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Application of Mathematical Models to Individually Allocate Feed of Group-fed Cattle

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ABSTRACT

A data set of group-fed growing and finishing steers with individual feed access was used to evaluate predictions of required individual DM by 2 mathematical models (Cornell Value Discovery System, CVDS; and beef NRC) to allocate feed of group-fed, commingled cattle. Forty-eight crossbred steers (BW = 296 kg) were assigned to 1 of 6 pens and fed 1 of 4 growing diets formulated to have different energy concentrations for restricted or ad libitum intake regimen for 56 d. The diets were a low-starch diet fed ad libitum, a high-starch diet fed ad libitum, a high-starch with restricted intake, and an intermediate diet fed ad libitum with an average energy intake between ad libitum low-starch and ad libitum high starch diets. On d 57, all steers (BW = 401 kg) were placed on the ad libitum high-starch diet for finishing until d 140. The CVDS was able to account for 61% of the variation in the observed DMI (oDMI) of steers during the growing period, and for 71% of the variation in oDMI during finishing, with an average overprediction of 3.76%. In the same fashion, the NRC model was able to explain 59% of the variation in oDMI after adjustment for known performance during the growing period with no bias ($P > 0.10$), and 57% of the variation in oDMI during the finishing period, with an average underprediction of 4.40%. Our overall evaluation suggested that the CVDS was more precise and accurate than the NRC model when predicting DMI for individual animals. Both models were sensitive to the previous level of nutrition of the cattle, suggesting that more variables are necessary to increase the prediction precision for cattle growing systems. The results from a risk analysis suggested that an amount of approximately $17.00/animal may be either over- or under-charged in the billing process of a commercial feedlot growing and finishing periods. Therefore, mathematical models could assist commercial feedlots to improve the accuracy of the billing process while maintaining the same income per pen.

Key words: cattle, growth, modeling, requirements, simulation, prediction

INTRODUCTION

Sorting systems have been developed to predict carcass composition of cattle to allow marketing of the feedlot animals at the optimum end point (Perry and Fox, 1997; Brethour, 2000). These systems strive to sort cattle into homogeneous groups for maximization of productivity, enhanced uniformity, and increased economic returns (Tedeschi et al., 2004). In the current beef marketing system, the reduction of nonconforming carcasses can improve the value of a group of cattle dramatically (Bruns and Pritchard, 2005).

Full utilization of these sorting systems in custom feedyards would require commingling of cattle owned by multiple customers, disrupting the billing process. Support systems that can predict individual feed requirements for an observed level of performance might be useful in assigning feed costs to animals of different ownership. Fox and Black (1977a,b,c) devised equations to predict performance and body composition of growing cattle. These equations have been modified to develop the Cornell Value Discovery System (**CVDS**; Tedeschi et al., 2004), and have been proposed as a support tool for feed allocation (Guiroy et al., 2001). The CVDS has been used to accurately allocate DMI among individual animals fed in pens (Tedeschi et al., 2006) and for genetic selection purposes (Williams et al., 2006).

The NRC (2000) included a computer model that uses information of cattle type, ration components, and environment to predict animal performance (Whetsell et al., 2006). The

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NRC (2000) model is well accepted and widely distributed and can be used to predict individual intake of cattle when performance level is known. However, the capacity of the NRC (2000) model for the purpose of feed allocation has not been extensively evaluated.

Because nutritional models rely on estimates of energy and nutrient requirements to calculate feed requirements, growing cattle programs that alter growth rate or body composition may influence the results of the applicability of models in practical conditions. To date, model applications have focused on feedlot production without regard to prior plane of nutrition.

The objectives of this study were (1) to evaluate the adequacy of CVDS and NRC (2000) models in predicting individual feed requirements of growing and finishing feedlot cattle; (2) to evaluate model application when growing diets are dissimilar; and (3) to determine the efficacy of model application to the billing process for commingled cattle fed in the same pen.

Table 1. Average composition and nutrient content of the diets fed during growing (56 d) and finishing period (84 d) of beef steers[1]

Item	Dietary treatments[2] AL-LS	AL-HS[3]	LF-HS	AL-IS
Ingredients	DM basis			
Corn grain, steam flaked, %	—	79.2	79.2	38.0
Cottonseed hulls, %	48.5	7.0	7.0	35.0
Fat-steep-molasses blend	3.0	3.0	3.0	3.0
Mineral and vitamins premix,[4] %	11.0	10.0	10.0	10.0
Wheat middlings, %	37.5	0.0	0.0	14.0
Chemical composition	DM basis			
CP, %	24.7	12.7	12.7	15.2
Diet ME, Mcal/kg	2.64	3.02	3.02	2.68
Ca, %	1.7	0.7	0.7	1.0
P, %	0.9	0.3	0.3	0.4

[1]Diets were based on NRC (2000) recommendations.

[2]Dietary treatments were as follows: AL-LS, a low-starch diet fed ad libitum; AL-HS, a high-starch diet fed ad libitum; LF-HS, the same high-starch diet as AL-HS limit-fed to approximate the caloric intake of AL-LS; and AL-IS, a diet fed ad libitum with approximately the midpoint daily energy content between AL-LS and AL-HS.

[3]Fed ad libitum to all treatments during finishing (84 d).

