cattle, with a period of feed restriction after the point at which fattening may normally occur, followed by good feed supply. Note that at the same empty body weight (or carcase weight) animals restricted in early life are fatter, and those restricted in later are leaner than their continuously well-grown contemporaries.

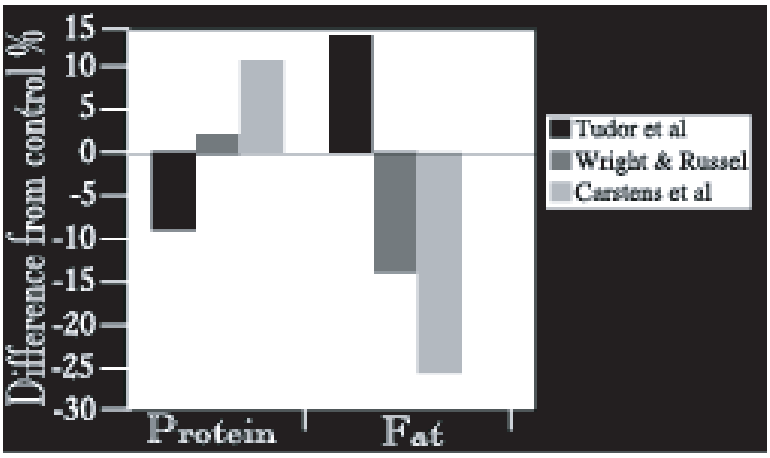

Figure 3a-4. Effect of previous restriction on body composition at same carcase weight as well fed control animals. Growth rates were restricted to: 0.5 kg/d in Hereford calves for 200d beginning at four days of age (Tudor et al., 1980); 0.45 kg/d in Charolais crossbred steers for 216d beginning at 8 months of age (Wright and Russel, 1991); and 0.40 kg/d in Angus/Hereford crossbred steers for 189d beginning at 10 months of age (Carstens et al., 1991). Differences in tissue composition within experiment were significant. Treatment differences were evaluated at empty-body weights (EBW) of 330, 365 and 450 kg for the three experiments, respectively. Data summarised by GE Carstens, (1995) Symposium: Intake by Feedlot Cattle. Oklahoma State University.

It should be noted that if animals were allowed to grow out to mature weight then there would be little difference in composition at maturity due to previous nutrition. However, cattle are not normally slaughtered at maturity but at some point before. Thus differences in carcase composition can occur at similar carcase weights as a consequence of previous nutrition.

The point at which previous nutrient restriction sets up an animal to be fatter or leaner is still to be precisely determined, but is somewhere around normal weaning weight (say 250 kg), or approximately 40% of mature weight. It is likely that this point can be varied by the extent of prior nutrition, but this remains to be determined.

An example of the extent to which timing of nutritional treatment can affect fatness is shown in the following table (Figure 3a-4, data summarised by Carstens, 1995). Cattle light for their age do not always do better in a feedlot. Cattle held back early grow no better, and may grow worse, than well-grown cattle and may become fatter earlier. Moreover, cattle held back later grow better than well-grown cattle during finishing and are leaner.

Variation in fatness affects meat quality in two ways. Where the growth pattern (or finishing system - in simple terms, the effects of past and current nutrition) affects intramuscular fat content (marbling) it can affect flavour and, in some markets, price paid for meat. Where growth pattern influences subcutaneous fat (P8, 12th rib) depth it can affect rate of cooling of the carcase and hence toughness.

The pattern of growth has an additional effect on toughness, principally through affecting the relationship between muscle fibres and the connective tissue matrix that holds the fibres in place. Slow growth increases the physical effects of the connective tissue matrix and results in increased baseline toughness.

These relationships have been repeatably observed in Beef CRC research projects and now underpin the MSA system. They imply that management of growth pattern of cattle is important to achieve, growth, fatness, yield and meat quality goals in a range of different production systems.

