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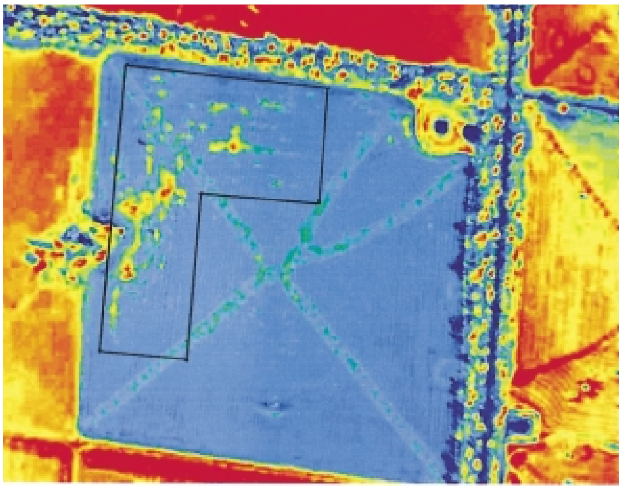

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Sustained growth promotion, carcass and meat quality of steers slaughtered at three liveweights

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Abstract. The experiment measured the effect of a sustained growth promotion strategy on growth rate, carcass characteristics, and meat quality of Brahman and F_1 Brahman crossbred steers. Meat quality was assessed objectively by laboratory measurement and a subset of samples evaluated subjectively by consumer taste panels. Steers were allocated to one of 12 treatment groups; 2 implant strategies × 3 liveweights at slaughter × 2 nutritional finishing strategies. The 2 implant strategies were unimplanted controls and implantation with 20 mg oestradiol-17β (Compudose) every 100 days. The target carcass weights at slaughter were about 220 kg (Australian domestic market), about 280 kg (Korean market) and about 320 kg (Japanese market). Steers were finished either at pasture or on a grain-based diet in a feedlot.

For every treatment group except where steers were finished in a feedlot for the domestic market, the implant strategy resulted in significantly (P<0.01) heavier final liveweights, significantly (P<0.01) greater cumulative liveweight gains and significantly (P<0.05) heavier carcass weights. The magnitudes of the significant liveweight responses ranged from 30 kg for pasture fed steers for the domestic market to 47 kg for pasture fed steers for the heavier weight Japanese market.

Repeated treatment with oestradiol-17β had no significant effect on carcass composition as determined by indices of carcass lean and carcass fat. The additional yield of retail beef from implanted steers was principally associated with increased carcass weight. The magnitude of the increase in beef yield was 8 kg (n.s.) for domestic, feedlot steers; 15 kg (P<0.01) for Korean, feedlot steers and 18 kg (P<0.001) for Japanese, feedlot steers.

In steers finished in the feedlot for the Korean and Japanese markets, sustained growth promotion was associated with a significant (P<0.01) decrease in meat tenderness as measured by peak force. In contrast there was no such effect in other groups measured (domestic market, feedlot finished and Japanese market, pasture finished). Consumer assessment of eating quality was conducted on steaks from steers, finished in a feedlot for the Korean and Japanese markets. At both slaughter weights there was no significant effect of treatment on tenderness, juiciness, flavour, overall acceptability or meat quality score which combined tenderness, juiciness, flavour and overall quality. However, mean preference scores from implanted steers were consistently lower than those from control steers.

It was concluded that the aggressive implant strategy resulted in substantial increases in weight gain that were more pronounced during periods of moderate growth rate relative to periods of very low rates of gain. During periods of low weight gains or weight stasis there was little advantage from implantation. Carcass composition was not significantly modified by treatment with oestradiol. The effect of the aggressive implantation strategy on eating quality of the beef was equivocal and further investigation is certainly warranted.

Additional keywords: cattle, oestradiol-17β.

Introduction

The use of hormonal growth promotants to increase liveweight gain and reduce the age of turn-off of steers is widespread in the northern Australian beef industry. Sales figures show that of the 2.5 million doses of hormonal growth implants that were sold in Australia in the 1997–98 financial year, about 1.2 million were sold for use in pasture fed steers in northern Australia. The increased liveweight gain from a single implant is usually 10–20 kg over 100–150 days (Sawyer and Barker 1988). An implant with a functional life of 400 days is available (Compudose 400, Elanco Animal Health, Australia), although few published studies exist which report weight gains for the period that corresponds to the expected functional life. In one such experiment the liveweight gain response was 21 kg in 386 days (Mason *et al.* 1986). Hunter *et al.* (1998)

