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Evaluation of the 1996 Beef Cattle NRC Model Predictions of Intake and Gain for Calves Fed Low or Medium Energy Density Diets

Trey Patterson
University of Nebraska-Lincoln

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

Todd Milton
University of Nebraska-Lincoln

Dennis R. Brink
University of Nebraska-Lincoln, dbrink1@unl.edu

Evaluation of the 1996 Beef Cattle NRC Model Predictions of Intake and Gain for Calves Fed Low or Medium Energy Density Diets

Trey Patterson
Terry Klopfenstein
Todd Milton
Dennis Brink[1]

The NRC model did not accurately predict intake and gain of growing calves over a wide range of diets, and predicted gain differed greatly from actual when low quality roughages were fed.

Summary

Data from feeding 54 diets in seven previous beef cattle growing studies were used to evaluate the 1996 NRC model for the accuracy of intake and gain predictions. Calf weights and diets were inputs into the model, and actual intakes were used to calculate predicted gain and actual gains were used to calculate predicted intakes. The model over-predicted calf intakes on low quality diets and under-predicted intakes on high quality diets. The model over-predicted gains on high quality diets and under-predicted gains on low quality diets. The NRC model did not accurately predict performance of cattle on low quality roughage diets.

Introduction

The 1996 Nutrient Requirements of Beef Cattle (NRC) comes with a software package that models the dynamic interactions between cattle type (physiological state), cattle age, diet quality, environment and other management factors on cattle intake, gain and nutrient requirements/balances. The NRC model has been shown to predict intake of finishing cattle relatively close to actual values on average, while tending to under-predict intake over the course of the finishing period in some studies (1998 Nebraska Beef Cattle Report, pp. 80-83). Likewise, the model tends to accurately predict gain of finishing cattle at the mid-point of the finishing period, while over-predicting gains early and under-predicting gains late in the finishing period. This may be attributed to the prediction equations being developed using average weights and gains over the course of the finishing period. However, with accurate estimates of cattle intake and gain, the model appears to accurately predict the metabolizable and rumen degradable protein balances of cattle on a finishing diet.

Unlike typical finishing programs, growing cattle diets use a wide range of feedstuffs with varying energy and protein contents. In addition, different growing programs target different levels of gain. The NRC model provides a potential means for producers and nutritionists to predict intake and gain of growing calves fed varying diets. Therefore, our objectives were to use previous growing trial data from the University of Nebraska to evaluate the accuracy of the NRC model equations in predicting intake and gain of growing calves.

Procedure

Seven growing trial studies previously conducted at the University of Nebraska, incorporating 54 different diets, were used to evaluate NRC predictions. Diets included low quality forage diets, medium quality (silage based) forage diets and diets incorporating various levels of energy from non-forage fiber products or concentrates. For more information regarding the details related to specific diets and/or experiments, refer to previous Nebraska Beef Reports

(1983, pp. 21-22; 1988, pp. 34-38; 1988, pp. 40-42; 1988, pp. 51-56; 1990, pp. 49-50; 1991, pp. 25-27; 1993, pp. 34-35).

Actual cattle weights and diets were used as inputs into the model. No adjustments were made for environment on either intake or gain, as the temperature was set at 60°F, the temperature considered to be thermoneutral by the NRC. Actual calf intakes were used to calculate a predicted ADG, and gain then was forced to the actual gain by using the NEm and NEg adjusters in the NRC software to get the predicted intake. The NEm and NEg adjusters can be changed from 80% (when gain is over-predicted) to 120% (when gain is under-predicted) to force the predicted gain to the actual gain (100% is no change). Both NEm and NEg adjustments were made by the same magnitude in the same direction, and will be subsequently referred to as the NE adjusters. If predicted gain could not be reached by the NE adjusters (NE adjusters >120% or < 80%), the predicted intake was recorded with gain as close as possible to the actual gain. Predicted intake at the actual gain was recorded for both 11-month-old and 14-month-old calves. Linear regression analyses were performed on predicted versus actual values to determine the statistical significance of the relationships.