From theory to practice - CRC results

Growth to weaning

Severe pre-weaning growth restriction, prior to 200 kg live weight, will lead to a reduction in future growth potential and an increase in fatness of the finished carcase. The effect on eating quality is less clear. CRC researchers investigated the effect of growth rate before weaning on subsequent growth and meat quality. Calves were grown at two rates (<0.5 kg/d and >0.8 kg/d) until weaning. Thereafter they were allowed unlimited access to irrigated Ryegrass until they reached feedlot entry weight (domestic feedlot entry ~300kg), and finished to domestic weights (200-260 kg carcase weight). Dr David Hennessy and collaborators carried out the studies at Grafton, over a period of several years. Pre-weaning growth was varied by adjusting the nutrition of the cows by supplementation with cottonseed meal (low growth calves were from unsupplemented cows, high growth calves were from supplemented cows). They found that there was no reduction in eating quality of calves growth at <0.5 kg/d prior to weaning compared to those grown at >0.8 kg/d. Slowly grown calves did not catch up to the weight of better-grown calves, despite having access to high quality feed after weaning.

Better pre-weaning nutrition (and growth rate) of the calves brought about changes in biochemical composition and size of muscle fibres, but there was no consistent effect on eating quality.

Early weaning and subsequent growth

In northern Australia, early weaning (at three to four months of age) is carried out to increase reproductive rate of the cowherd. In southern Australia early weaning systems are being considered to increase carrying capacity, particularly when coupled with spring calving.

The northern Australia experience has shown that without adequate inputs (and thus calf growth rate) early weaners (3 months - 100 kg) may be up to 6 months older at turn –off than calves weaned at 7-9 months. Moreover, calves with low growth in the first dry season had lower growth rates in the feedlot later in life (feedlot entry 420 kg exit 580kg), and markedly increased variation in carcase weight (Table 3a-1). Meat from calves with low growth rate (<0.5 kg/d) in the first dry season were potentially "chewier" (i.e. compression, the measure of connective tissue toughness was higher). A growth rate of at least 0.6 kg/d in the first dry season seems to be the most cost-effective strategy.

Lessons for southern Australia production systems are that if early weaning is used, then calf growth rates of >0.6 kg/d should be aimed for at least until the calves weigh more than 250 kg. Anything less may impair subsequent performance in the feedlot.

Table 3a-1. Effects of nutrition following early weaning on age to reach feedlot entry (months), feedlot gain, proportion of animals in carcase weight cateogry, and baseline toughness of their meat (LD Instrom compression) (Data from high grade i.e. > 5/8 Brahman steers from J.A. Lindsay, Swans Lagoon Research Station, North Queensland.

Treatment	Age to Reach 420 kg	Feedlot Gain (kg/d)	Proportion in Carcase Weight Class			Potential chewiness Instrom Compression (kg)
			<279 kg	280-299	<300 kg	
Low (0.4 kg/d)	26	1.32	0.31	0.19	0.50	2.48
Medium (0.6 kg/d)	24	1.56	0.12	0.44	0.44	-
High (0.8 kg/d)	22	1.59	0.05	0.56	0.39	1.95

Weaning Methods

If you are preparing feeder steers for a feedlot, then consider the method of weaning. Results from the Beef CRC and MLA studies conducted by Lloyd Fell, Keith Walker and colleagues have shown that yard weaning reduces the amount of time that steers take to adapt to a feedlot. The main advantages of yard weaning are enhanced rate of gain in the first 28 days in the feedlot and reduced respiratory sickness during the entire time on feed.

Effect of Post-weaning Growth (Backgrounding) on Finishing Growth

Growth rate in the feedlot or during finishing on "high" quality pastures is inversely related to growth rate during backgrounding. That is, if growth during the backgrounding phase is moderate (0.6 kg /d) then growth rate in the feedlot will be higher compared to cattle that experienced a higher (0.8 kg/d) backgrounding growth rate (Table 3a-2). Animals with the low background growth tend to have higher retail meat yield, less fat cover and less intramuscular fat content (intramuscular fat is a chemical indicator of marbling).