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established that sustained growth promotion could be achieved over lengthy periods of time. In an animal house experiment of 60 weeks duration they demonstated that steers treated alternately with an oestrogenic hormone and then an androgenic hormone every 100 days continued to exhibit accelerated growth rate. The same effect was also demonstrated with oestrogen treatment, repeated every 100 days. More recently, Hunter *et al.* (2000) reported the liveweight response to 4 implantations with 20 mg oestradiol-17β (Compudose 100) at 105-day intervals was in excess of twice that achieved with a single implantation of 45 mg oestradiol-17β (Compudose 400; 49 *v.* 21 kg over 420 days). Steers were kept in positive energy balance throughout the experiment by transferring them from dryland pasture to irrigated pasture during that part of the dry season when the quality of the dryland pasture was not sufficient to support liveweight gain. That experiment also showed that when comparisons were made at the same carcass weight, oestradiol treatment had no significant effect on the yield of retail beef or on the degree of carcass fatness. The additional yield of beef from the steers treated with oestradiol was principally due to the increased growth rate and the heavier carcasses of those steers.

In this study, grazing steers were allowed to go through the seasonal fluctuations of liveweight gain, liveweight stasis and liveweight loss that are typical in the semi-arid rangelands of northern Australia. They were finished at carcass weight specifications for 3 different markets (domestic, Korean and Japanese) either at pasture or in a feedlot where they were fed a grain-based diet. Liveweight responses to the implant strategy in each of these production systems and the effect of implantation on carcass and meat quality attributes were determined.

Materials and methods

Animals and treatments

Experimental steers were derived from the Cooperative Research Centre for Cattle and Beef Quality's northern crossbreeding experiment (Upton *et al*. 2001). Calves were born at either the Brigalow Research Station or the Duckponds property, in Central Queensland, between August and September 1995. Calves from Brigalow Research Station were transferred to Duckponds following weaning at 4–6 months of age in May 1996. Thereafter, they were managed as a single group with the steers born at Duckponds. In total, 236 Brahman and F_1 Brahman crossbred steers were used for the experiment. Experimental steers grazed buffel grass (*Cenchrus ciliaris*)-dominant pastures at Duckponds from August 1996 (mean ± s.e. liveweight, 224 ± 2.4 kg) until the commencement of the experiment in December 1996 (liveweight, 272 ± 2.5 kg), about 1 month after the onset of seasonal rains. Steers were allocated to 12 treatment groups that consisted of 2 implant strategies by 3 market end points by 2 nutritional finishing strategies. Allocations were made using an optimisation procedure (Robinson 1995), which considered age, initial weight, genotype sire within breed and property of origin and ensured that steers within these classes were evenly distributed across all treatment groups. There were initially 19, 20 or 21 steers in each treatment group. Implant strategies included non-implanted controls and an implanted group that was administered 20 mg oestradiol-17β (Compudose 100) about every 100 days. Old implants were removed before new ones were inserted.

Steers were slaughtered when the mean liveweight of each treatment group was predicted to be at target carcass weight (220, 280 and 320 kg for domestic, Korean and Japanese markets respectively). Steers were finished either at pasture or in a feedlot on a grain-based diet. Pasture finished steers were maintained on buffel grass-dominant pasture at Duckponds for the entire experimental period. Grain finished steers were transported 45 km from Duckponds to Goonoo feedlot where they were finished on a grain-based diet (13.5 MJ/kg dry matter, 13.4% crude protein). Domestic market-weight steers entered the feedlot at a mean liveweight of about 300 kg and were fed for at least 70 days. Export-market weight steers entered the feedlot at a mean liveweight of about 400 kg and were fed for either 100 or 150 days for the Korean and Japanese markets, respectively.

At Duckponds, steers were weighed at intervals of 6 weeks. They were mustered the day before weighing and held in yards overnight with access to water. At Goonoo, unfasted liveweights were recorded every 3 weeks. When the steers in each treatment group reached their target slaughter weight (unfasted), they were transported to a commercial abattoir and slaughtered according to the procedures described by Perry *et al.* (2001*b*). After chilling overnight, sides were quartered at the 12th or 13th rib. Eye muscle area and P8 fat depth were measured 20 minutes after quartering. One side of each carcass was broken down into separate muscle and fat portions for measurement of retail beef yield. Retail beef yield measurements were not made on carcasses from steers finished on pasture for the Korean and Japanese markets as these steers were slaughtered at a different abattoir. A description of the carcass measurements taken is given in Table 1. About 15 cm of the *M. longissimus dorsi* from the left side of each carcass, caudal to where it was sectioned at the 12th or 13th rib site, was trimmed of excess fat, weighed, blast frozen and stored at –20°C for subsequent meat quality analyses and taste panel evaluations.

