

THE RELATIONSHIPS BETWEEN FEED INTAKE, DAILY GAIN AND FEED EFFICIENCY IN FAST-GROWING FEEDLOT STEERS

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ABSTRACT

The relationship between feed intake and ADG or feed/gain in the feedlot generally is poor. This may result partially because feed intake tends to plateau at higher ADG whereas at lower ADG the relationship is mostly linear with a relatively good correlation. We further addressed this issue in steers fed three dietary energy treatments. We compared feedlot steers with average liveweight gains (1.4 to 1.8 kg/day) to those with rapid gains (1.8 to 2 kg/day). Faster growing steers did not have higher intakes than those gaining at an average rate, but they had increased proportion of their ADG as carcass. This response was observed for all three different dietary energy levels tested, but it proportionally was higher with the lowest dietary energy concentration. The prediction equation indicates that as intake increases to an extremely high level, ADG of fast-growing steers should plateau or a decline. This suggests that very high feed intakes may be of no benefit to feedlot managers striving maximize profit.

INTRODUCTION

At a previous symposium on feed intake, Gill et al. (1986) posed the question about whether feedlot cattle would benefit from an increase in feed intake. Logically, one would expect that an increase in intake would increase gain and benefit the feed/gain ratio. Indeed, prediction equations based on net energy (NRC, 1984) would suggest that rate of gain should increase with a slightly curvilinear downward trend and that feed/gain should decrease (improve) asymptotically. Thus, at some point, further increases in feed intake may not be beneficial. This has been substantiated indirectly where slight restriction of high energy diets have improved biological and economic efficiency (Meissner and Roux, 1984; Plegge, 1986; Lofgreen et al., 1987; Murphy and Loerch, 1994). Furthermore, the correlations between feed intake and gain or feed/gain of cattle in feedlots (Gill et al., 1986; Meissner et al., 1993) generally are poor; this questions the desirability of efforts to increase feed intake.

Average daily gains (ADG) in most trials and commercial feedlots seldom exceed 1.5 kg/day but some 10 to 15% feeder cattle have ADG exceeding 2 kg/day. To further address the question of whether feed intake should be raised, we asked the question, "Do faster gaining cattle have higher feed intakes?" We also investigated the effects of high rates of gain on feed/gain on a both a live and a carcass basis.

PROCEDURES

Medium-to-large-frame weaner and yearling steer calves were fed individually using a transponder-electronic gate system. Steers were implanted with zeranol and fed until grade reached Super A, which is obtained between body weights (BW) of 350 to 450 kg, depending on mature size and sex. The Super A grade is defined as a carcass of a young animal with 3 to 7 mm subcutaneous fat measured over the 13th rib 50 mm from the midline. Initially, 10 to 12 comparable steers were slaughtered to estimate carcass weight of test steers. Unfasted BW and feed intake of test steers were recorded weekly. All steers were slaughtered on reaching the grade of Super A; their cold carcass weights were recorded. Dietary energy concentrations in the three trials which are reported were respectively, 11.5 MJ metabolizable energy (ME)/kg feed DM, 12.0 MJME/kg feed DM, and 12.5 MJME/kg feed DM, where 1 Mcal = 4.184 MJ. Expressed on the net energy basis, these are equivalent to NEg values (per hundred pounds of dry matter) of 54, 58, and 62 Mcal.

Prediction equations were developed for ADG, ME intake (MEI)/ADG, and carcass gain using least squares procedures (SAS, 1985). Where applicable, MEI/ADG also was converted to feed DMI/ADG. Various covariables were included in multivariate models and their linear and quadratic contributions to the overall variation tested in a step-down procedure. Furthermore, feed DMI was correlated with ADG and

feed DMI/ADG, and ADG with feed DMI/ADG using simple and quadratic regression analyses.

