

Evaluation of Total Fecal Collection for Measuring Cattle Forage Intake

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Abstract

Conventional digestibility trials with steers were conducted to evaluate relationships between actual forage intake and estimated forage intake using the total fecal collection procedure. Actual forage intake of 6 of the 9 forages fed was not accurately estimated by the widely used technique of dividing total fecal output by forage indigestibility estimated by *in vitro* procedures. This was because 48-h *in vitro* digestibility poorly estimated *in vivo* digestibility of 6 forages. Regression equations based on *in vivo-in vitro* digestibility relationships can reduce but not solve this problem because *in vivo* processes such as mastication and rumination are bypassed with *in vitro* techniques. The use of a 36-h microbial digestion period for nongrasses and a 72-96-h microbial digestion period for grasses shows potential to improve *in vitro* digestibility estimates of cattle *in vivo* digestibility. Another potential means of improving *in vitro* digestibility estimates is to select the highest digestibility value from forage or diet samples subjected to 36-, 48-, 60-, 72-, 84- and 96-h microbial digestion periods.

Although mechanisms controlling forage intake in ruminants have been described by Ellis (1978), Mertens (1977), Church (1979), Van Soest (1982), and Mertens and Ely (1982), present techniques to measure intake of pasture and range forages by ruminants are laborious, costly, and subject to numerous errors (Cordova et al. 1978, Kartchner and Campbell 1980). The total fecal collection method discussed by Van Dyne (1969) has become the most favored approach for estimating forage intake by domestic ruminants. Although this procedure has been widely used, evaluation of its accuracy is limited (Van Dyne and Meyer 1964). Our objective was to evaluate the total fecal collection/indigestibility method of Van Dyne (1969) for determining intake.

Methods

Two independent studies were conducted in 1980 and 1982 at the New Mexico State University farm. Details of each study will be reported separately.

Study 1

Three feeding trials were conducted between May and September of 1980. Steers were fed alfalfa (*Medicago sativa*) hay for 3 weeks before each trial. Five Hereford × Angus yearling steers, weighing approximately 340 kg each, were used in each trial. Trials were 14 days long with 10 days for adaptation and 4 days for data collection. Schneider and Flatt (1975:124) concluded that a 5-day adjustment period was adequate to clear previously fed diets from the digestive tract; Dubose and Embry (1956) reported that a 4-day collection period was sufficient to quantify fecal excretion in steers and lambs.

Trials were in drylot pens where steers were fed *ad libitum* individually. Feed intake was determined by conventional hand-fed methods (Schneider and Flatt 1975:57). Steers were harnessed with fecal collection bags. Total fecal output was measured daily. Forages fed in the 3 drylot trials included milo hay (*Sorghum vulgare*) that had the heads removed, alfalfa hay, and oat hay (*Avena sativa*) that contained about 10% alfalfa. Feed was avail-

able free choice throughout the day.

Five esophageal fistulated cows were used to collect diet samples in all 3 trials for diet *in vitro* organic matter digestibility, crude protein, and fiber evaluation. *In vivo* organic matter digestibility of the milo, alfalfa, and oat hays was determined by the conventional procedure (Schneider and Flatt 1975).

Study 2

Study 2 was conducted with 6 yearling steers, weighing approximately 273 kg, in 6 digestion trials during the summer of 1982. Six different hays representing 2 forage classes (3 grasses and 3 non-grasses) were fed to the 6 steers in a Latin square design. All 6 hays were fed in each 15-day trial and randomized within rows and columns. Hays used were alfalfa, Eski sainfoin (*Onobrychis viciifolia*), kochia (*Kochia scoparia*), millet (*Panicum miliaceum*), timothy (*Phleum pratense*), and silver bluestem (*Bothriochloa saccharoides*) prairie hay. Steers were confined to 6 × 15 m individual pens. Hays were chopped to a 2-4 cm particle size to reduce selective feeding.

Intake was determined by conventional hand-fed methods (Schneider and Flatt 1975:57) and estimated by the procedure of Van Dyne (1969) described in Study 1. Feed was available free choice daily, and intake was evaluated for each steer daily for 5 days after 10 days of adjustment to the feed.