Objective measurements of meat quality

Not all animals that were measured for growth traits had accurate meat tenderness data recorded due to ineffective electrical stimulation of carcasses of steers finished at pasture for the domestic (37 steers) and Korean markets (33 steers). Electrical stimulation was used to prevent the effects of cold shortening that results from rapid chilling of carcasses. Cold shortening is known to increase meat toughness, particularly in leaner and lighter carcasses (Harris and Shorthose 1988).

The tenderness of cooked samples of *M. longissimus dorsi* was determined by objective measurements using (i) a modified Warner-Bratzler shear, and (ii) instron compression following the established methods of Bouton and Harris (1972*a*, 1972*b*), Bouton *et al.* (1975, 1977) (Table 1). The measurements from modified Warner-Bratzler shear force deformation curves were (i) peak force, a measure of total toughness of meat; (ii) initial yield, an index of the myofibrillar contribution to meat toughness (Harris and Shorthose 1988); and (iii) the difference between peak force and initial yield, an index of the contribution of connective tissue to meat toughness (Harris and Shorthose 1988). All Warner-Bratzler measurements were recorded in kg, with higher values indicating tougher meat. Instron compression measurements were recorded to determine differences in connective tissue strength between muscles (Harris and Shorthose 1988), with higher values indicating tougher meat. All meat quality measurements were made on samples from cooked (70°C for 1 h) 250 g blocks of muscle. Sarcomere length was determined by the method of Bouton *et al.* (1973).

Eating quality

Eating quality was determined only for beef from 46 steers that were finished in the feedlot, and slaughtered for the Korean and Japanese markets. Data from feedlot-finished domestic weight steers were not

Table 1. Definition of carcass and meat quality attributes measured in this experiment

Attribute	Definition
Carcass weight	Hot standard carcass weight
Dressing percentage	Ratio of carcass weight to preslaughter liveweight (unfasted)
Adjusted retail beef yield	Total weight of primal cuts, trimmed of fat to a retail level, plus total manufacturing meat adjusted to 85% chemical lean and expressed as a percentage of recovered weight (muscle, fat and bone)
Weight of retail primals	Total weight of primal cuts trimmed to a uniform fat cover of 3 mm
Eye muscle area	Chiller Visual Image Analysis eye muscle area
Cold P8 fat depth	Fat thickness at the P8 rump site (Anon. 1985)
Intramuscular fat percentage	Percentage of lipid (marbling fat) in *M. longissimus dorsi* (an intramuscular fat percentage of ~3% equates to 1 AUSMEAT marbling score)
Ultimate pH	Ultimate pH of meat sample, calculated as mean of 4 measurements using a probe-type combined electrode
Peak force	Peak force (kg) which represents the total meat toughness (Harris and Shorthose 1988)
Initial yield	Initial yield (kg), an index of the myofibrillar contribution to meat toughness (Harris and Shorthose 1988)
Peak force – initial yield	Difference between peak force and initial yield (kg), an index of the contribution of connective tissue to meat toughness (Harris and Shorthose 1988)
Instron compression	Instron compression (kg) , measured to determine differences in connective tissue content between muscles (Harris and Shorthose1988)
Taste panel tenderness	Subjective untrained consumer evaluation of meat tenderness on a 0–100 scale, with 0 being least tender and 100 being most tender (Polkinghorne *et al*. 1999)
Taste panel juiciness	Subjective untrained consumer evaluation of meat juiciness on a 0–100 scale, with 0 being least juicy and 100 being most juicy (Polkinghorne *et al*. 1999)
Taste panel flavour	Subjective untrained consumer evaluation of meat flavour on a 0–100 scale, with 0 being poorest flavour and 100 being best flavour (Polkinghorne *et al*. 1999)
Taste panel overall acceptability	Subjective untrained consumer evaluation of overall meat acceptability on a 0–100 scale, with 0 being least acceptable and 100 being most acceptable (Polkinghorne *et al*. 1999)
Taste panel CMQ4 score	Combined score of untrained consumer evaluation of meat, weighted thus: tenderness × 0.4; juiciness × 0.1; flavour × 0.2; and overall acceptability × 0.3 (Polkinghorne *et al*. 1999)

included in the analysis because only 4 control steers and 6 implanted steers were represented. Data from steers finished at pasture for the domestic and Korean markets were not included because electrical stimulation of carcasses was ineffective. Data from steers finished at pasture for the Japanese market were unavailable. Eating quality was determined by untrained consumer panels as a score on a 0–100 scale for tenderness, juiciness, flavour and overall acceptability, with a score of 0 being least acceptable and a score of 100 being most acceptable. Individual scores were also combined, using weightings of 0.4, 0.1, 0.2 and 0.3 for tenderness, juiciness, flavour and overall acceptability respectively, into a combined meat quality score (CMQ4) (Polkinghorne *et al.* 1999). Details of design, cooking procedures, conditions of tasting and number of panellists are given by Perry *et al*. (2001*a*).