[4]Composed of 5.44% Ca, 0.20% P, 4.43% NaCl, 0.51% Mg, 3.94% K, 0.29% S, 1.83% Na, 827 ppm Mn, 1,286 ppm Zn, 633 ppm Fe, 135 ppm Cu, 0.17 ppm Se, 2.68 ppm Co, 13.64 ppm I; 18,651 IU of Vit. A/kg and 110 IU of Vit. E/kg. All diets contained monensin (30 mg/kg) and tylosin (11 mg/kg).

MATERIALS AND METHODS

Experimental Data

A data set including performance (ADG), DMI, and carcass data from steers (n = 48) fed in individual feeders (American Calan, Northwood, NH) was obtained from an experiment conducted at the Texas A&M University Agricultural Experiment Station in Bushland, TX (Vasconcelos, 2006). Care, handling, and management of steers were approved by the Cooperative Research, Education, and Extension Triangle Animal Care and Use Committee (Texas Agricultural Experiment Station, USDA-ARS, and West Texas A&M University). Briefly, steers (296.0 ± 16.7 kg of BW) were implanted with Synovex-S (20 mg of estradiol benzoate and 200 mg of progesterone; Fort Dodge Animal Health, Overland Park, KS) and individually fed 4 different growing diets for 56 d: a low-starch diet fed ad libitum (**AL-LS**); a high-starch diet fed ad libitum (**AL-HS**); the same high-starch diet as AL-HS limit-fed to approximate the caloric intake of AL-LS (**LF-HS**); and a diet fed ad libitum with approximately the midpoint daily energy content between AL-LS and AL-HS (**AL-IS**). On d 57, all steers (400.6 ± 31.9 kg of BW) were placed on AL-HS diet for an 84 d finishing period.

Growing and finishing diets are presented in Table 1. The ME density of the diets was estimated using the Cornell Net Carbohydrate and Protein System (Fox et al., 2004) and averaged 2.64, 2.68, and 3.02 Mcal/kg of DM for AL-LS, AL-IS, and AL-HS, respectively. Low-starch diets were formulated without corn grain, whereas high-starch diets relied on corn grain as the primary energy source. All formulas included molasses, tallow, and a supplement containing feed additives and formulated to meet or exceed minimum recommendations of the NRC (2000) for minerals (Ca, P, Na, Mn, K, S, Mg, Zn, Cu, Se, Co, I, and Fe) and vitamins (A and E).

On d 140, all steers had approximately the same fat thickness (10 mm) measured by real time ultrasound (SSD-500V; Aloka Co., Wallingford, CT). Steers were harvested (BW = 569.3 ± 36.2 kg) at a commercial packing plant. Carcass characteristics were evaluated by trained personnel of the Cattlemen's Carcass Data Service (West Texas A&M University, Canyon, TX) after a 24-h chill at –4°C. Carcass measurements included hot carcass weight, fat thickness, LM area, KPH, and marbling scores.

Generation of Individual Intake Predictions

Individual predictions of feed intake were generated by the CVDS (Tedeschi et al., 2004) and NRC (2000) models by predicting DM required (**DMR**) to achieve observed levels of performance using animal characteristics (age, gender, breed, initial BW, and BCS), diet nutritional composition, and environmental information (temperature, humidity, hours of sunlight, wind speed, mud, hair depth, and hair coat), as applicable, as model inputs. Animal, diet, and environmental inputs were held constant for use in either model.

The NRC System

The prediction of DMR using the NRC system was conducted using Level 1 solutions. The mean BW (**MBW**) was calculated based on initial and final shrunk BW for the appropriate period. Shrunk BW was calculated as 0.96 × BW (NRC, 2000). Intake, which is typically an input to the model, was changed manually and iteratively until model-predicted ADG matched the observed ADG. The level of DMI necessary for that performance was considered the NRC predicted DMR to support observed levels of production. Mature weight was adjusted for each steer and carcass fat was held at 27% (slight marbling).

The Cornell Value Discovery System

The CVDS model can be used to predict either ADG when DMI is known or to predict DMR when ADG is known (Tedeschi et al., 2004). Adjusted final BW at 28% empty body fat is computed using the carcass information (hot carcass weight, fat thickness, LM area, and marbling scores) acquired from each animal. In the current study, the CVDS was used for prediction of DMR with 2 different options: (1) using the equations based on the mean MBW for the appropriate period, calculated in the same manner as shown above for the NRC system; or (2) using the equations based on an iterative, dynamic growth model (Tedeschi et al., 2004).

Evaluation Of DMR Predictions

Correspondent with the objectives, several evaluations were generated. First, regressions of observed DMI (**oDMI**), i.e., the amount of feed actually consumed by the individual animal, were compared with individual predictions without distinction among growing treatments within growing or finishing periods. Second, oDMI was regressed on predicted DMR from each model system by treatments. This evaluation was conducted for growing and finishing periods.

Individual DMR Predictions of Growing and Finishing Feedlot Cattle

Data from steers of different treatments were pooled for comparison of the different models on predicting DMR during the growing and finishing periods. Data were used for the development of 4 regression equations and coefficients used for evaluation of precision and accuracy of the CVDS and NRC (2000).