We measured total fecal output in collection bags during the same 5 days we measured intake. During each 5 days of intake and fecal output measurement, samples of the feed offered to each steer were collected for laboratory analyses.

Nutritive Analysis

Preparation of samples for nutritive analysis and nutritive analysis procedures were the same for both studies. Feed and fecal samples were ground through a 1-mm screen in a Wiley laboratory mill and dry matter and ash content were determined following AOAC (1980). Feed samples (esophageal fistula samples in Study 1) for each steer/feed combination were analyzed for Kjeldahl N, P, and ether extract (AOAC 1980) and neutral detergent fiber, acid detergent fiber, and acid detergent lignin using Goering and Van Soest (1970) procedures. Crude protein (N % × 6.25), hemicellulose, and cellulose were calculated. *In vitro* digestibility was evaluated following Tilley and Terry (1963) as modified by Moore (1970) and Harris (1970). We composited rumen inoculum from 2 steers fed alfalfa hay. *In vitro* digestibility (48-h) of all samples was calculated from 3 replicates in each of 3 runs. In Study 2, microbial digestion periods of 0-, 4-, 8-, 24-, 36-, 60-, 72-, 84- and 96-h were used as well as the standard 48-h period. Two runs of triplicate tubes were used for all digestion periods in Study 2. Chemical composition of the 9 feeds is shown in Table 1.

For each feed we compared actual intake, estimated intake using total fecal output divided by *in vivo* indigestibility, and estimated intake using total fecal output divided by 48-h *in vitro* indigestibility using analysis of variance for a completely randomized design and LSD mean separation (Steel and Torrie 1960). Simple linear correlation was used to evaluate the relationship between *in vivo* and 48-h *in vitro* digestibility.

Results and Discussion

Actual forage intake and estimated forage intake using the procedure of Van Dyne (1969) differed ($P < .05$) for 6 of the 9 forages in our study (Table 2). However, intakes estimated from

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Table 1. Forage nutritional characteristics for Studies 1 and 2.

Forage characteristics ^a	Study 1			Study 2					
	Milo hay	Alfalfa hay	Oat hay	Millet hay	Timothy hay	Bluestem hay	Alfalfa hay	Sainfoin hay	Kochia
Crude protein %	4.9	25.7	18.0	13.6	7.8	6.5	20.2	21.2	8.9
Phosphorus %	—	—	—	.20	.11	.10	.23	.40	.18
Ether extract %	1.75	1.76	2.00	2.01	2.22	2.19	1.98	1.94	1.62
Neutral detergent fiber %	76.9	48.1	74.2	68.7	70.2	77.9	44.4	52.3	68.1
Acid detergent fiber %	57.5	40.5	50.0	40.8	40.5	47.5	35.2	47.0	43.4
Acid detergent lignin %	8.4	9.6	11.3	3.2	5.3	6.2	7.5	9.3	6.8
Cellulose %	49.1	30.9	38.7	37.6	35.1	41.2	27.6	37.7	36.6
Hemicellulose %	19.4	7.6	24.2	27.9	29.7	30.4	9.2	5.3	24.7
Cellulose + Hemicellulose %	64.5	38.5	62.9	65.6	64.8	71.6	36.8	43.0	61.3
Digestibility % (in vivo)	54.0	71.0	67.0	72.0	69.0	60.0	69.0	70.0	59.0
Digestibility % (in vitro)	56.0	61.0	48.0	68.0	60.0	47.0	65.0	69.0	52.0
Organic matter intake (% body weight)	.87	1.98	2.00	2.55	2.23	1.21	2.74	2.32	1.18
Digestible organic matter intake (% body weight)	.47	1.41	1.34	1.84	1.54	.73	1.89	1.62	.70

^aAll forage nutritive quality data including in vitro and in vivo digestibility are on an organic matter basis.

Table 2. A comparison of actual forage intake (organic matter, % body weight) with forage intake estimated from total fecal output combined with in vivo and in vitro organic matter digestibilities.