Chemical and statistical analysis

Intramuscular fat content of *M. longissimus dorsi*, an indicator of marbling, was determined by chemical extraction with diethyl ether in a Soxhlet apparatus for 48 h [method 920.39 of the Association of Official Analytical Chemists (1998)].

Data were analysed by analysis of variance (Statistical Analysis Systems Institute 1992) with finishing regime (pasture *v.* feedlot), treatment (control *v.* implantation) and market (domestic, Korean and Japanese) as fixed effects. Final liveweight, liveweight gain and carcass weight were analysed with initial liveweight as a covariate. Dressing percentage, retail beef yield, weight of retail primals, eye muscle area, P8 fat depth, intramuscular fat percentage, ultimate pH, objective measurements of meat quality and subjective eating quality assessments were analysed using carcass weight within market end point as a covariate.

Results

Twenty-one steers were withdrawn during the course of the experiment for injury, death or being absent for 2 consecutive weighings. In addition, another 9 lost implants and were also withdrawn. This left 203 steers (49 Brahmans and 154 Brahman cross) in the experiment. The numbers remaining in each treatment group are shown in Table 2. Meat quality data from all 203 steers are not presented. There was ineffective electrical stimulation of carcasses of steers finished at pasture for the domestic and Korean markets that precluded meaningful measurements of tenderness. The period of implantation for the different treatment groups varied from 92 days for feedlot-finished, domestic-weight steers to 671 days for pasture-finished, Japanese-weight steers (Table 2). Patterns of cumulative liveweight change for feedlot-finished and pasture-finished Japanese-weight steers over the life of the experiment are shown in Figure 1. The average daily liveweight response to the implant strategy was greater in steers that maintained uninterrupted positive growth rates than those that experienced arrested growth rate during a northern dry season. Pasture-finished, domestic-weight steers and feedlot-finished, Korean- and Japanese-weight steers had liveweight gain advantages over their respective controls of 0.15, 0.13 and 0.13 kg/day respectively (Table 2). By comparison, pasture-finished, Korean- and Japanese-weight steers had daily liveweight gain advantages of 0.08 and 0.07 kg/day respectively. The liveweight advantage of feedlot-finished, domestic-weight, implanted steers was 0.08 kg/day. However, these steers

Table 2. Age and weight at slaughter, weight gain over the implantation period, carcass weight and dressing percentage of Brahman and Brahman crossbred steers implanted with Oestradiol 17β within market destination and grass or grain finishing regime

Data were adjusted by covariance to a common initial liveweight; values are mean ± s.e.

	Domestic market			Korean market			Japanese market			Effect of	Signif. of
	Control	Oestradiol	Signif.	Control	Oestradiol	Signif.	Control	Oestradiol	Signif.	market	covariate
					Feedlot-finished steers						
No. of animals	18	17		20	17		16	16			
Implantation period (days)	—	92		—	266		—	315			
Number of implants		1			3			4			
Age at slaughter (days)	537 ± 9	542 ± 9	n.s.	704 ± 8	702 ± 9	n.s.	758 ± 9	756 ± 9	n.s.	P<0.001	n.a.
Final liveweight (kg)	413 ± 8	420 ± 8	n.s.	510 ± 8	544 ± 8	P<0.01	566 ± 9	607 ± 9	P<0.001	P<0.001	P<0.001
Cumulative liveweight gain (kg)	141 ± 8	148 ± 8	n.s.	238 ± 8	271 ± 8	P<0.01	293 ± 9	335 ± 9	P<0.001	P<0.001	P<0.01
Daily liveweight gain (kg)	1.54 ± 0.04	1.62 ± 0.04	n.s.	0.89 ± 0.04	1.02 ± 0.04	P<0.05	0.93 ± 0.05	1.06 ± 0.05	P<0.05	P<0.001	P<0.05
Carcass weight (kg)	234 ± 5	241 ± 5	n.s.	287 ± 5	307 ± 5	P<0.01	329 ± 5	356 ± 5	P<0.001	P<0.001	P<0.001
					Pasture-finished steers						
No. of animals	19	18		19	14		18	12			
Implantation period (days)	—	203		—	442		—	671			
No. of implants		2			5			7			
Age at slaughter (days)	646 ± 9	646 ± 10	n.s.	883 ± 9	883 ± 11	n.s.	1122 ± 10	1124 ± 11	n.s.	P<0.001	n.a.
Final liveweight (kg)	401 ± 7	431 ± 7	P<0.01	499 ± 7	535 ± 8	P<0.001	600 ± 7	647 ± 8	P<0.001	P<0.001	P<0.001
Cumulative liveweight gain (kg)	128 ± 7	158 ± 7	P<0.01	226 ± 7	262 ± 8	P<0.001	327 ± 7	374 ± 8	P<0.001	P<0.001	n.s.
Daily liveweight gain (kg/day)	0.63 ± 0.02	0.78 ± 0.02	P<0.001	0.51 ± 0.02	0.59 ± 0.02	P<0.01	0.49 ± 0.02	0.56 ± 0.02	P<0.01	P<0.001	n.s.
Carcass weight (kg)	206 ± 3	221 ± 4	P<0.01	271 ± 3	286 ± 4	P<0.01	335 ± 4	368 ± 4	P<0.001	P<0.001	P<0.001