RESULTS AND DISCUSSION

Variables that contributed ($P \leq .01$) to the variation in ADG were ME concentration of the diet, initial BW, feed DMI, and days fed. The total variation in ADG explained by these variables was 57%, with the partial contributions being, for feed DMI 5.2%, for initial BW (accounting for the weight differences between weaner and yearling calves) 12.4%, for days fed 18.6%, and for ME concentration 1.2%, respectively. The relatively small contribution of feed DMI to the overall variation in ADG also follows from the low R^2 of .37 shown in Figure 1. That R^2 corresponds with the relatively low R^2 of .50 reported by Gill et al. (1986) for a large data set of pen-fed cattle. The multivariate prediction model for ADG was:

$$\begin{aligned} \text{ADG (kg/day)} &= .058 \text{ ME(MJ/kg DM)} \\ &- .003 \text{ Initial BW (kg)} + 1.236 \text{ feed DMI (kg/day)} \\ &- .065 (\text{feed DMI})^2 - .007 \text{ Days fed} - 3.225 \quad [1] \end{aligned}$$

Careful examination of the data in Figure 1 reveals that feed DMI for steers with ADG of 1.8 to 2.2 kg/day (points in rectangle) was no higher than feed DMI of steers with ADG of 1.4 to 1.8 kg/day. Thus, steers that gained liveweight at rates exceeding 2 kg/day because they had high feed intakes. This implies that the energy requirement of rapidly gaining steers must be lower than predicted (ARC, 1984; NRC, 1984).

Furthermore, both the multivariate model (Equation (1)) and the equation in Figure 1 predict that if DMI exceeds 9 to 10 kg/d, further increasing DMI will not increase ADG; indeed, ADG is predicted to decline! This lends further support to the contention that fast gaining steers do not attain the high gains because of exceptionally high feed intake.

In the multivariate model predicting MEI/ADG, contributions from MEI, days fed and ADG all were significant ($P \leq .01$; $R^2 = .99$). Due to interaction between days fed and ADG, it was not possible to calculate the partial contributions to the overall variation, but proportionally, ADG contributed >70%. This indicates that the correlation between feed DMI and feed DMI/ADG is not strong (Figure 2), whereas the correlation between ADG and feed DMI/ADG is strong (Figure 3). In their analysis, Gill et al. (1986) found an $R^2 = .0009$ between average feed intake and feed/gain which corresponds with our values. The multivariate prediction model for MEI/ADG was:

$$\begin{aligned} \text{MEI/ADG (MJ/kg)} &= 1.525 \text{ MEI (MJ/day)} \\ &- .005 (\text{MEI})^2 - .006 \text{ Days fed} - 113.0 \text{ ADG} \\ &(\text{kg/day}) + 23.11 (\text{ADG})^2 - 78.59 \quad [2] \end{aligned}$$

The effect of dietary energy concentration and feed DMI on ADG and feed DMI/ADG, as extrapolated for fast and slow growing steers consuming either 7 (low) or 9 (high) kg feed DM/day, is shown in Table 1. As dietary energy concentration increased, ADG

Table 1. Calculated ADG and feed DMI/ADG of calves of 200 kg initial BW and fed for either 80 or 140 days, as affected by dietary energy concentration and feed intake.

	Days fed				Avg	Days fed				Avg
	80		140			80		140		
Feed DMI, kg 7	9	7	9		7	9	7	9		
Diet ME, MJ/kg	ADG, kg/day					Feed DMI/ADG				
11.5	1.75	2.14	1.31	1.74	1.74	4.00	4.21	5.34	5.17	4.68
12.0	1.79	2.18	1.35	1.78	1.78	3.91	4.13	5.19	5.06	4.57
12.5	1.81	2.19	1.37	1.80	1.79	3.87	4.11	5.11	5.00	4.52
Avg	1.78	2.17	1.34	1.77		3.93	4.15	5.21	5.08	

Table 2. Calculated carcass gain, feed DMI/carcass gain and kg carcass gain/100 MJ MEI as affected by dietary energy concentration and ADG of calves of 200 kg initial BW, and fed to the same market weight.