Individual DMR Predictions when Growing Diets are Dissimilar

Each model was applied to predict DMR for steers within different treatments during the growing and finishing period, with each treatment group (n = 12) as a pen cohort. Separate analyses were conducted for each treatment and model combination. These data were used for the development of 16 different regression equations (8 for growing and 8 for the finishing period).

Individual DMR Predictions for the Combined Growing and Finishing Data

Data from different treatments and feeding periods were also pooled and evaluated for prediction of DMR during the entire 140-d period by both models. The ability of the CVDS in predicting DMR for individual steers with the input of 2 different levels of nutrition for 2 different periods was assessed. For the NRC, a weighted mean value for oDMI was calculated with data from both periods. These data were used for the development of 2 regression equations.

Group Intake Prediction

Data set of the current study was also used for evaluation of the models for group prediction of DMR during growing and finishing. Values of DMR were calculated using the: (1) mean value of the individual predictions for each animal by treatment, or the (2) value predicted for mean values of the inputs by treatment.

Adjustment Factor for Correction of Model Prediction

An adjustment factor to correct the model-predicted DMR to match oDMI was identified for each treatment group in order to account for total feed fed within a pen, such that pen total oDMI is equal to the summation of individual DMR times the correction factor. Then, this factor was multiplied by each model-predicted DMR value.

Application of Predicting Individual Feed of Commingling, Pen-fed Feedlot Cattle

Our data set was used to evaluate the application of the CVDS model in commercial feedlot situations. A sensitivity analysis was conducted with the Monte Carlo technique using the @Risk version 4.5 (Palisade Corp., Newfield, NY) on the distribution, mean, and variation of the initial shrunk BW and dietary ME, assuming the values obtained in the 4 different levels of nutrition during the growth phase (treatments) for 140 d of simulation. In the Monte Carlo analysis, inputs are described as probability density functions from which samples are drawn to drive the model and derive probabilities of possible model solutions (Hillier and Lieberman, 1986). The sampling technique chosen for drawing samples from the distribution was the Latin Hypercube in which the probability density function is divided into intervals of equal probability, and from each interval a sample is randomly taken (McKay et al., 1979). Five thousand samples for simulation were completed. For each sampling, different random numbers were used to execute the CVDS model. A multiplicative factor was used to ensure the average DMR simulated by the model matched the oDMI of each treatment.

Statistical and Model Analyses

Evaluations of the precision and accuracy of the CVDS and NRC models were conducted by regressing oDMI on predicted DMR. Data were analyzed using the Model Evaluation System v. 2.0.7 (Tedeschi, 2006). Observations with high-studentized residual (greater than |2.5|) were considered outliers and removed from the data set when information about the steer obtained during the period of the experiment could explain anomalies. Measures of model accuracy included mean bias (**MB**), computed by dividing the difference of the mean Y-variate (oDMI) and the mean X-variate (DMR) by the mean of the X-variate, and model accuracy, which indicates how far the regression line deviates from the line that passes through the origin and has slope of unity (45°). The *P*-value of the MB (null hypothesis of MB = 0) was computed using 2-sample *t*-test analysis (Tedeschi, 2006). Measures of model precision included the coefficient of determination (**r^2**; Neter et al., 1996); and the coefficient of model determination (**CD**), which is the ratio of the total variance of oDMI to the squared difference between model-predicted intake and mean of the observed data (Tedeschi, 2006). A simultaneous evaluation of model accuracy and precision, the generalized concordance correlation coefficient (King and Chinchilli, 2001), was also calculated.

RESULTS AND DISCUSSION

Individual DMI Predictions of Growing and Finishing Feedlot Cattle

The relationships between oDMI and DMR predicted by the CVDS and the NRC (2000) models for cattle during the 56-d growing and 84-d finishing periods are shown in Figure 1. Table 2 lists the results of the evaluation of precision and adequacy of the models' predictions. Within the CVDS predictions, the MBW option had a slightly better adequacy for the growing phase compared with the dynamic, iterative option, which was more adequate for the finishing phase. This is likely because the predictions of energy retained depend upon the composition of the body, which was estimated based on carcass information. Predictions of body composition from carcass measurements are more accurate near the slaughter date (Brethour, 2000).

The MBW option of the CVDS model was selected to compare both models' predictions because of their similarities in terms of equations used for predictions. The CVDS model was slightly more accurate than the NRC (2000) model for the growing and finishing phases (Table 2) when DMR was not corrected to total feed delivered to the pen. For the growing phase, the CVDS model underpredicted DMI by 180 g/d compared with NRC (2000), which underpredicted DMI by 390 g/d during the growing phase. Data shown in Table 2 suggest that both models predicted DMR with similar precision for growing animals, but the CVDS model generated more precise predictions of DMR than the NRC (2000) model for cattle in the finishing period. Tedeschi et al. (2004) observed a range in r^2 from 0.71 to 0.74 with MB varying from (5.7 to 4.2% when predicting DMI for a given animal performance with the CVDS model. Guiroy et al. (2001) and Williams et al. (2006) also evaluated DMR predicted by CVDS against oDMI in finishing cattle. Guiroy et al. (2001) indicated that CVDS accounted for 74% of the variation in actual DM consumed, with low bias (0.34%), and a coefficient of variation of 8.18%. However, Williams et al. (2006) model application of the CVDS accounted for 44% of the phenotypic variation in oDMI. Results in this study were intermediate to these previously reported levels of precision.