spent only 92 days in the experiment. Figure 2 shows that for pasture-finished steers there was an increasing liveweight gain advantage to implanted steers during periods of moderate weight gain (0.73 and 0.85 kg/day) and a static, or decreasing advantage during periods of low weight gains (0.14 and 0.24 kg/day).

For every treatment group except feedlot-finished, domestic-weight steers, the implant strategy resulted in significantly (P<0.01) heavier final liveweights, significantly (P<0.01) greater cumulative liveweight gains and significantly (P<0.05) heavier carcass weights (Table 2). The magnitudes of significant liveweight responses ranged from 30 kg from 2 implants for pasture-finished, domestic-weight steers to 47 kg from 7 implants for pasture-finished, Japanese-weight steers.

Repeated treatment with oestradiol had no significant effect on adjusted retail beef yield (Table 3). This means that the additional retail beef from implanted steers was

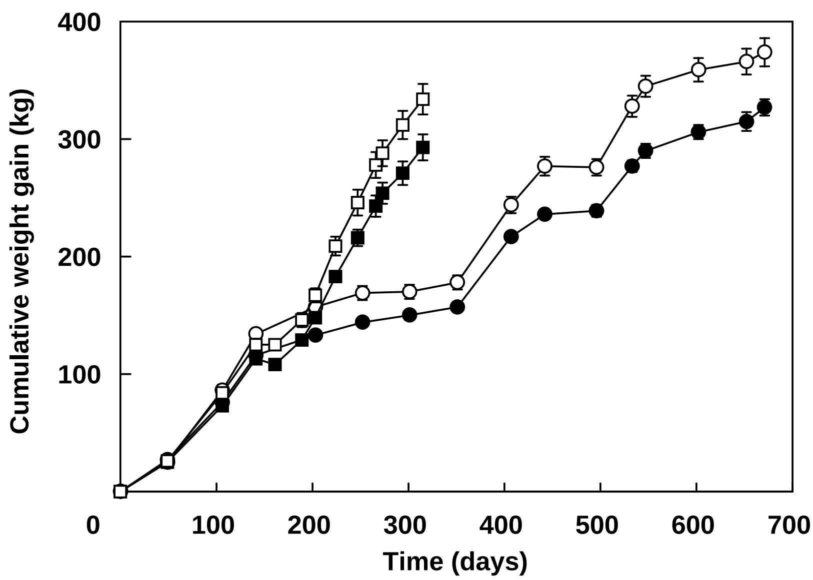

Figure 1. Cumulative liveweight gain of steers of initial mean liveweight 273 kg finished for the Japanese market: feedlot-finished, control (■); feedlot-finished, implanted (□); pasture-finished, control (●) pasture-finished, implanted (○).

principally due to their increased carcass weight. The magnitude of the increase was 8 kg (n.s.) for feedlot-finished, domestic-weight steers; 15 kg (P<0.01) for feedlot-finished, Korean-weight steers and 18 kg (P<0.001) for feedlot-finished, Japanese-weight steers.

Table 3 shows that at each market weight and for each nutritional finishing strategy, repeated treatment with oestradiol had no significant effect on ultimate pH, subcutaneous fat depth at the P8 site, or intramuscular fat percentage of the *M. longissimus dorsi* or eye muscle area when data were adjusted to a common slaughter weight within market end point. In feedlot-finished, Korean- and Japanese-weight steers, implantation was associated with a significant (P<0.01) increase in peak force. In contrast, there was no effect on peak force in feedlot-finished, domestic-weight steers or pasture-finished, Japanese-weight steers. Treatment differences in peak force minus initial yield and Instron compression, which are indices of connective tissue strength, were not significant.

There were no statistically significant differences between implanted and control steers in eating quality of steaks assessed by consumer taste panel, irrespective of treatment or market weight (Table 4). There was a tendency (P = 0.07) within the group, feedlot-finished at Korean market weight for CMQ4 scores to be higher for the control steers.