The main messages are:

- If you are preparing steers for a high marbling end point then high growth rates during backgrounding will increase the chance to achieve a good marbling outcome (if the steers have suitable genetics for marbling).

- If you are preparing steers for domestic finishing and cost of gain is important, you will benefit by using a lower rate of gain during backgrounding.

An extreme example of the effect of growth rate before feedlot entry on distribution of fat was observed in the Beef CRC. Steers (in this case Brahman, Santa Gertrudis and Belmont Red) were grown out and finished in both "southern" (Tullimba – 50 km west of Armidale) and "northern" environments (Duckponds – 200 km west of Rockhampton). The pattern of growth differed between these sites, such that post –weaning growth was higher at Tullimba. The distribution of fat in these animals is shown in Figure 3a-5. It can be seen those grown and finished in "southern" Australia had less fat trim and more intramuscular (marbling) fat than those grown and finished in "northern" Australia. We don't fully understand why this difference in fat distribution occurred (the animals were brothers of the same sires so a difference in genotype is not the reason for the difference).

With respect to meat quality (in *Bos taurus*), there were no significant effects of different post-weaning growth rates on objective and consumer measures of tenderness. *This was not the case in tropically adapted cattle. Consumers rated meat from cattle that had a low background growth rate (0.4 kg/d) consistently tougher than from cattle with higher background growth rate (0.8 kg/d).*

There were, however, differences in tenderness between steers finished on pasture compared to those finished in the feedlot – feedlot finished animals were slightly more tender.

In extreme studies where compensatory growth was deliberately introduced in cattle, which had been not allowed to grow for a period of some months, CRC scientists were able to show that animals undergoing faster rates of (compensatory) growth on a feedlot ration tended to have less connective tissue toughness (ie potentially less chewy meat).

Table 3a-2. Effects of background growth on feedlot performance, fatness and retail meat yield in *Bos taurus* cattle fed to domestic (400kg, 70 days) and export (540kg, 100 days, Korean: 600+ days, 150 days, Japanese) market specifications and finished in a feedlot (values shown are means across all feedlot finish categories).

Background Growth (kg/d)	Feedlot Entry Fat (mm)	Growth in Feedlot (kg/d)	Feedlot Exit Fat (mm)	Intramuscular Fat (%)	Retail Meat Yield (%)
0.62	4.6	1.34	11.8	4.1	67.3
0.66	5.0	1.27	11.9	4.1	67.2
0.79	5.8	1.22	12.6	4.7	66.5

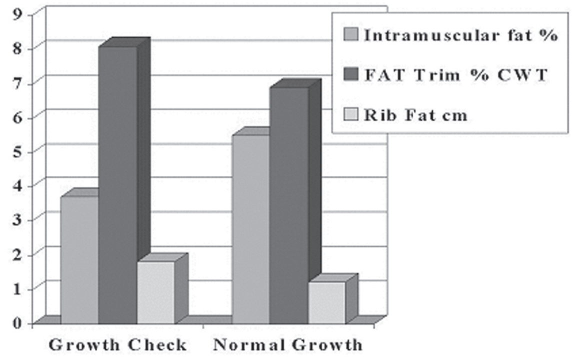

Figure 3a-5. Effects of growth between weaning and feedlot in temperate (normal growth) and tropical (growth check) environments on carcase traits of tropically adapted cattle (Brahman, Belmont Red and Santa Gertrudis cattle) feedlot finished to >300kg carcase weight for 150 days. The time taken to reach feedlot entry differed in each environment; in this case it took five months longer for animals in the tropical environment. Time on feed and feed specifications were the same in both environments.

In the feedlot

From a nutritional perspective, feedlots are luxury hotels for cattle. There is a "mythology" about the effect of diet on marbling of feedlot cattle; unfortunately studies conducted in the Beef CRC do not support the myths.