The variation not accounted for both models in our data set was likely due to individual variance in factors such as maintenance requirements, diet digestibility and metabolizability, and body composition of individual animals (Perry and Fox, 1997). Additionally, as expected in most models, the CVDS model accumulates errors in each of its components when predicting DM requirements (Fox et al., 2002); however, the prediction of empty body fat calculated with input data of carcass measurements in the CVDS model is likely an advantage when compared with the NRC model, and may have resulted in the improved precision observed for finishing period predictions with the CVDS model.

Evaluation of Individual DMI Predictions when Growing Diets are Dissimilar

AL-LS. When cattle fed the AL-LS diet during the growing period were treated as an independent group, neither the CVDS nor the NRC models provided accurate estimates of DMR during the growing phase. Precision of DMR estimates was also low during the growing phase for cattle on this treatment, as indicated by relatively low r^2 and CD values (Table 3). The AL-LS group was fed a high CP diet because of an unexpected excess in CP concentration of the wheat middlings. It is likely that the large variation on prediction of DMR was due to the high level of CP of this diet, which might have affected the energy required for maintenance. It is known that excess of dietary protein might increase energy required for maintenance due to the extra energy required to eliminate excess of N (Tyrrell et al., 1970).

AL-HS. The comparison of oDMI and DMR for steers fed AL-HS diet during the growing period shows that neither model was able to estimate DMR with precision or accuracy as in-

