A New Approach to Estimating Empty-Body Weight in Growing and Finishing Beef Cattle

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A New Approach to Estimating Empty-Body Weight in Growing and Finishing Beef Cattle

Charles B. Williams, John W. Keele, and Dale R. Waldo

Introduction

Animals require nutrients for maintenance and production. A large part of the calculated nutrient requirements is based on body weight, which includes the contents of the gastrointestinal tract (gut). Ruminants have a large gut capacity, and for a 1000 lb steer, gut contents can account for 50 to 250 lb of its body weight. These contents are not a part of the animal and should not be considered when calculating maintenance requirements. Therefore to translate nutrient requirements for each unit of empty-body weight (body weight minus the weight of gut contents) gain into requirements per unit gain in body weight, we need an accurate method of estimating the weight of gut contents. Several systems have been proposed to estimate empty-body weight. The National Research Council and the Agricultural Research Council used equations to calculate empty-body weight as a constant fraction of shrunk-body weight, or a constant fraction of body weight within three discrete dietary classes, respectively.

Results of previous research have demonstrated that in addition to body weight there is a continuous relationship between weight of gut contents and dietary characteristics such as percentage of dietary concentrates and neutral detergent fiber (indigestible and slowly digested fractions of the feed). Other work has also shown that weight of gut contents is much higher when animals consume hay vs silage prepared from the same forage source. Our objective was to develop and evaluate a method to estimate weight of gut contents and use this estimate to convert body weight to empty-body weight. To achieve this objective a model was developed to predict weight of gut contents in cattle as a function of forage neutral detergent fiber, physical form of forage dry matter (hay vs silage and pasture), proportion of dietary concentrates and body weight.

Procedures

Experimental data were used to develop an equation to predict the fraction of body weight associated with gut contents, from the percentage neutral detergent fiber in the forage. Factors were then developed using data from other experiments to adjust this fraction for the effects of body weight, percentage of dietary concentrates and the physical form of forage dry matter. The adjusted gut contents fraction was then multiplied by body weight to obtain the weight of gut contents. This weight was subtracted from body weight to obtain empty-body weight. All body weights used in model development represented weight recorded early in the morning with animals having access to food and water overnight. Hay and silage were the physical forms of forage dry matter used in the model. It was assumed that green pasture and dormant pasture were physically the same as silage or hay, respectively.

Data from 11 published experiments with 64 treatments (Table 1) were used to evaluate the model. Empty-body weight predictions obtained with the models used by the Agricultural Research Council (ARC) and the National Research Council (NRC) were also evaluated with these experimental data, and compared to the present model's predictions. The accuracy with which these three models (our present model, Agricultural Research Council, and National Research Council) predicted empty-body weight was evaluated by comparing observed to predicted values.

Results

The model to predict the weight of gut contents was:

\[ \text{weight of gut contents} = \text{body weight} \times (53.54 + 3.29 \times \text{percentage neutral detergent fiber of forage}) \times (\text{correction factor for body weight}) \times (\text{correction factor for fraction of concentrates in diet}) \times (\text{correction factor for forage physical form}), \]

where

- correction factor for body weight \( = (\text{body weight} / 200)^{-0.332} \)
- correction factor for fraction of concentrates \( = 1 - 0.246 \times (\text{fraction of concentrates})^2 - 1.481 \times (\text{fraction of concentrates})^3 + 1.107 \times (\text{fraction of concentrates})^4 \)
- correction factor for forage physical form was 1.35 for hays and 1 for silages.

Empty-body weight was calculated from the predicted weight of gut contents and the observed body weight. The model empty-body weight values calculated from predicted gut contents for the treatments using hay in Experiments 2, 4, and 5 were very different from observed values. In these experiments ammoniated stargrass and perennial ryegrass hay were used, and previous results have suggested that for ammoniated hays the correction factor for forage physical form should be 1. With this modification the calculated empty-body weight values using the present model predictions of gut contents were much closer to the observed values.

Observed empty-body weight is plotted in Figure 1, against the empty-body weight calculated with the present model, and empty-body weight predicted with the ARC and NRC models. For cases where the observed and predicted values are the same, then the points representing these paired values would lie on the 45 degree line shown in this figure. Points above the line mean that the predicted values underestimate the observed, and the opposite would be true for points below the line. Empty-body weight values calculated with the present model tended to be smaller than observed values for weights less than 400 lb. The method used by the ARC consistently overpredicted empty-body weight, and the NRC's method overpredicted empty-body weight for 50 of the 64 treatment means. These results confirm that the present model would be accurate in calculating empty-body weight from predicted weight of gut contents for weaned cattle, and suggest that it may not be appropriate between birth and weaning. This is understandable since these animals would be consuming milk, and their rumens have not been fully developed.

Referring to Figure 1, equations can be developed to adjust the empty-body weight predicted with the systems used by the ARC and NRC. It is possible that these adjusted predictions may be more accurate than the present model. These equations were developed, and the adjusted predictions of empty-body weight using the ARC and NRC models were compared to the present model's calculated empty-body weight values. The results of this analysis showed that the present model was still more accurate than the other two models.

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The present model was developed with data on cool-season grasses, legumes and corn silage and it has not been fully tested with warm-season grasses, however, preliminary results with stargrass show no inconsistencies. Also it is possible that the correction factor for the fraction of dietary concentrates may not be appropriate in cases where very low-quality forages are supplemented with either cereals of high-protein byproducts, or protein supplements that differ in ruminal degradability. As more data become available, the model needs to be tested under these experimental conditions. Data used to develop and evaluate the model were obtained from animals that were on a specific plane of feeding for over three weeks, and model predictions of empty-body weight may not be accurate in the early period when animals are switched from restricted to full feeding or vice versa. Model inputs are dietary characteristics that can be obtained from routine forage analyses and unfasted body weight. This makes the model easy to use. It can be incorporated into diet formulation programs and systems models of cattle production.

Table 1—Summary of data from 64 treatments in 11 published experiments used to evaluate the model

<table>
<thead>
<tr>
<th>Exp.</th>
<th>Number of treatments</th>
<th>Number of animals</th>
<th>Forage type</th>
<th>Neutral detergent fiber, %</th>
<th>Concentrate fraction in diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>54</td>
<td>Hay</td>
<td>40</td>
<td>0.0</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>102</td>
<td>Hay</td>
<td>75-82</td>
<td>0.23</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>24</td>
<td>Silage</td>
<td>51.0</td>
<td>0.38</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>48</td>
<td>Silage, hay &amp; pasture</td>
<td>51</td>
<td>0.0</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>102</td>
<td>Hay</td>
<td>65</td>
<td>0.44</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>24</td>
<td>Straw</td>
<td>80</td>
<td>0.59-0.87</td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>40</td>
<td>Hay</td>
<td>42</td>
<td>0.0</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
<td>40</td>
<td>Hay</td>
<td>66</td>
<td>0.6-0.95</td>
</tr>
<tr>
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<td>12</td>
<td>29</td>
<td>Straw</td>
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<td>0.83-0.88</td>
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<td>4</td>
<td>40</td>
<td>Silage</td>
<td>44-59</td>
<td>0.28</td>
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<tr>
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<td>6</td>
<td>32</td>
<td>Silage</td>
<td>51.9</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Figure 1 - Observed and predicted empty-body weight treatment means for 64 treatments in 11 published experiments.