	Actual ^a intake	Estimated ^{a,b} intake (in vivo digestibility)	Estimated ^{a,c} intake (in vitro digestibility)
Study 1			
Milo	0.87 ^d (9)	.78 ^d (9)	.82 ^d (8)
Alfalfa	1.98 ^d (6)	2.07 ^d (6)	1.54 ^e (5)
Oat	2.00 ^d (5)	2.12 ^d (5)	1.35 ^e (6)
Study 2			
Millet	2.55 ^d (2)	2.61 ^d (2)	2.28 ^e (3)
Timothy	2.23 ^d (4)	2.23 ^d (4)	1.77 ^e (4)
Bluestem	1.21 ^d (7)	1.10 ^d (8)	.83 ^e (9)
Alfalfa	2.74 ^d (1)	2.71 ^d (1)	2.40 ^e (2)
Sainfoin	2.32 ^d (3)	2.57 ^d (3)	2.48 ^d (1)
Kochia	1.18 ^d (8)	1.24 ^d (7)	1.04 ^d (7)

^aNumbers in parenthesis represent ranking of intakes from highest (1) to lowest (9).

^bIntake estimated using the equation:

$$\text{Organic matter intake (\% BW)} = \frac{(100) \times (\text{total fecal organic matter output, \% BW})}{(100) - (\% \text{ in vivo organic matter digestibility})}$$

^cIntake estimated using the equation:

$$\text{Organic matter intake (\% BW)} = \frac{(100) \times (\text{total fecal organic matter output, \% BW})}{(100) - (\% \text{ in vivo organic matter digestibility})}$$

^{d,e}Means in the row with different superscripts differ ($P < .05$).

Table 3. In vitro digestibility % for 9 periods of microbial digestion and in vivo digestibility % of the 6 forages in Study 2^a.

Digestion Period (h)	Feed % Digestibility											
	Alfalfa		Sainfoin		Kochia		Millet		Timothy		Bluestem	
	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE
0	40	.52	34	.06	28	.12	28	1.58	25	.25	19	.49
8	50	.50	50	.12	34	.17	37	1.31	28	.53	22	.18
24	62	.40	63	.89	48	.49	55	1.96	49	.34	34	1.76
36	67	.41	67	1.24	52	2.01	67	1.44	56	1.35	42	.65
48	65	.25	69	.86	51	.59	68	.78	60	1.00	47	.76
60	65	.38	69	.26	52	1.57	69	1.00	63	1.21	52	1.22
72	65	.47	68	.23	53	.60	70	1.04	64	1.37	51	.11
84	65	.59	69	.61	54	.45	70	.05	65	.77	54	.49
96	66	.53	70	.09	53	.39	71	.12	67	1.08	56	1.23
In vivo digestibility	69	.87	70	3.22	59	3.46	72	2.20	69	2.04	60	2.94

^aAll data are on an organic matter basis.

forages in Study 2. We surmise that a 36-h microbial digestion period for dicots and a 72-96-h microbial digestion period for grasses would provide more accurate estimates of cattle in vivo digestibility than the standard 48-h period. An alternative would be to observe 36-, 48-, 60-, 72-, 84-, and 96-h microbial digestions and select the highest in vitro digestibility value to estimate in vivo digestibility. The rationale for this approach is based on our observation that the time period giving the highest in vitro digestibility value for each feed in Study 2 also closely represented the in vivo digestion coefficient (Table 3). However, these procedures could inflate digestibility estimates of forages retained in the rumen for periods shorter than required for complete digestion. Because of its low fiber content and high intake (Table 1), the alfalfa in our study probably had a rapid passage rate. Its in vivo digestibility was estimated to within 2 units (Table 3) by both procedures we have suggested. Therefore, we believe these procedures have potential to improve in vitro estimates of in vivo digestibility. Information on mean rumen retention times of various range forages by cattle is needed to further establish the reliability of the procedures we have described.

Urness et al. (1977) and Brooks and Urness (1984) indicate the regression equations between in vivo and in vitro digestibilities can be used to improve the accuracy of in vitro digestibility estimates. However in vivo digestibility of many forages will still be poorly estimated even if regressions are used. The procedures we have described are much simpler than regression techniques and may be equal or superior in accuracy, particularly for forages with long retention times. Our suggestions appear to merit further study.

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