A TECHNIQUE FOR ESTIMATING DRY MATTER INTAKE OF TAME FREE-RANGING MOOSE

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Abstract: Forage intakes of two free-ranging moose (*Alces alces*) were estimated during July, 1983 and of one moose in January, 1984. Dysprosium (Dy), an inert digestive marker, was given orally to each animal twice daily for twelve days; feces were collected during the last five days for determination of marker concentrations which provides an estimate of total fecal output. During the winter trial, one animal received a pulse dose of Dy for estimation of turnover time of particulates in the rumen. Daily dose and mean fecal concentration of Dy were used to estimate total fecal output while digestibility of the selected diet was determined by *in situ* nylon-bag digestion from a simultaneous study. Daily dry matter intake was estimated to be 145 g/kg $BW^{0.75}$ during July and 40 g/kg $BW^{0.75}$ during January. These values ranged 7% lower to 10% higher than dry matter intakes estimated using the ratio or bite-count methods. However, this technique obviates the logistic difficulties of total fecal collections and bite-counts during continuous 24 hour scans. The estimated rumen turnover time of Dy-labelled feedstuff during January was 31.3 hr.

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Forage intake by moose (*Alces alces*), like other ruminants, is largely a function of rumen fill, particle size reduction and fragmentation, diet digestibility and passage rate of the various pools from the rumino-reticulum. In free-ranging studies, the process of diet selection and the need for detailed observations add further complexity to the problems of estimating intake.

Forage dry matter intake can be estimated by several techniques. The *bite-count* technique has been used extensively to estimate forage consumption of free-ranging *Cervidae* (Collins 1977, Hobbs 1979, Nietfeld 1983, Wickstrom et al. 1984, Renecker and Hudson 1985). However, the method is labour intensive and requires detailed accounts of plant selection, bite size and bite rates. The *fecal nitrogen index* relies on a consistent relationship between dietary and fecal nitrogen which is highly dependent on accurate simulation of diet selection (Renecker and Hudson 1985). Alternatively, the method of choice may be the *ratio technique* which requires total fecal collections combined with estimates of diet digestibility. Daily fecal output has been determined from animals fitted with collection bags (Holechek and Vavra 1982) or from collections made by an observer (Renecker and Hudson 1985). Short et al. (1972) reviewed the use of external markers to estimate fecal output without total collections. However, few studies have explored this technique (Young et al. 1976) and compared methods which were conducted concomitantly.

The objectives of this study were to determine daily intake of tame free-ranging moose using the external marker dysprosium (Dy) and to estimate rumen turnover time of the solids pool during winter.

METHODS AND MATERIALS

This study was conducted at the Ministik Wildlife Research Station, approximately 48 km southeast of Edmonton. This area is located on the Cooking Lake glacial moraine within the aspen boreal forest zone of central Alberta (Rowe 1972).

Two habituated hand-reared moose cows were maintained in a 2 ha

pasture on a pelleted aspen-concentrate ration (Schwartz et al. 1985). The moose were 3.5 years of age at the time of this study and neither was pregnant. The animals were released into a 65 ha enclosure during July, 1983 and January, 1984 for an average of 4 weeks prior to sampling to allow for digestive adjustment (Renecker and Hudson 1985). During winter fecal output was only estimated for one animal while rate of passage of digesta was determined in the other.

Daily fecal dry matter output was estimated by administering a dose of Dy chloride to each animal twice daily for seven days prior to the trial. The purpose of the daily doses was to obtain equilibrium within the digestive tract and a constant rate of outflow of external marker in the feces. The external marker was introduced into the animal by adding a solution of distilled water and Dy chloride crystal (0.10 and 0.19 g twice daily in summer and winter, respectively) to a hollowed apple, allowing the solution to dry and then hand-feeding the apple to the moose.

Total fecal collections were made over a continuous 24 hr period and then opportunistic grab samples were taken for 3 days subsequent to the trial. Fecal samples were oven-dried at 60°C for 48 hours and then ground through a 20-mesh screen of a Wiley mill. Subsamples were accurately weighed into irradiation vials; the remaining volume of each vial was filled with sugar and the vial was heat-sealed. Fecal samples were analyzed in The University of Alberta SLOWPOKE reactor facility, using the Dy INAA scheme (Kennelly et al. 1980).