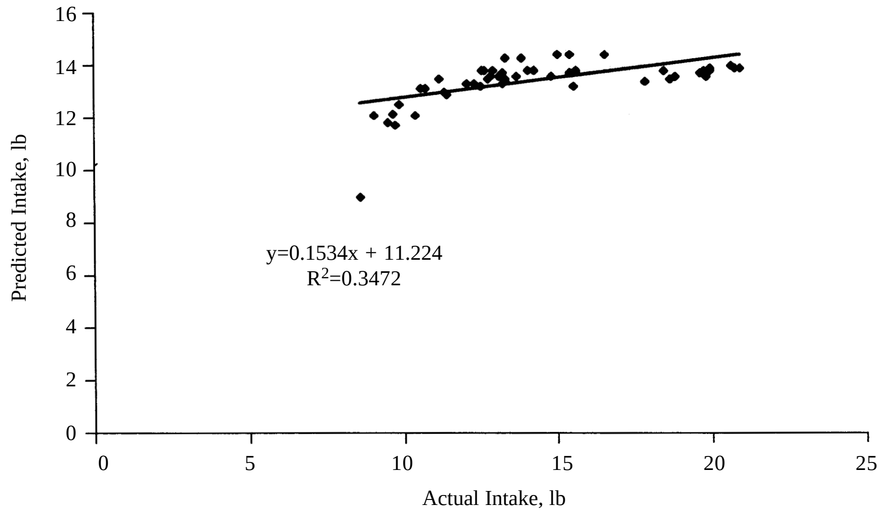

Figure 1. Actual intake versus intake predicted by the 1996 NRC model for 54 growing cattle diets in seven studies (DM).

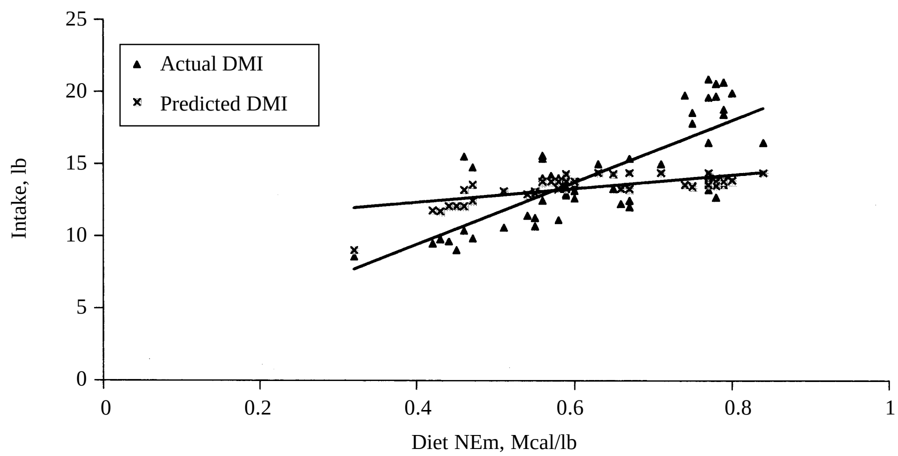

Figure 2. Predicted and actual calf DMI across increasing dietary energy level.

Results

The NRC model uses a different intake equation for growing yearling cattle (12 months or older) than for calves (under 12 months), based on data showing that older "yearling" cattle eat more as percentage of body weight than calves. However, intake changes on a continuum rather than a break at 12 months. Most cattle in growing programs will be between 8 and 14 months old (similar to those in the validation studies) and likely will have feed intakes more similar to a calf compared with a yearling. Over the range of the 54 diets evaluated, the calf equation did a better job of predicting intake than the yearling equation (16.0, 13.3, 14.3 lb/day for predicted yearling, predicted calf, and actual intake, respectively). However, when diet NEm was greater than .70 Mcal/lb (n = 19), the yearling equation predicted intake more accurately than the calf equation (16.4, 13.8, 17.9 lb/day for predicted yearling, predicted calf, and actual intake, respectively). When diet NEm was less than .70 Mcal/lb (n = 35), the calf equation was more accurate (15.7, 13.2, 12.5 lb/day for predicted yearling, predicted calf, and actual intake, respectively). Potential reasons for the varying accuracies of intake predictions across diet qualities will be discussed. Subsequent referrals to predicted intake will be using the calf equation.