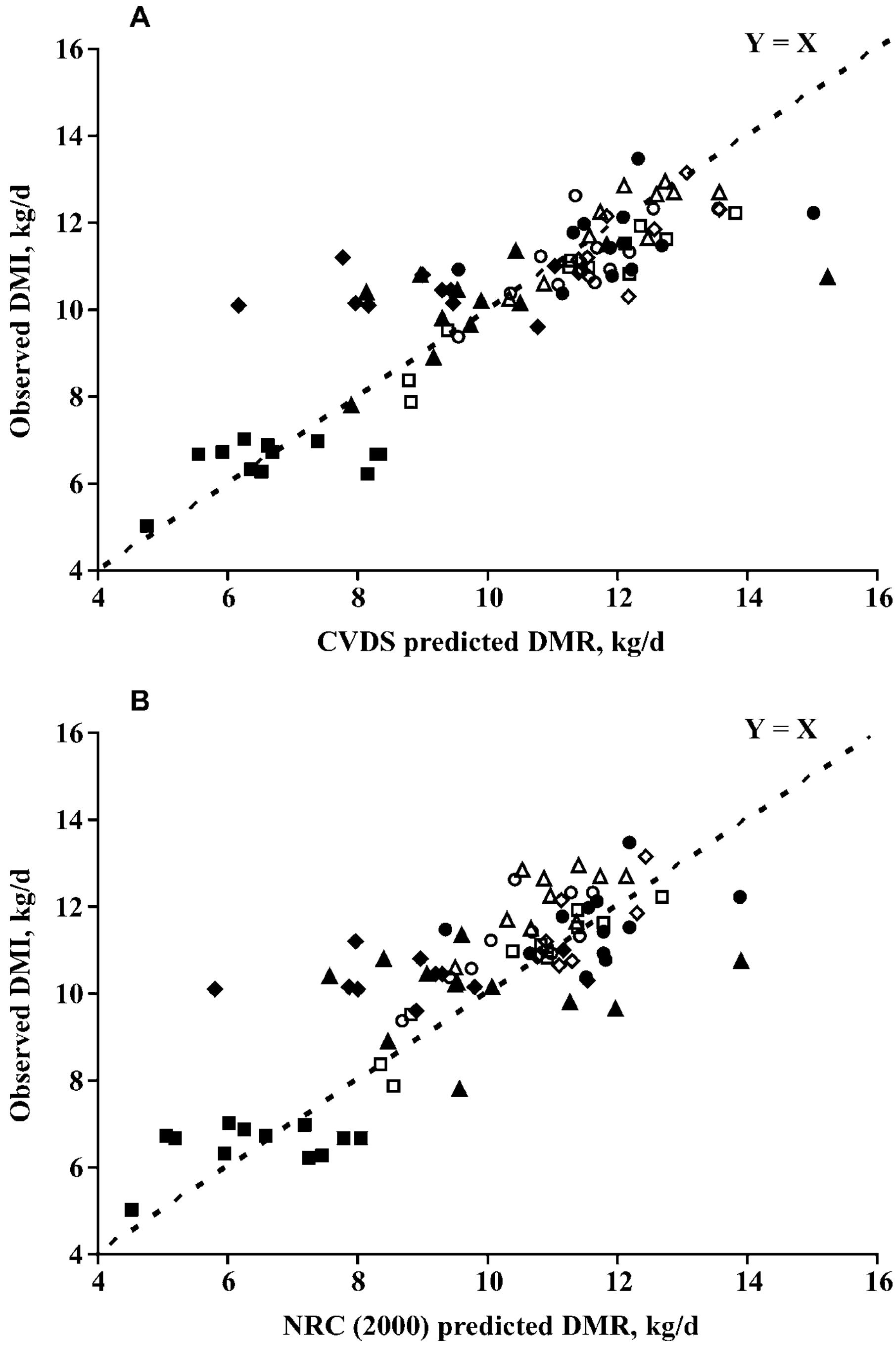

Figure 1. Relationship between DM required (DMR) and observed DMI by the (A) Cornell Value Discovery System (CVDS) and (B) NRC (2000) models for growing (solid symbols) and finishing (empty symbols) phases by treatments (AL-LS: a low-starch diet fed ad libitum, ◇,◆; AL-HS: a high-starch diet fed ad libitum, Δ,▲; LF-HS: the same high-starch diet as AL-HS limit-fed to approximate the caloric intake of AL-LS, ■, □; AL-IS: a diet fed ad libitum with approximately the midpoint daily energy content between AL-LS and AL-HS, ●, ○). Linear equations were as follows: CVDS - ◇: y = 0.81x + 1.71; ◆: y = –0.0013x + 10.41; Δ: y = 0.86x + 1.66; ▲: y = 0.23x + 7.78; ■: y = 0.20x + 5.14; □: y = 0.82x + 1.37; ●: y = 0.27x + 8.29; ○: y = 0.68x + 3.31. NRC — ◇: y = 0.94x + 0.61;? ◆: y = 0.098x + 9.55; Δ: y = 0.87x + 2.60; ▲: y = 0.04x + 9.60; ■: y = 0.18x + 5.35; □: y = 0.96x + 0.45; ●: y = 0.2568x + 8.572; ○: y = 0.83x + 2.52.

Table 2. Model predictions of DM required during growing and finishing feeding phases

Item[1]	NRC	CVDS[2] Mean BW	DIM[3]
MB, %			
Growing	4.24	1.92	5.80
Finishing	4.40	–3.76	–0.51
r^2			
Growing	0.59	0.61	0.60
Finishing	0.57	0.71	0.69
CD			
Growing	0.76	0.74	0.73
Finishing	1.05	0.88	1.04
CCC			
Growing	0.75	0.77	0.75
Finishing	0.68	0.78	0.84
Cb			
Growing	0.98	0.99	0.97
Finishing	0.90	0.93	1.00

[1]MB = mean bias; r^2 = coefficient of determination; CD = coefficient of model determination; Cb = model accuracy; CCC = concordance correlation coefficient.

[2]CVDS = Cornell Value Discovery System.

[3]DIM = dynamic, iterative model (Tedeschi et al., 2004).

dicated by low r^2, model accuracy, concordance correlation coefficient, and CD values (Table 3). During the finishing period, however, both models were able to satisfactorily predict DMR, although the NRC model was less accurate. The CVDS model predicted DMR with a high degree of accuracy.

LF-HS. For the groups of animals fed the LF-HS diet during the growing period, the CVDS and NRC models were not able to predict DMR with precision and accuracy. During the finishing period, however, both models estimated DMR with good precision (Table 3). Measures of accuracy suggest that the NRC model generated more accurate estimates of DMR than the CVDS model for finishing animals previously fed LF-HS. These results suggested that limit-fed animals' individual response might be

Table 3. Comparison of 2 different models for prediction of DM required of growing and feedlot steers[1]

	r^2		MB (%)		Cb		CCC		CD	
	CVDS[2]	NRC	CVDS	NRC	CVDS	NRC	CVDS	NRC	CVDS	NRC
Growing (by treatment)[3]										
AL-LS	0.20	0.12	9.90	12.55	0.82	0.76	–0.36	–2.67	0.52	0.47
AL-HS	0.20	0.17	1.36	6.51	0.29	0.58	0.36	–0.23	0.25	0.11
LF-HS	0.18	0.14	–3.91	0.50	0.74	0.77	0.31	0.29	0.20	0.22
AL-IS	0.17	0.11	–3.59	–0.67	0.85	0.96	0.35	0.33	0.38	0.59
Finishing (by treatment)										
AL-LS	0.23	0.37	0.64	0.11	0.57	0.96	0.28	0.58	0.99	0.87
AL-HS	0.73	0.62	–0.67	10.74	1.00	0.53	0.85	0.42	0.99	0.39
LF-HS	0.90	0.91	–6.20	0.46	0.89	0.99	0.85	0.95	0.62	1.01
AL-IS	0.58	0.49	–3.24	0.49	0.93	0.81	0.70	0.57	0.71	0.72

[1]r^2 = coefficient of determination; MB = mean bias; Cb = model accuracy; CCC = concordance correlation coefficient. CD = coefficient of model determination.

[2]CVDS - Cornell Value Discovery System.

[3]Dietary treatments were as follows: AL-LS, a low-starch diet fed ad libitum; AL-HS, a high-starch diet fed ad libitum; LF-HS, the same high-starch diet as AL-HS limit-fed to approximate the caloric intake of AL-LS; and AL-IS, a diet fed ad libitum with approximately the midpoint daily energy content between AL-LS and AL-HS.

predictable when placed on a finishing diet after a period of restricted nutrition.

AL-IS. For animals fed AL-IS, neither model was able to precisely estimate DMR during growing period, as indicated by low r^2 values. Predictions for the finishing period were reasonable for both models.