Discussion

This study has shown that by regular implantation of steers with oestradiol, growth promotion was sustained during periods in which growth rates were moderate. During periods when growth was near zero, growth promotion did not occur. This suggests that a less aggressive implant strategy than that used in this experiment might be of commercial significance in northern Australia. Implanting every 100 days during the growing season with a 100-day implant, followed by a longer life implant, e.g. 200 days, for the duration of the dry season, would seem more appropriate, given the likelihood of a reduced weight gain response during the drier months and the mustering costs for an additional implantation. A 200-day implant would ensure accelerated growth in the event of unseasonal rains or an early break to the wet season. Another experiment (R. A. Hunter unpublished data) has shown that implantation during the dry season is essential if the weight advantage over implantation during the wet season is to be maintained. In that study, steers in 1 group were implanted with Compudose 100 or Revalor (140 mg trenbolone acetate plus 28 mg oestrodiol-17β) at the beginning of the wet season and then not until the beginning of the next wet season. The weight advantage of implanted steers at the end of the first implant period was eroded by the time the second implant period commenced. More regular implantation during periods of moderate to rapid liveweight gain is needed if liveweight response is to be maximised. It can be predicted from the data of Hunter *et al.* (2000) that 2 treatments with Compudose 100 during the wet season would result in a liveweight advantage of 24 kg over 200 days compared with an advantage of 12 kg with 1 treatment with a longer acting Compudose formulation.

Analysis of carcass composition and meat quality data with carcass weight within market as a covariate allowed the effect of treatment to be separated from the effect of carcass

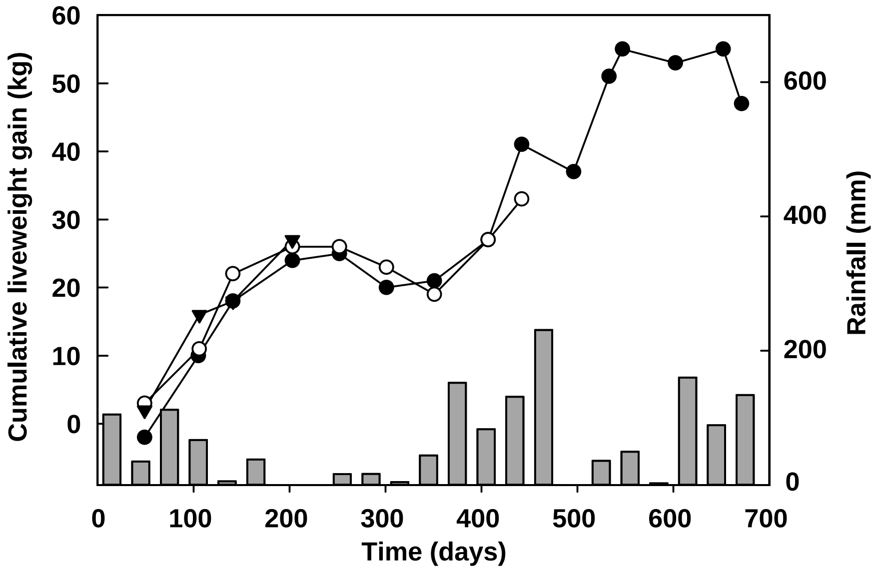

Figure 2. Monthly rainfall (solid bars) and the cumulative advantage in liveweight of implanted pasture-finished steers over the controls: domestic weight (▼), Korean weight (○) Japanese weight (●).

Table 3. Carcass quantity and meat quality attributes of Brahman and Brahman crossbred steers

PFIY, peak force minus initial yield
Data were adjusted by covariance for carcass weight within market; values are mean ± s.e.

