MEASUREMENT OF FEED INTAKE AND FEED EFFICIENCY IN FEEDLOT CATTLE.

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SUMMARY

Measurement of feed intake is repeatable even over short periods, but estimates of weight gain are not. Given measurements of intake over a relatively short period (7-9 weeks including time to adjust to the automatic feeding system), a more reliable assessment of efficiency was achieved by relating feed intake to gain modelled using a growth curve based on all weights recorded in the feedlot, instead of simply using weights for the period when intake was recorded.

Keywords: Beef cattle, feed intake, weight gain, feed efficiency

INTRODUCTION

Feed is a major cost in the production of grain-fed beef. Ideal feedlot stock should utilise feed efficiently and economically, ie grow well with moderate feed consumption. If efficiency can be improved, benefits may extend beyond the feedlot. It is thought that animals which grow efficiently on grain could also grow efficiently on grass and perhaps have lower feed requirements when mature. If so, identification of efficient feedlot stock might reduce production costs not just for the feedlot, but also the breeding herd, estimated to account for 52-89% of metabolizable energy needed for beef production (Thompson and Barlow 1986). Accurate measurement of feed efficiency, however, requires a testing period of 10 or more weeks (Archer 1996). The main expenses relate to measurement of intake, which may be repeatably measured over shorter periods, but at least 10 weeks are required for accurate measurement of weight gain. Here we consider consequences on accuracy of selection and effects for other traits of relating a more limited set of intake data to growth modelled from all weights recorded in the feedlot.

MATERIALS AND METHODS

The design of the Cooperative Research Centre for the Cattle and Beef Industry (**CRC**) research programme was described by Robinson (1995). Measurements analysed here were of 308 steers from two groups of *Bos taurus* steers purchased at weaning in 1995 and 1996 from 9 Angus, 4 Shorthorn, 3 Hereford and 2 Murray Grey herds and a group of *Bos indicus* steers purchased in July 1994 from a Santa Gertrudis and a Brahman herd. *Taurus* steers were grown out at the Agricultural Research Station, Glen Innes on pasture, or pasture supplemented with concentrates or forage in 1995 and in 1996 on the same pastures, unsupplemented, but subject to differences in pasture fertility and possible carry-over effects from 1995. *Indicus* steers were grown out in central Queensland until December 1994, then transferred south for a further three month's grow-out on pasture. Feedlot finishing commenced once each group averaged 400 kg. Groups were further subdivided for finishing to Korean (target 520 kg) and Japanese (640 kg) markets, making a total of six management groups or cohorts. A specially written suite of computer programs was used to find the most efficient experimental design, given the number of breeds, birth herds, numbers of offspring of each sire, desired treatment combinations and genetic links with other groups/years/treatment combinations. Table 1 shows numbers of animals, breeds and birth herds for the six cohorts, plus mean feed intakes, weights and weight gains.

Table 1. Numbers of steers, measurements, and means by group (I=*indicus*, T=*taurus*)

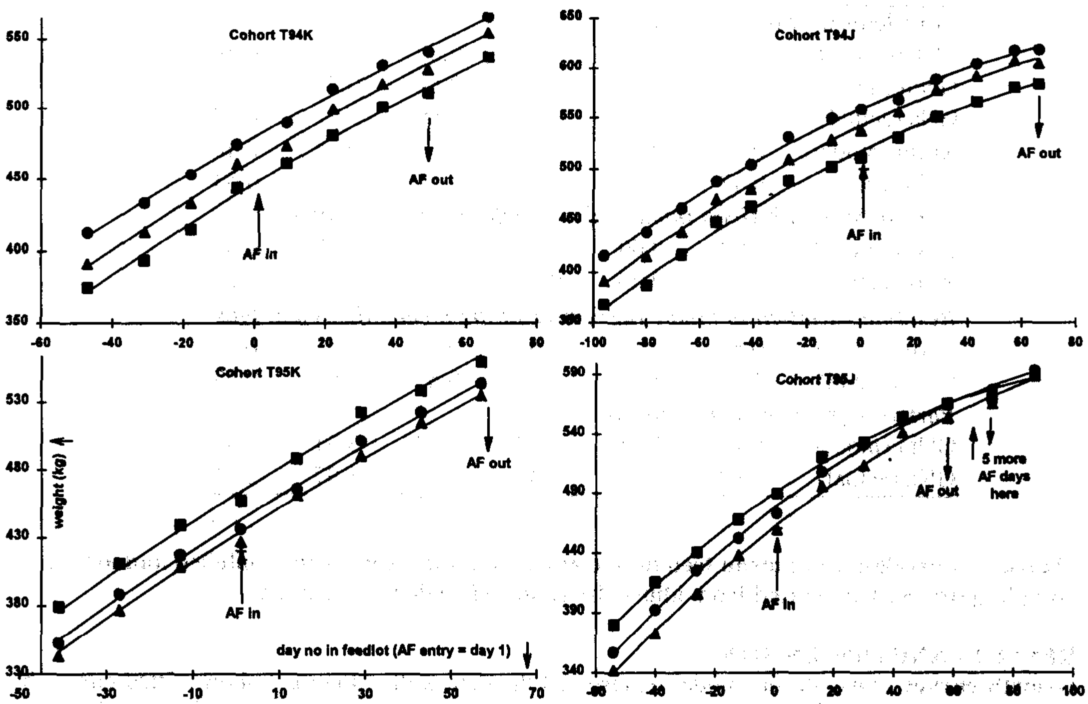
	Numbers of					Means while in AF (automatic feeder) pens				
Group & Market	Steers	Birth herds	weeks in AF pens	Weight records In AF pens	Weight records Total	Weight (kg)	Gain (kg/ day)	Intake (kg/ day)	eating sessions (no./day)	Time feeding (min/day)
I94K	16	2	8	4	9	494	1.21	12.10	12.4	89.1
I94J	17	2	12	7	15	552	0.75	10.29	14.2	81.5
T94K	81	11	7	4	9	499	1.26	11.73	4.7	103.0
T94J	82	11	9	5	13	575	1.12	11.36	5.5	90.6
T95K	55	7	8	5	8	499	1.90	14.56	6.0	122.0
T95J	57	7	9	5	11	525	1.51	14.29	7.1	107.4

