COMPARISON OF ONE AND TWO COMPARTMENT MODELS FOR PREDICTION OF FECAL OUTPUT OF CATTLE GRAZING WHEAT PASTURE

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Story in Brief

External markers may be used to estimate fecal output, a measure used to estimate forage intake of grazing cattle. However, the mathematical model used to fit the marker excretion curves may influence fecal output estimates. Steers grazing wheat pasture, with and without supplemental low-quality forage, were dosed with Yb-labelled wheat forage, and one and two compartment models with time delays were fit to the fecal Yb concentration data. Overall, fit of the marker data was improved by using the two compartment model. Fecal outputs predicted for the two compartment model were generally more precise (lower residual standard deviation) but less accurate, due to a tendency for underprediction. In cases where the one compartment model fit the marker data poorly, fecal output was overestimated. No systematic effect due to lack of fit was observed for the two compartment model. Also, no loss of precision for estimates of fecal output was observed with increasing lack of fit for the two compartment model.

(Key Words: Compartment Models, Wheat Pasture, Fecal Output)

Introduction

External markers may be used to estimate rate of passage, fecal output, and subsequently forage intake of grazing ruminants. However, controversy has arisen over the choice of model used to make these estimates. Both the one and two compartment models with time delays have been used with varying degrees of success in fitting marker data and identifying model parameters. The objective of this research was to compare the one and two compartment model estimates of total fecal output with observed values for cattle grazing wheat pasture.

Materials and Methods

Three groups of steers (291 kg body weight) were assigned to supplement treatments in a 3X3 Latin square design. Supplement treatments were ad libitum access to wheat straw and wheat pasture, ad libitum access to sorghum-sudan hay and wheat pasture, and ad libitum access to only wheat pasture. The three time periods were fall grazing before winter wheat dormancy (December through mid-January), winter dormancy (mid-January through February), and lush spring growth (March). Each period consisted of 11 day adaptation and 5 day fecal collection phases. At the beginning of the collection phase, steers were dosed with 195 g wheat forage dry matter labelled with 1.6 g Yb. Feces was sampled 6, 10, 14, 24, 30, 36, 48, 58, 72, 82, 96, 106 and 120 hours later. Yb was determined by atomic absorption spectroscopy. One and

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two compartment models (Ellis et al., 1979) were fit to the fecal Yb excretion curves using a modified Marquardt method to estimate rate constants (k_i) and lag time (Tau). Predicted daily fecal output of steers was calculated as follows for the one compartment model

$$(\text{Marker dose} / k_0) * 24 \text{ h}$$

and for the two compartment model

$$(\text{Marker dose} / k_0) * k_2 * 24 \text{ h}$$

Actual (observed) fecal output of steers was measured by total collection with fecal collection bags.

Results and Discussion

The marker excretion data was best fit to the two compartment model (Table 1). Average mean square error was 7531 and 2148 (mg Yb/kg fecal dry matter)^2 for the one and two compartment models, respectively. Simple correlation coefficients (r) for predicted and observed fecal outputs were .71 and .84 for the 27 one and two compartment model observations, respectively (Table 1 and Figure 1). Residual (predicted-observed) fecal outputs were analyzed and found to be unrelated to either supplement treatment, period or steer weight for either model (P>.15). The lower residual standard deviation for the two compartment model (Table 1) reflects more precise estimates although the two compartment model estimate may have been more biased, due to a tendency for underprediction (Figure 2). This underprediction corresponds to a 9% loss of Yb marker. Thus, the bias would disappear if estimated initial marker concentration values were increased by this amount.

As fecal output increased, the two compartment model tended to underestimate fecal output (r=-.40, Table 2). However, this was due to one anomalous observation where both models overestimated fecal output by about .7 kg (Figure 2). Residual fecal output was related to mean square error for the one compartment model (P<.001) but not for the two compartment model (P>.25). Residual fecal output was also related to estimated parameter values for the one compartment model (P<.01). In cases where the one compartment model fit the marker data poorly, fecal output was overestimated (Figure 3). No systematic effect due to lack

Table 1. **Comparison of the one and two compartment models' fit of marker excretion data and prediction of fecal output.**

Item	Compartments	
	One	Two
Average marker mean square error (mg/kg)^2	7531	2148
Predicted fecal output		
Correlation with observed	.71	.84
Mean residual (predicted-observed)	.003	-.159
Standard deviation residual	.383	.230

