FOOD PASSAGE RATE IN MOOSE

Charles C. Schwartz,[1] Wayne L. Regelin,[2] Albert W. Franzmann,[3] Robert G. White,[4] Dan F. Holleman,[5]

[1]Alaska Department Fish and Game, Moose Research Center Soldotna, AK 99669; [2]U. S. Fish and Wildlife Service, Denver Research Center; [3]Alaska Department Fish and Game, Moose Research Center Soldotna, AK 99669; [4]Institute of Artic Biology, University of Alaska, Fairbanks, Ak 99701; [5]Institute or Arctic Biology, University of Alaska, Fairbands Ak 99701

ABSTRACT: Four tame moose (*Alces alces*) were used to measure dry matter digestion and rates of fluid passage of three diets: a pelleted ration, a mixture of pellets and winter clipped aspen (*Populus tremuloides*), and a mixture of winter clipped aspen, willow (*Salix spp.*), and paper birch (*Betula papyrifera*). Dry matter digestion was greatest for the pellets (64.3%) followed by the pellet-aspen mix (58.9%) and the mixed browse (31.1%). Time of first appearance (15.8 h), rumen turnover time (31.2 h), and total mean retention time (53.6 h) of the fluid phase of digesta were longest for the mixed browse diet.

ALCES VOL. 24 (1988) pp.97-101

In an earlier work (Schwartz *et al.* 1988) we estimated the digestibility of birch, willow, and aspen mixtures in moose. Concurrent to those studies, we measured the rate of movement of the liquid phase of material in the digestive tract and attempted to measure the same rate for solids. That work is reported here.

METHODS

Rates of passage were measured using adult (2-3 years of age) moose during three winter trials. Moose were fed *ad libitum* amounts of (1) pelleted diet (Schwartz *et al.* 1985), (2) a 60:40 mixture of the pelleted diet and current annual growth of aspen clipped in winter, and (3) a browse diet containing winter clipped current annual growth of paper birch, aspen, and willow mixed in equal parts on a wet weight basis. Moose used in all trials were hand-reared (Regelin *et al.* 1979) and maintained on the pelleted diet.

Rumen turnover times were measured using a liquid phase marker-chromium (^{51}Cr-EDTA), and a particle marker-ruthenium (^{103}RuCl). The radiolabeled markers were given as a single dose by mixing the marker with a small portion of food at a dose rate of 100 μCi and 30 μCi per 100 kg body weight for ^{51}Cr-EDTA and ^{103}RuCl, respectively. The marker was applied by pipetting an acid solution containing the isotope onto the test diet. Animals were given the food for a 30 min period, after which the uneaten portion was removed.

Fecal samples were collected after every defecation for the first 24 h and at approximately 6 h intervals for the next three days. Subsamples for radioassay were placed in pre-weighed counting vials, freeze-dried to constant weight and assayed with a dual channel gamma spectrometer (Searle Analytical Model 1195). Normal gamma-ray spectrum stripping methods were used to calculate the marker concentrations which were expressed as cpm/g water (^{51}Cr-EDTA) and cpm/g dry matter (^{103}RuCl). Time of first appearance (transit time, TT), rumen turnover time (RTT), and total mean retention time in the alimentary tract (TMRT) were calculated according to Grovum and Phillips (1973) and assuming that turnover time of rumen-reticulum contents exceeded that of the large intestine (Faichney and Boston 1983). Difference in the slope of regression lines was determined according to Neter and Wasserman 1974:160).

The reliability of ^{103}RuCl as a particle marker was tested by taking a 10 gram sample

Table 1. Particle binding of Ruthenium 103 chloride to a pelleted ration.

Time after dosage(h)	% Dosage recovered		
	Supernate (P1)	Filtrate (P1F)	Total liquids (P1 + P1F)
1.5	27.7	25.5	53.2
3.0	14.2	12.0	26.2
4.5	20.3	19.3	39.6
9.0	35.0	27.2	62.2
22.0	12.6	15.3	27.9
29.0	20.9	25.9	46.8
46.0	30.7	31.5	62.2
70.0	34.2	30.9	65.1

of the pelleted diet and labeling it with a known quantity of ^{103}RuCl (D) in a tube containing 35ml of McDougal's buffer (McDougall 1948: Table 1). Tubes were incubated at 37°C while being continuously shaken. Samples were removed at various times, centrifuged at 3000 RPM for 30 minutes, and 5ml of the supernatant removed and assayed (P1). The supernatant remaining was filtered and assayed (P1F). The % dose recovered from the supernatant was calculated as:

$$\text{Recovered} = \frac{(\text{P1 or P1F}) * (35/5)*100}{D}$$

Foods and orts were analyzed for crude protein (micro-Kjeldahl nitrogen X 6.25), gross energy, ash, and minerals (A.O.A.C. 1965), cell-wall constituents (CWC), acid-detergent fiber (ADF), and acid-detergent lignin (Van Soest 1963, Van Soest and Wine 1967, Goering and Van Soest 1970). Estimates of in vitro dry matter digestion were made using the techniques of Tilley and Terry (1963) and Pearson (1970). Rumen liquor for our studies was collected from a wild moose on winter range.

RESULTS AND DISCUSSION

Results of the experiment to test ^{103}RuCl as a solid particle marker indicated that it did not bind well with the target particles. There was a range of 26.2-65.1% of the activity associated with the liquid phase or small particles (Table 1). Time of incubation seemed to have little effect on the amount of binding taking place so that correction for nonbinding was not possible. These results confirm findings of Faichney (1980) for sheep fed concentrate diets and they verify that there would be masking of particulate flow rate and digesta particles would be retained longer than determined in this study (Hubbert 1985). Because the solid marker did not perform adequately, we will only present results for liquid markers.

Composition of the pelleted diet and individual components of the mixed diets (Table 2) varied chemically. The fiber component as indicated by CWC and ADF estimates, varied markedly between the pellets and mixed browse diets. The aspen-pellet diet was similar to the pelleted ration. Voluntary intake and digestion of dry matter were higher for the pelleted diet and the aspen-pellet diet than for the mixed browse diet (Table 3). Estimates of in vitro dry matter digestion (Table 2) were very similar to those obtained with conventional digestion trials (Table 3). Time of first appearance of the markers (TT) was similar

Table 2. Chemical composition of diets fed to moose during rate of passage studies at the Kenai Moose Research Center, Soldotna, Ak.

		Analysis of Dry Matter						
Trial No. (diet)	Dry Matter (%)	Gross Energy (kal/g	Crude Protein (%)	CWC (%)	ADF (%)	Lignin (%)	Ash (%)	In vitro Dig(%)
1 (pelleted ration)	80.4	4.3	12.1	54.4	26.8	5.8	5.8	62.6
2 (pelleted ration)	83.4	4.3	12.9	59.4	19.7	4.1	6.7	67.9
(aspen)	43.6	5.1	7.9	54.9	40.1	10.5	1.9	42.0
3 (birch)	66.0	5.2	6.7	72.8	58.0	26.5		19.9
(willow)	54.4	5.1	7.6	64.1	54.2	25 1		30.8

among the three trials; however, RTT and TMRT for the liquid fraction was significantly ($P < 0.05$) longer for the browse diet (Table 3).

RTT of the liquid phase of the mixed browse diet (31.2 h, Table 3) was within the range presented by Hjeljord *et al.* (1982) for a variety of browse species (21.3-33.9 h range). RTT of the liquid phase of the mixed diet (aspen-pellets) and the pelleted diet was faster than both the hay and browse diets fed by Hjeljord et al. (1982).

Studies of food passage rates in domestic sheep (Uden *et al.* 1982) and muskoxen (*Ovibos moschatus*) (Holleman *et al.* 1984) consistently demonstrated faster movement of the liquid phase marker as compared to the particulate matter marker, suggesting a faster movement of the liquid phase of digesta. The latter study presented data which indicated that ^{103}RuCl was an acceptable particulate matter marker, based on a separation between the solid and liquid phases. Our results clearly demonstrate that the ^{103}RuCl was not an adequate solid marker. Additional studies with an adequate solid particle marker are required to determine if solids and liquids flow at different rates through the digestive tract of moose.

ACKNOWLEDGEMENTS

Many individuals contributed to various aspects of data collection and analysis. We thank M. A. Schwartz, D. Johnson, and D. C. Johnson for help with animal care and digestion experiments and M. E. Hubbert, L. A. Renecker, K. B. Schneider and S. R. Peterson for reviews of the manuscript. Funding for these studies was provided in part by the

Table 3. Intake of dry matter (DM) and liquid passage rates for three diets fed to adult moose in winter at the Moose Research Center, Soldotna, Alaska.