Although the NRC model predicted intake relatively close to actual intakes on average (within 1 lb), it did not accurately predict intake over the range of the 54 diets evaluated (Figure 1, $R^2 = .35$). The model under-predicted intake at high actual intakes and over-predicted intake at low actual intakes (slope = .15). Figure 2 shows both actual and predicted calf intakes across dietary NEm levels. The NRC model accurately predicted intake at moderate energy levels (.58 - .60 Mcal/lb NEm), but over-predicted at low and under-predicted at high energy levels. There was one data point, where the dietary energy level was extremely low (.32 Mcal/lb NEm), that the predicted intake estimate was identical to the actual intake. This appears as an outlier in Figure 1, while other data from the same experiment (but higher energy levels) were similar to those in other

(Continued on next page)

trials.

When actual intakes were used as inputs, the NRC model predicted ADG (Figure 3) to increase twice as fast as actual ADG (slope = 2.2; R^2 = .75). The model under-predicted ADG at low actual ADG, but over-predicted gain at the high end of actual ADG. It is important to note these values for predicted gain are based on metabolizable energy (ME) allowable ADG, but the NRC model also predicts a metabolizable protein (MP) allowable ADG. Either MP or ME will show the lowest ADG, depending on which is first limiting. In certain cases in these data where dietary energy concentrations were high, MP allowable gain was slightly lower than ME allowable gain (n = 15). Although the MP allowable predicted ADG was still greater than the actual gains at these high energy levels, using MP allowable gain in place of ME allowable gain in these situations slightly improved the correlation between predicted and actual gains (slope = 1.7; R^2 = .80). Nevertheless, MP was not limiting in these diets when predicted gains were driven closer to actual gains by decreasing the NE adjusters. Thus, the focus of this discussion will be on gains predicted by net energy equations (ME allowable ADG) and not on those equations involving MP.

Figure 4 shows predicted and actual calf ADG across increasing dietary NEg. At low levels of NEg, the model under-predicted ADG, while it over-predicted ADG when dietary energy levels were higher. The NE adjusters thus had to be increased to get predicted ADG equal to actual ADG at low energy levels, and decreased at high energy levels. Table 1 shows predicted versus actual intakes and gains in the 54 diets evaluated, categorized according to dietary NEm. The diets in each NEm category fit into one of six NE adjustment categories (the NE adjustment required to get a predicted ADG equal to actual ADG). These data show, as previously discussed, that the model-over predicted intake and under-predicted gain at low energy levels, while the opposite was true at high energy levels. Fifteen out of 21 diets ranging in NEm from .32 to .58 Mcal/lb (first 2 energy ranges) had NE adjusters greater

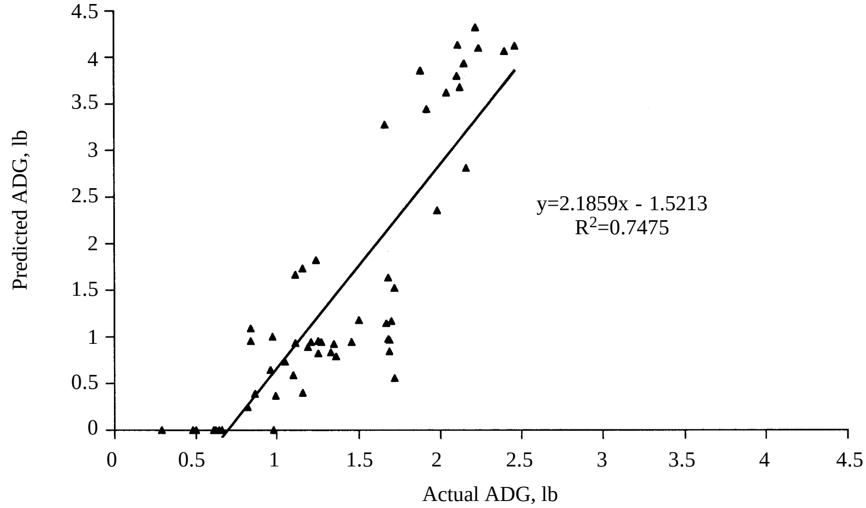

Figure 3. Actual ADG versus ADG predicted by the 1996 NRC model for 54 growing cattle diets in seven studies.