Daily fecal output was calculated as the ratio of Dy administered to the Dy in the fecal dry matter (DM). This was compared with total collection. Dry matter intake (DMI, g) was calculated from the estimated total fecal output and *in situ* nylon-bag digestibility of the diet determined by

Renecker and Hudson (1985) in a simultaneous study.

Flow rate of the particulate pool was estimated by administering a pulse dose of Dy chloride to one moose during January. A solution of distilled water and 0.723 g of Dy chloride crystal was placed in a hollowed apple, allowed to dry and then fed to the free-ranging animal. Total fecal collections were made over a continuous 24 hour period and then opportunistic rectal grab samples of feces were made for 3 additional days. Samples were oven-dried and prepared for analysis as described previously.

Outflow of Dy from the rumino-reticulum was determined by least squares regression of the natural log of marker concentration on time after the marker was administered. The resulting slope was the rate constant (k_1). Rumen turnover time (RTT) was calculated from the reciprocal of k_1 (Hungate 1966).

RESULTS AND DISCUSSION

Variation in Fecal Dy

Fecal Dy concentrations averaged 27.44 ± 1.57 ug/g DM for the two moose in July (individuals not significantly different, $P>0.05$) and 127.13 ± 2.78 ug/g DM for a single animal in January. Diel sampling schedule revealed somewhat lower values from collections made at night during July but not in January (Table 1). These daily fluctuations are consistent with results presented by Young et al. (1976) who observed lower Dy concentrations in the feces of cattle during the PM periods of the day. Since moose are less active during the night, this suggests that the lower fecal concentration may be associated with diel feeding patterns and dilution rates or variable fecal excretion rates.

Table 1. The Diel Variability in Fecal Excretion of External Marker (Dy) by Female Moose at Ministik Research Station, Alberta.

Time of Day	$\bar{X}$±SE Dy Concentration (ug/g DM)	
	Moose No. 727	Moose No. 211
July		
Morning	33.6 ± 0.3	28.9 ± 0.7
Afternoon	28.3 ± 1.9	26.1 ± 2.2
Night	20.5 ± 0.1	23.6 ± 0.2
January		
Morning	121.4 ± 4.5	
Afternoon	133.8 ± 1.8	
Night	125.0 ± 1.1	

Daily Intake and Fecal Output

Use of the Dy ratio resulted in a 8-10% over-estimation of fecal output when compared to total collections. No significant ($P>0.05$) differences were observed between the two methods probably as a result of the small sample size. However, the magnitude of these differences between techniques was consistent. Perhaps, with further testing, a correction factor could be incorporated into the equation.

Using the Dy ratio technique, the free-ranging moose consumed an average of 137.7 ± 3.2 g DM/kg $BW^{0.75}$ and 40.1 g DM/kg $BW^{0.75}$ during July and January, respectively (Table 2). In general, forage intake varied an average of 8.5% from values reported by Renecker and Hudson (1985) during a simultaneous study and were similar to those reported

Table 2. Estimates of Total Fecal Output and Dry Matter Intake of Free-Ranging Moose During July, 1983 and January, 1984.

Month	Body Weight (kg)	Daily Fecal Output (g)		Intake (g/kg $BW^{0.75}$)	
		Dy	Total Collection	Dy	Total Collection
July					
Moose No. 727	315	3,958	3,602	134.5	122.4
Moose No. 211	343	4,437	4,112	140.8	130.4
January					
Moose No. 727	346	1,805	1,652	40.1	36.7

[1] Estimates of dry matter digestibility were obtained from Renecker and Hudson (1985).

by Schwartz et al. (1984) for penned moose in Alaska. Considering the potential error of the bite-count technique and the impracticality of total fecal collections in field studies, the 10% error of intake estimates should be acceptable for seasonal free-ranging studies.

Rate of Passage

Disappearance of Dy from the rumino-reticulum was in a logarithmic pattern (Fig. 1). Fluctuations in the marker curve were probably a function of marker dilution from polyphasic feeding periods (Renecker 1985).