Diet ME, MJ/kg	Carcass gain, prop. of ADG		Feed DMI/carcass gain		kg carcass gain/100 MJ MEI	
	Slow ^a	Fast ^a	Slow	Fast	Slow	Fast
11.5	.62	.65	9.3	6.4	.94	1.36
12.0	.65	.67	8.6	6.0	.97	1.39
12.5	.67	.68	8.3	5.9	.96	1.36

^aSlow, Fast - Respectively 1.2 and 2.1 kg ADG

increased and feed DMI/ADG was improved. The higher feed DMI of 9 kg/day increased ADG for both slow and fast growing steers. Higher DMI improved feed DMI/ADG of slow growing steers but did not improve feed DMI/ADG of fast growing steers. While it is recognized that this example represents an extreme scenario, it may explain partially the poor relationship between feed intake and feed/gain (Figure 2). One can postulate that a steer that grows fast because of high intake may be depositing more fat (Béranger, 1977; Slabbert et al., 1992b) and/or has a higher maintenance requirement (Andersen, 1977; Hicks et al., 1988) than a steer that grows fast for reasons not associated with high intake. As intakes exceed 9 to 10 kg feed DMI/day, both Equation (1) and the equation in Figure 1 predict that ADG should increase no further and may even decline. This adds credence to the weak relationship between DMI and feed/gain.

Carcass gain for this data set was predicted from dietary energy concentration, feed DMI, and ADG with a $R^2 = .97$. All covariable contributions to the overall variation were significant at $P \leq .01$. The multivariate prediction model for carcass gain was:

$$\begin{aligned} \text{Carcass gain (kg/day)} = & -.371 \text{ ME(MJ/kg DM)} \\ & + .018 (\text{ME})^2 + .009 \text{ Feed DMI (kg/day)} \\ & + .435 \text{ ADG (kg/day)} + .077 (\text{ADG})^2 + 1.930 \quad [3] \end{aligned}$$

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The effect of dietary energy concentration and ADG on carcass gain and efficiency of feed conversion to carcass gain is shown in Table 2. An increase in dietary energy concentration increased carcass gain as a proportion of ADG, and non-linearly improved feed DMI/carcass gain. This agrees with work of Slabbert et al. (1992a). Regardless of dietary energy concentration, faster ADG increased carcass gain and improved feed DMI/carcass gain. In contrast, carcass gain/MEI was almost constant across all three dietary energy concentrations but was profoundly influenced by ADG. The carcass gain/MEI also remained unchanged by level of intake for steers fed the same diet at levels between *ad libitum* and 80% *ad libitum* (Hicks et al., 1988; Slabbert et al., 1992a).

IMPLICATIONS

Our results indicate that steers with liveweight gains over 2 kg/day consume no more feed than steers gaining at slower rates. Based on our results and indirect evidence from the literature, higher intakes would increase no ADG to the detriment of feed/gain. Of significance to the feedlot industry is the fact that feed conversion to carcass gain still was improved progressively as ADG increased even though feed intake may level off. Therefore, striving to increase ADG still appears to be important, but striving to increase feed intake may not increase ADG.