	Domestic market			Korean market			Japanese market			Effect of	Signif. of
	Control	Oestradiol	Signif.	Control	Oestradiol	Signif.	Control	Oestradiol	Signif.	market	covariate
					Feedlot-finished steers						
No. of animals	18	17		20	17		16	16			
Dressing percentage (%)	56.6 ± 0.5	57.4 ± 0.5	n.s.	56.2 ± 0.4	56.5 ± 0.5	n.s.	58.2 ± 0.5	58.6 ± 0.5	n.s.	n.s	n.s.
Adjusted retail beef yield (%)	67.5 ± 1.03	68.6 ± 0.95	n.s.	65.7 ± 0.51	66.1 ± 0.56	n.s.	63.2 ± 0.66	63.6 ± 0.80	n.s.	n.s	n.s.
Weight of retail primals (kg)	147.9 ± 2.16	149.1 ± 1.98	n.s.	147.3 ± 1.06	148.2 ± 1.17	n.s.	140.7 ± 1.38	140.0 ± 1.67	n.s.	n.s	n.s.
Eye muscle area (cm^2)	76.7 ± 3.2	78.6 ± 2.5	n.s.	77.7 ± 1.6	78.5 ± 1.8	n.s.	74.9 ± 2.1	75.0 ± 2.6	n.s.	n.s	P<0.001
Cold P8 fat depth (mm)	13.4 ± 1.7	12.7 ± 1.5	n.s.	16.2 ± 0.9	15.6 ± 1.0	n.s.	16.7 ± 1.2	16.4 ± 1.3	n.s.	P<0.05	P<0.001
Intramuscular fat (%)	2.1 ± 0.41	1.8 ± 0.36	n.s.	2.6 ± 0.21	2.2 ± 0.22	n.s.	3.3 ± 0.27	3.5 ± 0.33	n.s.	n.s	n.s.
Ultimate pH	5.60 ± 0.020	5.59 ± 0.018	n.s.	5.56 ± 0.010	5.60 ± 0.011	n.s.	5.55 ± 0.013	5.58 ± 0.016	P<0.05	n.s	n.s.
Peak force (kg)	4.4 ± 0.38	4.5 ± 0.33	n.s.	4.3 ± 0.20	4.8 ± 0.14	P<0.01	4.7 ± 0.25	5.4 ± 0.31	P<0.05	n.s	P<0.001
Initial yield (kg)	3.4 ± 0.34	3.7 ± 0.30	n.s.	3.3 ± 0.17	3.4 ± 0.12	P<0.05	3.5 ± 0.22	3.7 ± 0.27	n.s.	n.s	n.s.
PFIY (kg)[A]	1.0 ± 0.22	0.9 ± 0.19	n.s.	1.1 ± 0.11	1.4 ± 0.10	n.s.	1.2 ± 0.14	1.7 ± 0.17	n.s.	P<0.05	n.s.
Instron compression (kg)	1.8 ± 0.09	1.8 ± 0.08	n.s.	1.8 ± 0.05	1.8 ± 0.05	n.s.	1.7 ± 0.06	1.8 ± 0.07	n.s.	n.s	n.s.
					Pasture-finished steers						
No. of animals	19	18		19	14		17	12			
Dressing percentage (%)	53.1 ± 0.7	52.6 ± 0.6	n.s.	54.4 ± 0.3	53.3 ± 0.4	P<0.05.	55.0 ± 0.6	54.4 ± 0.8	n.s.	n.s	n.s.
Adjusted retail beef yield (%)	69.8 ± 0.36	70.7 ± 0.35	n.s.	—	—	—	—	—	—	—	P<0.05
Weight of retail primals (kg)	112.1 ± 0.71	112.0 ± 0.69	n.s.	—	—	—	—	—	—	—	P<0.001
Eye muscle area (cm^2)	67.4 ± 1.3	69.8 ± 1.3	n.s.	—	—	—	—	—	—	—	P<0.01
Cold P8 fat depth (mm)	4.3 ± 1.4	4.6 ± 1.2	n.s.	7.5 ± 0.7	7.4 ± 0.8	n.s.	8.9 ± 1.2	8.9 ± 1.7	n.s.	—	n.s.
Intramuscular fat (%)	1.0 ± 0.22	1.0 ± 0.19	n.s.	2.0 ± 0.11	1.9 ± 0.13	n.s.	2.6 ± 0.22	2.0 ± 0.30	n.s.	n.s	n.s.
Ultimate pH	5.64 ± 0.038	5.61 ± 0.032	n.s.	5.59 ± 0.018	5.58 ± 0.022	n.s.	5.56 ± 0.037	5.61 ± 0.050	n.s.	P<0.05	n.s.
Peak force (kg)	—	—	—	—	—		6. 0 ± 1.48	6.3 ± 1.98	n.s.	—	n.s.
Initial yield (kg)	—	—	—	—	—		3.7 ± 0.84	3.6 ± 1.12	n.s.	—	n.s.
PFIY (kg)				—	—		2.3 ± 0.84	2.7 ± 1.12	n.s.	—	n.s.
Instron compression (kg)	—	—	—	—	—		2.2 ± 0.11	2.4 ± 0.15	n.s.	—	n.s.

weight. It was clearly demonstrated that the increased retail beef yield from implanted steers (up to 18 kg) was largely due to their increased carcass weight, rather than a differential increase in protein deposition. Retail beef yield was the best measure of muscle weight taken in this experiment. Since anabolic agents are defined as substances that increase nitrogen retention and protein deposition in animals (Heitzman 1980), it might be expected that aggressive treatment with oestradiol would increase muscle mass at the expense of fat deposition. The scientific literature generally reports minimal effects on carcass fatness when oestradiol is implanted once or is repeated a small number of times (e.g. Duckett *et al.* 1997; Wilson *et al.* 1999; Hunter *et al.* 2000). This study reports a similar finding for steers implanted up to 7 times. Steers finished on pasture for the Korean and Japanese markets were under the influence of an anabolic agent for 442 and 671 days respectively which represented the latter 50–60% of the animals' life, yet there

Table 4. Eating quality assessment of steaks from Brahman and Brahman crossbred steers implanted with oestradiol -17β and finished in a feedlot

Data were adjusted for carcass weight within market; values are mean ± s.e.