Overall, data suggest that it is likely that different growing systems affect model prediction of DMR during the finishing phase when previous plane of nutrition is not accounted for, despite the number of animals in this analysis. Even though these models utilize BCS to account for previous level of nutrition on energy for maintenance, more robust adjustments are needed regarding the effects of previous nutrition prior to finishing.

Table 4. Model predictions of DM required for group-fed growing and finishing steers

		DM predicted for group-fed steers,[2] kg		DM predicted for group fed steers,[3] kg	
Treatments[1]	Observed DMI, kg	CVDS[4]	NRC	CVDS	NRC
Growing					
AL-LS	10.03	9.13	8.91	9.11	9.12
AL-HS	10.19	9.72	9.72	9.69	9.22
LF-HS	6.49	6.75	6.46	6.79	6.50
AL-IS	11.56	11.99	11.64	11.59	11.58
Finishing					
AL-LS	11.17	11.94	11.33	11.91	11.25
AL-HS	11.55	11.97	10.78	11.96	10.75
LF-HS	10.28	11.34	10.55	11.37	10.78
AL-IS	11.15	11.52	10.53	11.52	10.59

[1]Dietary treatments were: AL-LS, a low-starch diet fed ad libitum; AL-HS, a high-starch diet fed ad libitum; LF-HS, the same high-starch diet as AL-HS limit-fed to approximate the caloric intake of AL-LS; and AL-IS, a diet fed ad libitum with approximately the midpoint daily energy content between AL-LS and AL-HS.

[2]Mean value.

[3]Value predicted for the mean of the group data by treatment.

[4]CVDS = Cornell Value Discovery System.

Evaluation of Individual DMI Predictions for the Combined Growing and Finishing Data

The relationships between oDMI and DMR predicted by both models for the entire 140-d period are shown in Figure 2. The CVDS and the NRC precisely and accurately estimated oDMI of steers during the entire 140 d. Although when used specifically for each phase as previously described, neither the CVDS nor the NRC were able to account for a large amount of the variation during growing; the combination of the data for both growing and finishing increased precision and accuracy.

Group Intake Prediction

The overall group predictions of the CVDS model (mean value of the 2 different approaches; Table 4) were –10.0, –4.7, 1.8, and 2.2% of oDMI of AL-LS, AL-HS, LF-HS, and AL-IS during the growing period, respectively. For the finishing period, CVDS predictions were 4.1, –1.5, 6.5, and –1.1% of the actual DMI. With the NRC, predictions were –9.2, –7.2, 2.4, and 0.21% of oDMI for AL-LS, AL-HS, LF-HS, and AL-IS during the growing period. During the finishing period, the NRC predictions were 3.7, –1.7, 7.7, and –0.9% of the actual DMI. These findings are in agreement with Fox et al. (2002), who suggested the predictions of DMI of groups of animals instead of individuals reduces the error of prediction; however it limits the application for sorting purposes. Guiroy et al. (2001) evaluated this reduction in error by randomly creating small groups of cattle (5, 10, 20, 40, or 80) within 365 individually fed animals. The coefficient of variation was reduced more than 50% (from 8.18 to 3.76%) when predicting DMR for groups of 5 animals instead of individuals, and was less than 2% in groups of more than 20 animals (Guiroy et al., 2001). This analysis suggested the error in the intake prediction is greatly reduced when larger groups of animals are used. This is an important concept for feedyards us-