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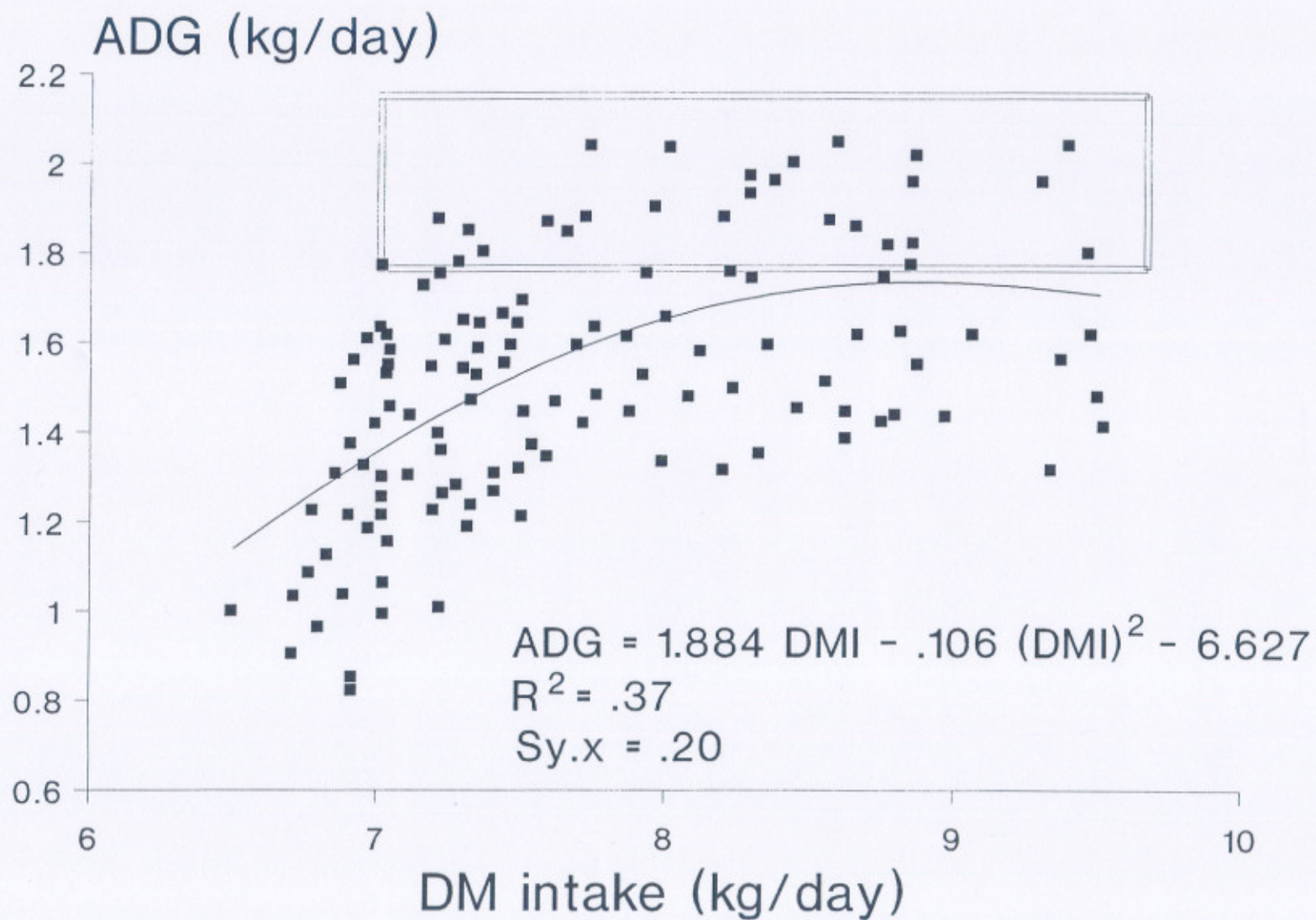


Figure 1. The relationship between feed dry matter intake (kg/day) and average daily gain (kg/day) of feedlot steers fed diets with an energy concentration of 12 MJ ME/kg feed DM. Data points in the rectangle indicate fast-growing steers (ADG between 1.8 and 2.2 kg/day) showing similar feed DM intake than average-growing steers (ADG between 1.4 and 1.8 kg/day).