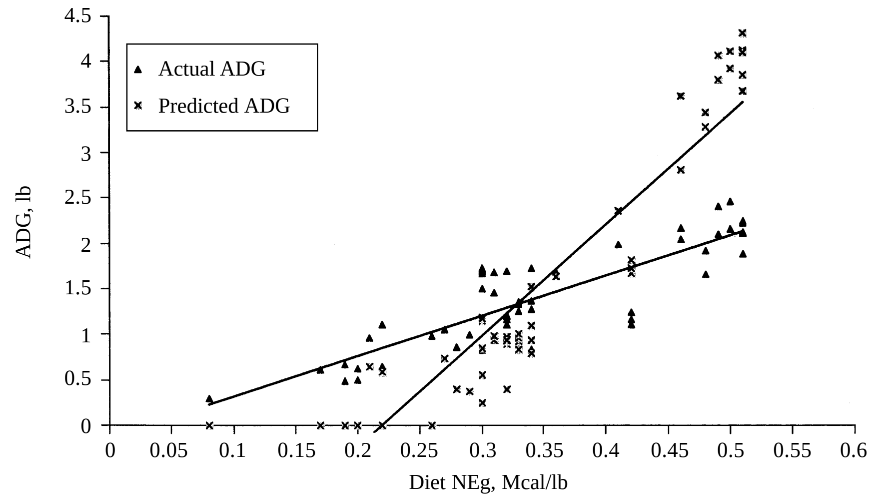

Figure 4. Predicted and actual calf ADG across increasing dietary NEg.

Table 1. NRC predictions of intake and gain versus actual intake and gain in growing calves across diets varying in energy concentration, and frequency of net energy adjusters required to achieve actual gain in the model.[a]

	Diet NEm, Mcal/lb				
Item	.32-.47	.51-.58	.59-.65	.66-.77	.78-.84
Number of diets	9	12	11	13	9
Diet NEg, Mcal/lb	.19	.30	.32	.41	.49
Predicted DMI, lb	12.0	13.4	13.8	13.7	13.9
Actual DMI, lb	10.8	12.8	13.3	15.9	18.6
Predicted ADG, lb	.14	.70	.91	2.33	3.62
Actual ADG, lb	.65	1.35	1.30	1.58	2.05
Frequency, NE adjusters:[b]					
< 80	0	0	0	5	7
81-90	0	0	0	3	2
91-100	0	0	0	3	0
101-110	0	1	3	2	0
111-120	1	4	8	0	0
>120	8	7	0	0	0

[a]Data collected from 54 diets in 7 previous growing trials at the University of Nebraska.
[b]Net energy (NE) adjusters are used to adjust feed energy values to drive predicted gain to actual gain in the NRC model. The units are in percent of normal (100 is no change). Given are the frequency of diets in the given energy range that required adjustments in each category.

than 120, meaning the model would not predict the actual ADG. Although the model predicted intake accurately with medium energy diets (.59-.65 Mcal/lb NEm), it continued to under-predict ADG. All 12 diets where the model markedly over-predicted ADG (NE adjusters < 80) were from one study in which lecithin and soapstock were mixed with soyhulls and added to a sorghum silage, alfalfa, and corn diet at graded levels replacing corn (1993 Nebraska Beef Report, pp. 34-35) . Truly, data from this study are the highest intakes and gains represented in the seven reviewed studies.