After introductory and intermediate diets in weeks 1 and 2, steers were fed standard finisher rations. *Ad libitum* intake was measured by automated feeders (**AF**), developed by the CRC. Each group pen has a feeding space which only one animal may access at a time. An electronic identification tag is read every time an animal enters the feeder and weight of food plus time spent eating recorded. Due to limited capacity of AF pens, intake was measured first on Korean steers. Japanese steers were measured at a later part of their growth curve, with heavier average weights and lower weight gains (Figure 1). Weights were recorded approximately fortnightly throughout time in the feedlot, resulting in 8-9 measurements for Korean steers and 11-15 for Japanese. Table 2 shows pooled correlations of gains from the first 8 weighings (14 weeks) in the feedlot. Weight gains were not repeatable, even over longer periods. Correlations between gains in weeks 1-8 and weeks 9-16 were 0.71, 0.43, -0.09, .02, -0.07, -0.16 for cohorts I94K, I94J, T94K, T94J, T95K, T95J respectively.

Table 2. Correlations (pooled over cohorts) of successive weight gains (from approximately fortnightly measurements, below diagonal) and weekly intake measurements (above diagonal)

		Intk 1	Intk 2	Intk 3	Intk 4	Intk 5	Intk 6	
		0.561	0.434	0.318	0.323	0.375	0.317	Intk 2
Gain 1	-0.388		0.704	0.511	0.500	0.571	0.584	Intk 3
Gain 2	0.008	-0.274		0.600	0.627	0.650	0.546	Intk 4
Gain 3	0.130	0.000	-0.334		0.509	0.586	0.481	Intk 5
Gain 4	0.036	0.088	0.065	-0.310		0.710	0.502	Intk 6
Gain 5	-0.009	0.000	-0.034	0.085	-0.344		0.671	Intk 7
Gain 6	-0.053	-0.002	0.106	-0.130	0.128	-0:374		
	Gain 2	Gain 3	Gain 4	Gain 5	Gain 6	Gain 7		

Figure 1. Fitted growth curves by nutrition for 4 cohorts of *taurus* steers (lines), together with raw means (points) and entry/exit to automatic feeder (AF) pens (arrows). (■= pasture (P), ▲= P + concentrates, ● = P + forage; supplements 1995; pasture fertility/carry-over effects 1996).



Statistical modelling of weight records. For each cohort, the weight, w_{ij}, of steer i at time j, was modelled using program ASREML (Gilmour 1996) by the equation

$$w_{ij} = \mu + ld_j + qd_j^2 + \alpha b_i + h_i + p_j + n_i + n_{li}d_j + n_{qi}d_j^2 + a_i + \beta_i d_j + \gamma_i d_j^2 + e_{ij} + \varepsilon_{ij} \qquad (1)$$