Over a number of studies, CRC scientists have been unable to show effects of

(a) An increases in fat content of the ration to >6%
(b) Inclusion of "Rumentek" protected lipids
(c) Increase in free Calcium concentration
(d) Variation in metabolisable protein content of the diet (both substantial increase and decrease above "requirements")

… on intramuscular fat content.

There was no effect of diet on growth rate in the feedlot, but there were quite large differences between diets on cost of gain ($ feed/ kg liveweight) in the feedlot.

Tenderness, juiciness and flavour are major determinants of consumer acceptability of beef. Meat Standards Australia (MSA) is a quality assurance system that has been developed through extensive consumer taste panel studies, and objective measures of the animal both before it arrives at the processor and in the chiller.

Factors, which affect eating quality that producers can influence, include breed type, weight, age (and thus ossification and dentition), fatness, marbling and muscle glycogen level. These impact on objective measures that affect the projected eating quality score as follows:

- **Breed type**
  - (i) an increase in *Bos indicus* content beyond 50% will reduce the projected eating quality score.
  - (ii) cattle from breeds (or sires) with inherently higher marbling (i.e. higher IMF EBVs) will increase the projected eating quality score.
- **Weight for age**
  - (i) influenced by growth rate. Faster growth rate results in heavier animals at the same age, or younger animals at the same weight. The main contributor to growth rate is how you manage the supply and quality of feed available to your cattle.
- **Ossification (degree of calcification of the bones)**
  - (i) as animals become older ossification score increases. At the same age, heifers have higher ossification scores than steers. You can ensure animals achieve ossification scores below the maximum allowable (300) by ensuring a whole of life growth rate of more than 0.6 kg/day.
- **Fatness / marbling**
  - (i) within a progeny group these are mainly affected by growth rate. Higher growth results in increased fat thickness and intramuscular (marbling) fat content at the same weight. You can influence these by how you manage feed quality and supply. Consumers rate marbling as important to eating quality, even though a relationship between marbling and objective measurements of toughness is not well established.
- **Muscle glycogen content**
  - (i) affects eating quality when there is too little glycogen present. Low muscle glycogen may result in meat with a pH greater than 5.8. This meat may also be darker than acceptable. Muscle glycogen can be maintained by ensuring cattle keep growing for at least 2 weeks before slaughter, and are not unduly stressed immediately before slaughter.

There are small effects of the pattern of growth on eating quality, but these are secondary to the main effects shown above. Results from the Beef Quality CRC show that large differences in background growth rate does influence eating quality traits, at least in tropically adapted cattle. Our present understanding of the relationship between nutrition (pattern of growth) and meat quality is summarised in Table 3a-3.

Conclusion

There is no single solution to the job of producing a quality feeder steer. With respect to growth, it is important to ensure adequate early growth so as not to impair potential in the longer term. The backgrounder can affect the profitability of the feedlot operator by changing the propensity of cattle to deposit fat and thus affect growth and cost of gain. In all cases, it is important to recognise that all sectors, the breeder, backgrounder and finisher contribute to the economic production of a quality beef animal.

Table 3a-3. Summary of effects of growth rate and pattern of growth on carcase attributes and meat quality.

Effector	Carcase	Toughness	MSA Tests
Compensatory Growth after Late Growth Check	↓fat ↓marbling ↑yield	↓compression[a]	ND[b]
Early Growth Check (Low Background growth)	↑fat ↓marbling ↓ yield	↓↑compression	~MSA[c]
Low Background growth (Tropically adapted cattle)	↑fat ↑marbling ↓yield	↑compression	↓ MSA
High Background Growth	↑fat ↑marbling ↓yield	↓compression	~MSA
Feedlot v's Pasture	↑fat ↑marbling ↓yield	↓compression ↓peak force	↑ MSA

Note: a Compression measurement of toughness, equivalent to chewiness of meat
b Not determined
c MSA Meat Standards Australia sensory evaluation