When the predicted ADG of cattle receiving all forage diets (no addition of non-forage fiber based energy or concentrate) was regressed on actual ADG, the correlation was less (predicted gain = -.37 +.85 * (actual ADG); R^2 = .73) than if the same regression was made for cattle consuming diets that had added non-forage energy (predicted gain = -2.01 + 2.62 * (actual ADG); R^2 = .83). When data from the study where lecithin and soapstock were added to the diet were removed and predicted ADG from diets with added non-forage fiber or concentrate were regressed on actual ADG, the correlation was very high (-1.09 + 1.65 *(actual gain); R^2 = .92). The model predicted performance closer to actual when higher quality feeds were fed, yet as indicated in Table 1, the predictions drifted further from actual values with diets of higher energy density.

The over-prediction of gain at high energy levels could be related to environmental temperatures at times when the studies were conducted. Since the temperature/weather conditions during each of the seven trials evaluated were not known, the diets were evaluated at thermoneutrality. However, temperatures were not likely at thermoneutral when most of the growing trials were conducted (fall and winter). Colder environmental temperatures will increase the amount of energy required for maintenance and can increase DMI, depending on diet and duration of cold temperatures. At colder temperatures, the increase in the amount of feed that goes to meet maintenance requirement can be greater than the increase in the intake of feed, thus the amount of energy available for gain is reduced and gains decrease. However, the above-mentioned study, where lecithin and soapstock were added to the diet and gains were markedly over-predicted by the NRC, was conducted in the summer. Extremely hot or muddy conditions will also depress gains in cattle. Environmental effects on maintenance could partially explain the over-prediction of gain by the NRC model when higher quality diets were fed, but other factors may also contribute to poor predictions of gain at high energy levels. The energy available for gain in low energy diets is less to begin with, so the effects of extreme environmental conditions on cattle gain are magnified. Therefore, if environmental conditions were included in the model, the gain predictions on lower quality diets would be even further from actual values. As Figures 3 and 4 indicate, some gain predictions were erroneously at zero, even with no adjustment for environment. Over the 54 diets evaluated, predicted gain differed greatly from actual gain when low quality diets were fed.

The NRC model calculates the net energy (NE) values of the feedstuffs from ME values, which are derived from TDN estimates entered by the user. The calculations converting ME to NEm and NEg involve different estimates of the efficiency of ME use for both maintenance and gain, based upon the ME concentration of the diet or feedstuff (i.e. the forage/concentrate ratio). Diets with high ME concentration (low forage/concentrate ratio) have a higher efficiency of ME utilization for gain and maintenance than feedstuffs with low ME concentration (high forage/concentrate ratio). The efficiency of ME use for gain is affected more than that for maintenance when dietary ME concentrations are low. For example, the NE equations show diets with 1.45 Mcal/lb ME to have an ME efficiency of 68.6% for maintenance and 47.3% for gain, whereas diets with .91 Mcal/lb ME have an ME efficiency of 57.6% for maintenance and 29.6 % for gain (NRC, 1984). It is possible that these equations under-estimated the NE values of the low quality feedstuffs in the roughage growing diets, which in turn under-estimated the amount and efficiency of energy use for gain. This would explain why gain was under-predicted when cattle were on low quality diets. Thus, the lower end of the calculated NEg values shown on Figure 4 may be erroneously low. The composition of gain likely has an effect on this efficiency, as muscle is deposited more efficiently than fat. The use of the NE system and the associated equations are not new to the 1996 NRC, as the equations were developed as part of the California Net Energy System in 1968 and have been used in NRC publications since 1976. The ability to use the California Net Energy System equations in the 1996 NRC computer program allows for potential errors in calculating ME efficiency to be illustrated. Truly, fewer data reflecting the performance of cattle consuming low quality diets were available when the NE equations were developed than for medium and high quality diets.

In conclusion, the NRC model over-predicted intake of low energy growing diets and under-predicted intake of high energy diets. The model did not accurately predict gain for growing cattle diets, and was especially poor at predicting performance of calves grown on low quality roughage. This may be due to NE equations, used in NRC publications since 1976, calculating erroneously low NEg values for the low quality diets. More work is necessary to determine the proper equations necessary to predict intake and performance of growing calves across multitudes of diets.

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[1]Trey Patterson, research technician; Terry Klopfenstein, professor, Todd Milton, assistant professor, Dennis Brink, professor, Animal Science, Lincoln.