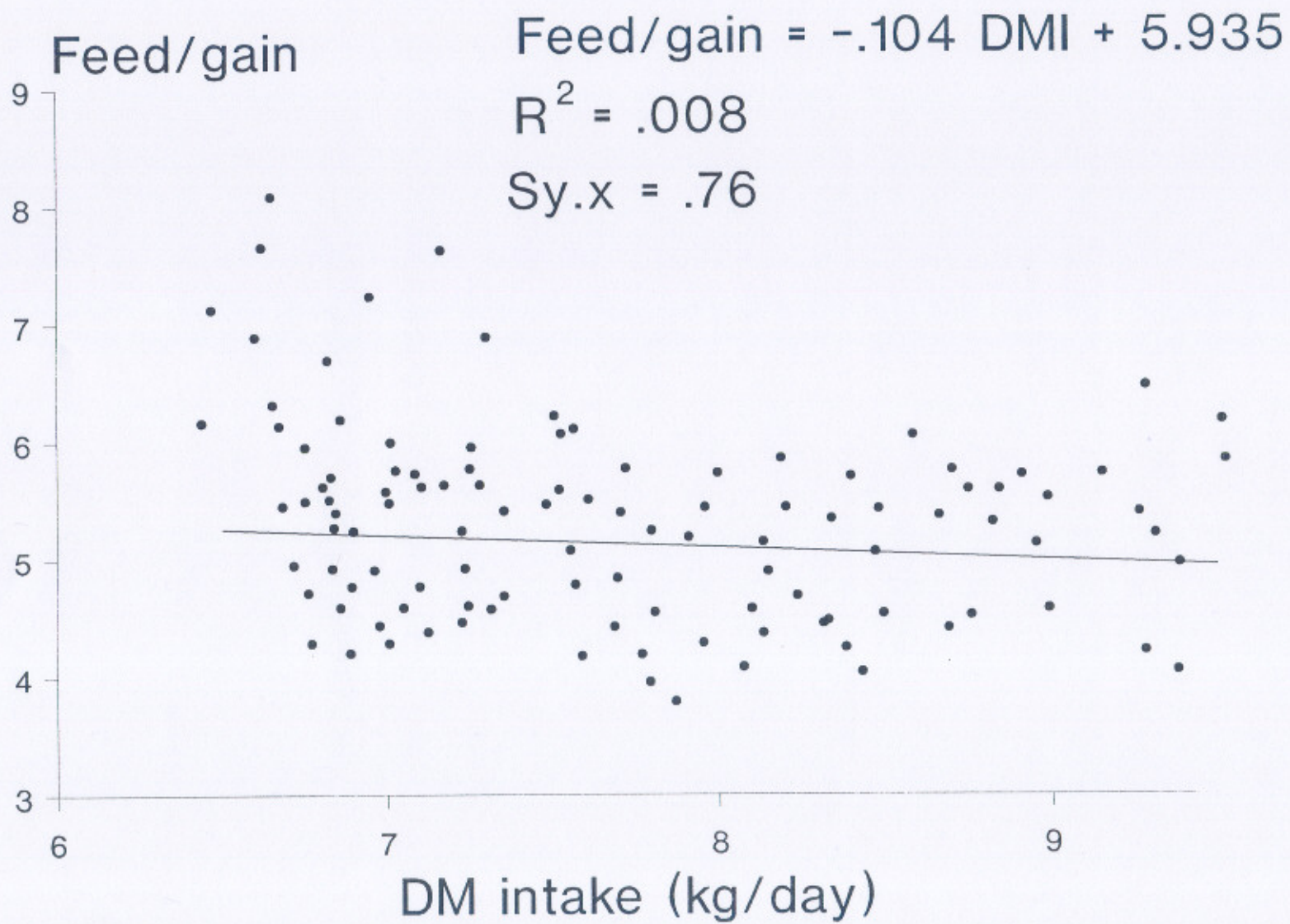


Figure 2. The relationship between feed/gain (kg/kg) and feed DM intake (kg/day) of feedlot steers. Dietary energy concentration = 12 MJ ME/kg feed DM.