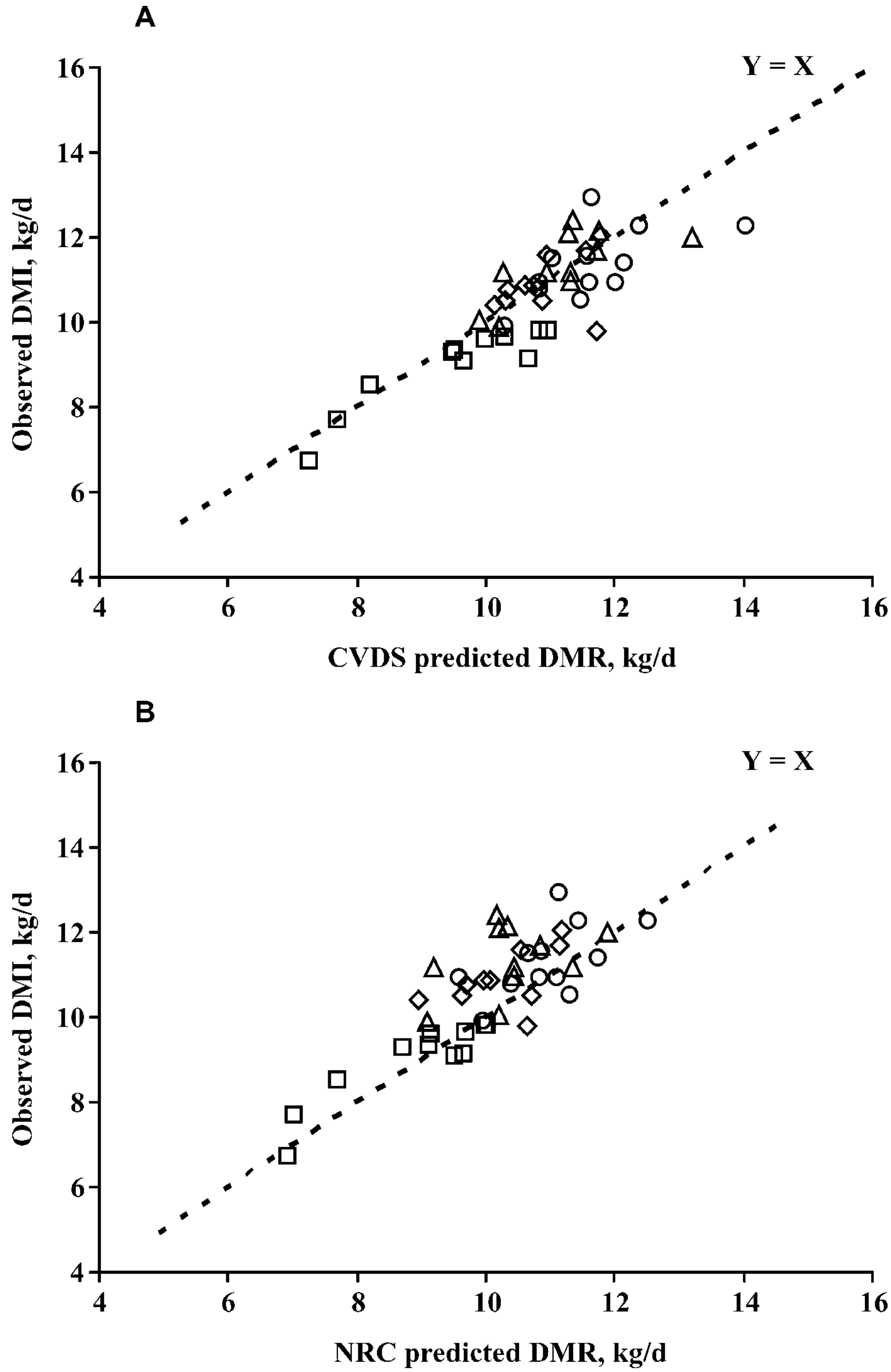

Figure 2. Relationship between DM required (DMR) and observed DMI by the (A) Cornell Value Discovery System (CVDS) and (B) NRC (2000) models for the 140-d period (AL-LS: a low-starch diet fed ad libitum, ◇; AL-HS: a high-starch diet fed ad libitum, Δ; LF-HS: the same high-starch diet as AL-HS limit-fed to approximate the caloric intake of AL-LS, □; AL-IS: a diet fed ad libitum with approximately the midpoint daily energy content between AL-LS and AL-HS, ○). Linear equations were as follows: CVDS — ◇: y = 0.43x + 6.23; Δ: y = 0.65x + 4.03; □: y = 0.70x + 2.29; ○: y = 0.55x + 4.94. NRC — ◇: y = 0.51x + 5.70; Δ: y = 0.44x + 6.83; □: y = 0.78x + 2.07; ○: y = 0.61x + 4.58.