The RTT of Dy-labelled solids in the moose during January was 31.3 hr. In comparison, Renecker (1985) observed a lower RTT for a moose fed a diet of twigs from aspen saplings and alfalfa. The delayed turnover

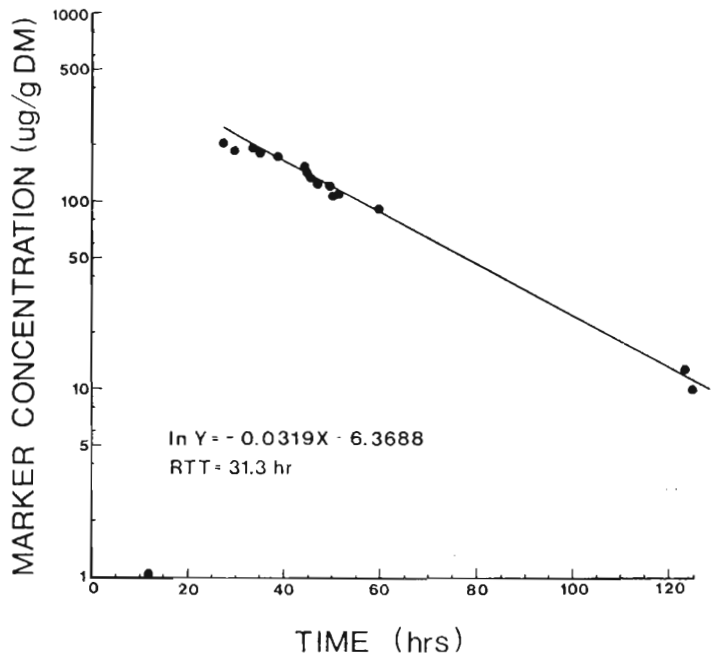

FIGURE 1. Concentration of Dysprosium (Dy) in the feces of a free-ranging moose (Moose no. 211) given a pulse dose of marker (Dy) during January, 1984.

time may reflect the reduced quality of the diet and a lower dry matter intake of free-ranging moose in this study.

Theoretically, it is possible to estimate DMI from this excretion curve (Krysl et al. 1984). In a steady-state system, intake equals output which is the product of passage rate and rumen volumes. In this trial, passage rate was 0.767%/d (24/31.3). This total volume of indigestible DM in the gastrointestinal tract can be estimated from peak Dy concentrations (at 27 hr post dosing) which was 241 ug Dy/g DM, as predicted by the equation in Fig. 1. Therefore, total fecal output is 1,392 g DM. Correcting for diet digestibility (Renecker and Hudson 1985), DMI is estimated to be 36.8 g/kg $BW^{0.75}$ (3,086 g DM) which corresponds to 35.8 g/kg $BW^{0.75}$ (3,000 g DM) for this animal using total collections (Renecker and Hudson 1985) and to 40.1 g/kg $BW^{0.75}$ (3,217 g DM) for moose no. 727 using the continuous dose method.

CONCLUSIONS

Although the sample size is small, the Dy ratio method appears to be a reasonable indicator of daily fecal output with grab sampling three times daily. The morning, afternoon and evening grab samples would avoid errors resulting from daily changes in excretion patterns. This technique, plus an *in vitro* or *in situ* estimate of dry matter digestibility, would provide an alternative procedure for determining dry matter intake. In spite of the small sample size, the results were consistent between animals during summer. The method has advantages over total collections and the bite-count technique including simplicity, applicability to free-ranging studies with large numbers of habituated moose and a lower demand for technical assistance. The technique has

an application in free-ranging studies, outside of an enclosure, where animals can be offered a Dy-labelled food, twice daily, which will be consumed readily.

This study indicates that a dose of Dy-labelled forage could be used to study passage rates of free-ranging ungulates. Although further investigations are warranted, the results are promising. Further studies with Dy-labelled feedstuffs and free-ranging moose will explain the effects of plant phenology on the retention time of digesta. However, if we want to calculate total fecal output of free-ranging animals then the pulse dose technique is clearly a reliable and more practical method. It appears to have the accuracy of the Dy ratio technique while only requiring a single dose of marker.

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