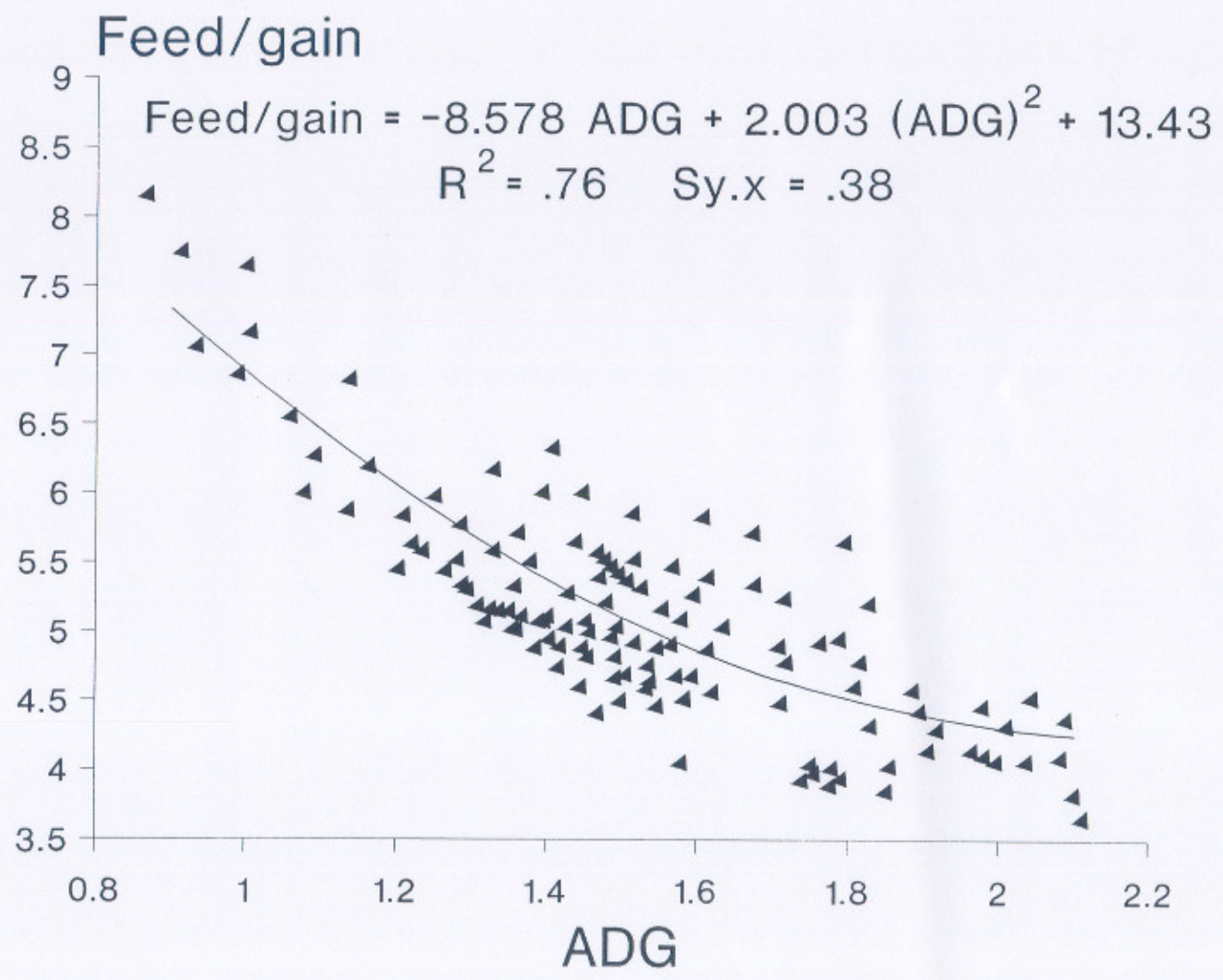


Figure 3. The relationship between average daily gain (kg/day) and feed/gain (kg/kg) of feedlot steers. Dietary energy concentration = 12 MJ ME/kg feed DM.