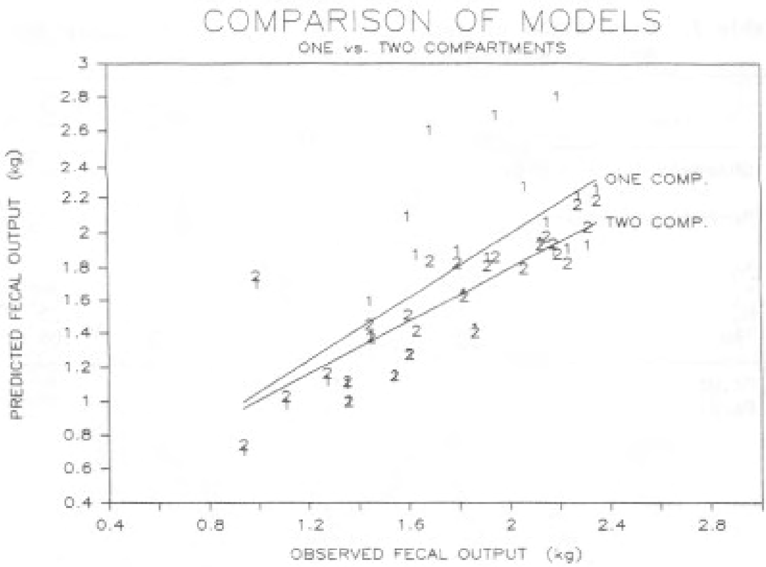

Figure 1. Relationship between predicted and observed fecal output for the one (1) and two (2) compartment models with best fit linear regression lines for steers grazing wheat pasture.

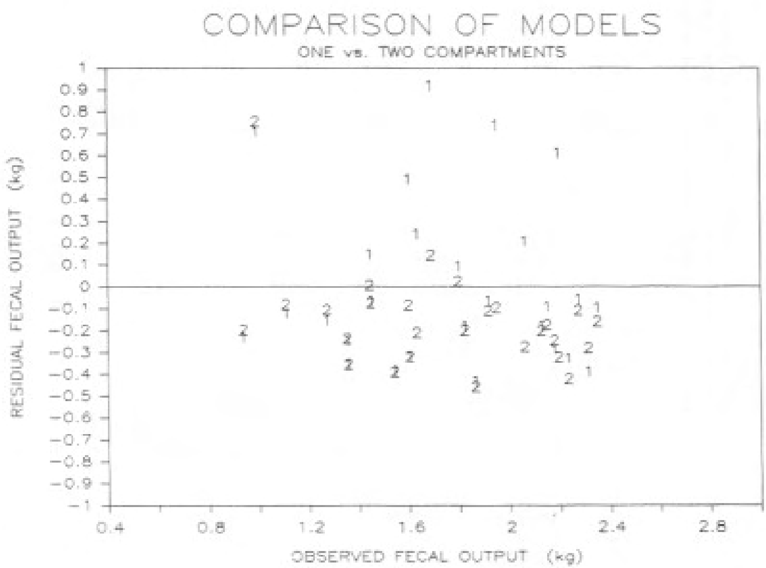

Figure 2. Relationship between residual and observed fecal output for the one (1) and two (2) compartment models for steers grazing wheat pasture.

Table 2. Correlation of fecal output, marker mean square and model parameters with residual fecal output.

Item	Compartments One	Compartments Two
Observed fecal output	-.07	-.40*
Marker mean square	.72**	-.22
k_0	-.61**	-.33
k_1	.54**	-.05
k_2	---	-.23
Tau	.73**	.05

*P<.05
**P<.01

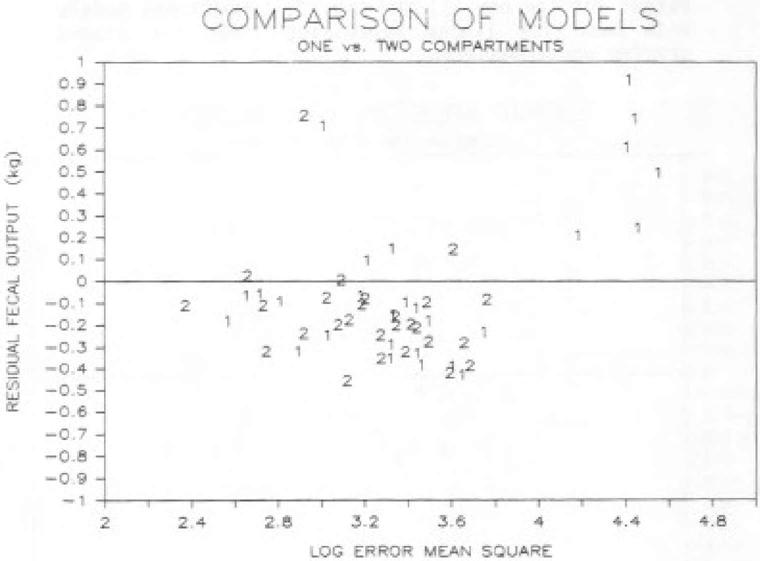

Figure 3. Relationship between residual fecal output and log error mean square of marker excretion data for the one (1) and two (2) compartment models for steers grazing wheat pasture.

of fit was observed for the two compartment model. Also, no loss of precision for estimates of fecal output was observed with increasing lack of fit of the two compartment model. In conclusion, this study suggests that although the use of either model has limitations, parameters estimated using the two compartment model should be used for estimation of fecal output when the two compartment model best fits marker concentration data.

Literature Cited

Ellis, W.C. et al. 1979. Quantitating ruminal turnover. Fed. Proc. 38:2702.