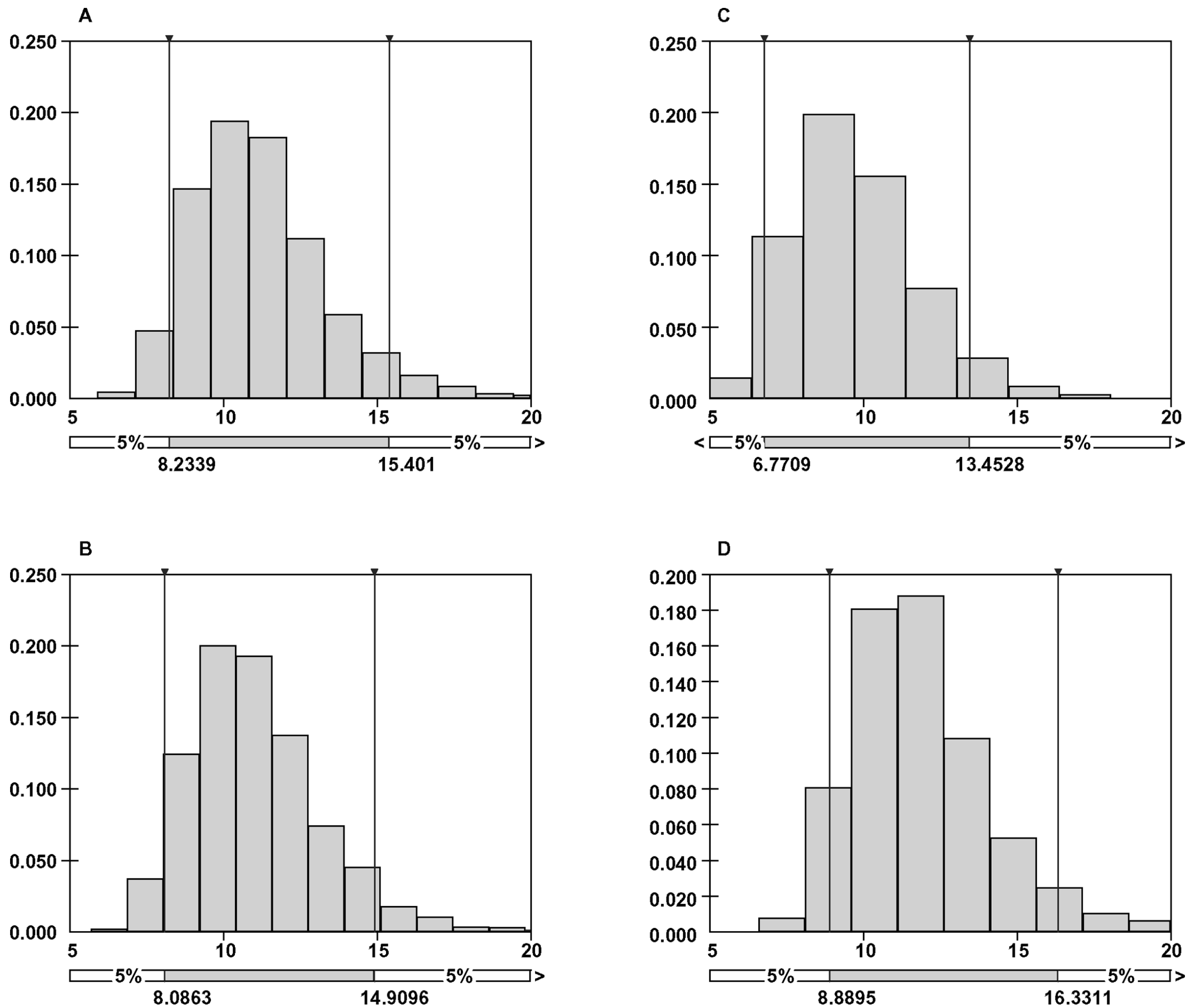

Figure 3. Distribution of DM required predicted by the Cornell Value Discovery System (CVDS) for the 140-d feeding period (A= AL-LS, a low-starch diet fed ad libitum; B = AL-HS, a high-starch diet fed ad libitum; C = LF-HS, the same high-starch diet as AL-HS limit-fed to approximate the caloric intake of AL-LS; and D = AL-IS, a diet fed ad libitum with approximately the midpoint daily energy content between AL-LS and AL-HS).

ing decision support systems to allocate feed consumed among small groups of cattle from the same owner within a pen (Fox et al., 2002).

Adjustment Factor for Correction of Model Prediction

An adjustment factor to correct the model-predicted DMR to match oDMI was identified for each treatment group in order to account for total feed fed within a pen, which was multiplied by each model-predicted DMR value. As expected, the regression of the adjusted DMR on oDMI improved accuracy and no changes were observed in the precision of the models, suggesting a shift of the predictions without affecting their distribution about the mean.

Application of Predicting Individual Feed of Commingling, Pen-fed Feedlot Cattle

Distributions of CVDS-predicted DMR for different planes of nutrition during the growing period are shown in Figure 3 and represent the 90% confidence interval for DMR of each 1 of the 4 groups. Confidence intervals were 8.23 to 15.40; 8.09 to 14.91; 6.77 to 13.14; and 8.89 to 16.33 kg, for AL-LS, AL-HS, LF-HS, and AL-IS, respectively. Overall evaluations of these data showed that feed intake varied from approximately 8.0 to 15.0 kg (90% confidence interval). These data suggest that DMR values outside the confidence interval were either approximately 18% lower or

29% higher than the group DMR mean values for DMR <5% and >95%, respectively. The simulations also showed that <5 and >95% values represented 2.6 kg and 4.31 kg of DMR, respectively. These values could represent approximately 364 to 603 kg of feed on a 140-d period, resulting in an over- or under-billing of 78 to 129 kg of feed in a 30-d period. Most commercial feedyards charge their customers on a monthly basis. These numbers represent an amount of approximately $17.00 per animal that is always being either overcharged or undercharged on a monthly basis (assuming a feedlot diet cost of $160.0/ton). The use of decision support systems may help feedlots to improve the accuracy of this billing process for their customers. Because predicted and observed intake deviations would add up to zero, there would be distributed errors without mean slippage for a pen. This simulation shows that there is an error associated with billing of feed consumed by feedlot cattle. Based on our data set, it is possible to confirm something most feedlot operators know — there is a considerable variability in DMI of pen-fed cattle. Models such as the CVDS and NRC may be able to reduce error in individual billing when applied to real-world situations, although the error is not reduced to zero. Our data set reflects most commercial operations and provides substantial information about how much error is involved in the billing process. It is up to the commercial operations to decide how much error is acceptable.

IMPLICATIONS

Data suggest that models predicted DMR for individual animals with an acceptable degree of accuracy, especially over longer time periods, which makes it possible to allocate feed intake among pen-fed cattle. Such models could be used to allocate feed to individual animals with mixed ownership within a pen in customer feedyards, facilitating sorting at entry. Both models were able to accurately predict DMI for groups of animals. In the current study, the prediction of DMR for finishing cattle was affected by the diet fed to cattle prior to the finishing phase. Therefore, cattle background information might be useful to increase accuracy of models designed to predict individual feed required. Our results also suggest that the use of decision support systems could help feedlots to improve the accuracy of the billing process for their customers while maintaining gross revenue for each pen.

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