where d_j represents day number in the feedlot, coded so day 1 was day of entry to the AF pens. The quadratic equation, $\mu + ld_j + qd_j^2$, therefore models the overall growth pattern; αb_i models age; h_i and p_j birth herd and day of weighing effects; $n_i + n_{li}d_j + n_{qi}d_j^2$ model changes in the growth pattern due to backgrounding nutrition; $a_i + \beta_i d_j + \gamma_i d_j^2$ deviations in the growth pattern for animal i. All terms except the first four were assumed to be random effects, so the magnitude of the fitted values reflected the variation of each term. The two error terms, e_{ij} and ε_{ij}, represent the two kinds of error found in sequences of measurements such as weights. The first is a random error, uncorrelated with errors at other times, due to variability in the weight of the animal over the course of a day, errors in weight measurements and other sources of variation such as deviations from the animal's typical feeding pattern. The second represents longer term departures from a typical growth pattern, such as illness or changes in eating behaviour which affect more than one weight record. The latter error term was modelled by a first order autoregressive process (Chatfield 1975).

Cohort	I94K	I94J	T94K	T94J	T95K	T95J
Correlations with feed intake						
Metabolic wt	0.76	0.84	0.51	0.60	0.81	0.68
GNm (model)	0.95	0.94	0.59	0.82	0.76	0.72
GNa (actual)	0.82	0.80	0.30	0.69	0.57	0.58
RFIm (model)	0.31	0.35	0.75	0.52	0.43	0.48
RFIa (actual)	0.47	0.49	0.81	0.56	0.46	0.53
Correlations with GNm (modelled from whole time in feedlot)						
RFIm (model	0.00	0.00	0.00	0.00	0.00	0.00
RFIa (actual)	0.23	0.29	0.29	0.26	0.21	0.24
Residual variation in intake (kg^2) after fitting metabolic weight plus						
GNm (model)	0.48	0.51	1.03	0.75	0.57	0.79
GNa (actual)	1.10	1.02	1.19	0.85	0.67	0.97
Partial regression coefficients for						
GNm (model)	6.42	5.95	3.97	6.33	3.31	4.43
GNa (actual)	2.92	2.23	1.43	2.91	1.97	2.36

Table 3. Correlations of mean feed intake and metabolic weight with modelled and actual weight gain. RFI estimated from above, by cohort (I=*indicus*, T=*taurus*)

RESULTS AND DISCUSSION

Growth curves. Overall, the model represented the data well. Figure 1 shows fitted curves by nutrition for *taurus* cohorts together with observed means and times of entry/exit to AF pens. Growth of steers up to Korean market weights was approximately linear with a small amount of curvature towards Japanese market weights. Some compensatory gain was evident in T95J. On any given day, means for each nutrition group show a similar effect, either all being above, below,or on the fitted curves. Entry/exit to AF pens had, however, no obvious effect on growth, suggesting current management practice of allowing up to 11 steers per AF pen was not a limiting factor. All cohorts show relatively large variation between animals and in three cohorts there was also substantial variation in weight due to breed/birth herd. The residual variation was of similar magnitude, 75-98 kg^2 in all cohorts. The autoregressive error term was highly significant in all cases, being .11-.45 the size of the residual variation, e_{ij}.

Relationship with feed intake. Residual feed intake was calculated as the residuals of the regression of average daily feed intake on weight$^{0.73}$ and average daily gain, either actual (**GNa**, giving residual intake **RFIa**), or modelled (**GNm, RFIm**). Modelled gain included all terms in equation 1 except dates of weighing, p_j and the error terms e_{ij} and ε_{ij}. Table 3 shows the residual variation was smaller in every cohort when GNm was used instead of GNa, indicating substantially more of the variation in feed intake could be explained by GNm. For *indicus* cattle the correlations between GNm, and intake were 0.95 and 0.94 for Korean and Japanese markets implying that gain was very strongly related to intake. Steers choosing to eat more, gained weight faster in the feedlot. The *indicus* cattle tested here also had different eating patterns, with more but shorter feeding sessions per day (Table 1). For this group of cattle, the data indicate it would be difficult to reduce voluntary intake of food without also reducing weight gain.

For *taurus* cattle, correlations between intake and GNm were lower, allowing some scope for reducing intake without lowering gain. In general, RFIa was more closely related to intake than RFIm. Furthermore, though RFIa was not correlated with gain in the AF feeders, it was correlated with RFIm. This is because RFIa is based on an inaccurate measure of gain, so adjustment for gain is incomplete, as indicated by the relatively low partial regression coefficient for GNa (Table 3). The incomplete adjustment means that animals with lowest RFIa will tend to have lower weight gains and care will be required to prevent selection for RFIa reducing growth. Accurate assessment of efficiency is not limited by measurement of food intake, but by measurement of weight gain. Modelled gain, eg GNm, should increase efficiency of selection relative to actual gain.

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