	Korean market			Japanese market			Effect of	Signif. of
	Control	Oestradiol	Signif.	Control	Oestradiol	Signif.	market	covariate
No. of animals	20	17		16	16			
Tenderness	57 ± 3.9	48 ± 3.1	n.s.	56 ± 3.3	49 ± 3.7	n.s.	n.s.	n.s.
Juiciness	58 ± 2.9	53 ± 2.3	n.s.	56 ± 2.5	50 ± 2.8	n.s.	n.s.	P<0.001
Flavour	58 ± 3.0	53 ± 2.5	n.s.	58 ± 2.6	54 ± 3.0	n.s.	n.s.	n.s.
Overall acceptability	58 ± 3.3	50 ± 2.7	n.s.	57 ± 2.8	50 ± 3.2	n.s.	n.s.	n.s.
CMQ4 score[A]	57 ± 3.3	50 ± 2.7	n.s.	56 ± 2.8	51 ± 3.2	n.s.	n.s.	n.s.

[A]CMQ4 score, combined score of untrained consumer evaluation of meat, weighted thus: tenderness × 0.4; flavour × 0.2; juiciness × 0.1; overall acceptability × 0.3 (Polkinghorne *et al.* 1999).

was no measurable effect on protein deposition at the expense of fat deposition. Advancing maturity of the animal, as defined by carcass weight, clearly had a greater influence on carcass fatness, at least in subcutaneous fat deposits and within the *M. longissimus dorsi,* than any anabolic effect of oestradiol.

Much greater variation existed in peak force measurements in implanted pasture-finished, Japanese-weight steers (6.3 ± 1.98 kg, standard errors >15% of the means) than in feedlot-finished, Japanese-weight steers (5.4 ± 0.31, standard errors <10% of the means). The treatment difference within the feedlot-finished Japanese weight cohort group was statistically significant (P<0.05). This is one of the few experiments in which an effect of implantation on peak force has been so marked. Duckett *et al.* (1997) compiled and examined a comprehensive database for experiments with hormonal growth promotants. They found that at any carcass weight, treatment with oestradiol increased shear force, though the magnitude of the increase was slight. The significance of the difference between implanted and control steers in the current study may have been associated with an implantation strategy that was more aggressive over a longer time period (266 and 315 days) than in other studies. There was no increase in peak force in feedlot-finished, domestic-weight steers where the length of the implantation period was only 92 days. The lack of a significant effect of implantation on peak force in pasture-finished, Japanese-weight steers is not consistent with this hypothesis, as these steers were implanted for the even longer period of 671 days. It could be argued that the variation within each treatment group precluded a statistically significant difference.

Despite the increased peak force of steaks from feedlot-finished, Korean- and Japanese-weight steers, there were no statistically significant differences between implanted and control steers in eating quality scores. Although the differences were not statistically significant, least squares mean values indicate that consumers tended to prefer steaks from non-implanted steers rather than implanted steers. Levels of significance may simply reflect higher coefficients of variation of subjective evaluations and the small numbers of animals that were evaluated by consumer panels. Though preliminary evidence is that the aggressive implantation strategy had a non-significant effect on eating quality, a final conclusion awaits a more extensive investigation.

From the results of this experiment and other studies, it can be concluded that a near maximum growth response to treatment with oestradiol-17β in northern Australia is likely to occur when treatment with the 100-day implant is repeated during the period of the year when liveweight gains are moderate. Treatment with 1 longer functional life implant *v.* 2 shorter life implants during the dry season when the rates of gain are low or non-existent, is also suggested to maximise annual growth responses, while reducing cattle handling costs. The weight of retail beef from carcasses was increased by up to 9% by the sustained growth promotion strategy. This increase in yield was principally associated with increased carcass weight rather than a partitioning of absorbed nutrients towards protein deposition at the expense of carcass fatness. The effect of an aggressive implantation strategy with oestradiol on eating quality of the meat remains equivocal and warrants further investigation. Objective laboratory measurements detected decreased tenderness of beef from 2 implant treatment groups. In other groups, implantation had no significant effect on objective measurements of tenderness or toughness. Unfortunately there were no sensory perception data from consumers for these groups.

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