	Diet		
Component + SE	pellets	Aspen/pellets	mixed browse
No. animals	4	3	4
Animal weight (kg)	353±2.1	347±6.3	419±8.8
Intake of DM ($g/kgW^{0.75}$/day)	80.1±0.9	52.4±6.3	25.4±1.8
DM digestion (%)	64.3±0.6	58.9±0.7	31.1±1.1
Transit time (h)	13.3±2.1a	13.0±1.5a	15.8±1.9a
Rumen turnover time (h)	17.6±1.5a	18.7±1.3a	31.2±2.3b
Total mean retention time (h)s	38.2+1.0a	38.0+1.8a	53.6+2.9b

a,b - Any two means followed by a different letter are significantly different ($P<0.05$) according to Duncan's New Multiple Range Test.

Morris Anim. Found. and from Fed. Aid in Wild. Restoration, Proj. W-17 and W-21.

REFERENCES

ASSOCIATION OF OFFICIAL AGRICULTURE CHEMISTS. 1965. Official methods of analysis. 10th ed. Assoc. Off. Agric. Chem., Washington, D. C. 957pp.

FAICHNEY, G. J. 1980. Measurement in sheep of the quantity and composition of rumen digesta and of the fractional outflow rates of digesta constituents. Aust. J. Agric. Res. 31:1129-1137.

FAICHNEY, G. J. and R. C. BOSTON. 1983. Interpretation of the fecal excretion patterns of solute and particle markers introduced into the rumen of sheep. J. Agric. Sci. Camb. 101:575-581.

GOERING, H. K., and P. J. VAN SOEST. 1970. Forage fiber analysis. U.S. Dep. Agric., Agric. Handb. 379. 20pp.

GROVUM, W. L., and G. D. PHILLIPS. 1973. Rate of passage of digesta in sheep. 5. Theoretical considerations based on a physical model and computer simulation. Br. J. Nutr. 30:377-400.

HJELJORD, O., F. SUNDSTOL, and H. HAAGENRUD. 1982. The nutritional value of browse to moose. J. Wildl. Manage. 46:333-343.

HOLLEMAN, D. F., R. G. WHITE, K.

FRISBY, M. JOURDAN, P. HENRICHSEN, and P. G. TALLAS. 1984. Food passage rates in captive muskoxen as measured with non-absorbed radiolabeled markers. Pages 188-192 in D. R. Klein and R. G. White, eds. 1st Int. Muskox Symp. Biol. Pap., Univ. of Ak. Rep. No. 4.

HUBBERT, M. 1985. Evaluating and testing techniques for moose management. *In.* Moose Research Center Report. Ak. Dept. Fish and Game. Fed. Aid Wildl. Rest. Prog. Rep. Proj. W-22-4.

MCDOUGALL, E. I. 1948. Studies on ruminant saliva. 1.The composition and output of sheep's saliva. Biochem. J. 43:99-109.

NETER, J., and W. WASSERMAN. 1974. Applied linear statistical models. Richard D. Irwin publ., Homewood, Il. 842pp.

PEARSON, H. A. 1970. Digestibility trials: in vitro techniques. Pages 85-91 *In* Range and wildlife habitat evaluation--a researach symposium. U.S. For. Serv., Misc. Publ. 1147.

REGELIN, W. L., C. C. Schwartz, and A. W. Franzmann. 1979. Raising, training, and maintaining moose (Alces alces) for nutritional studies. Proc. Int. Congr. Game Biol. 14:425-429.

SCHWARTZ, C. C., W. L. REGELIN, and A. W. FRANZMANN. 1985. Suitability of a formulated ration for moose. J. Wildl. Manage. 49:137-141.

SCHWARTZ, C. C., W. L. REGELIN, and A. W. K. 1988. Estimates of digestibility of birch, willow, and aspen mixtures in moose. J. Wildl. Manage. 52:33-37.

TILLEY, J. M. A., and R. A. TERRY. 1963. A two-stage technique for the in vitro digestion of forage crops. J. Br. Grassland Soc. 18:104-111.

UDEN, P. , T. R. ROUNSAVILLE, G. R. WIGGANS and P. J. VAN SOEST. 1982. The measurement of liquid and solid digesta retention in ruminants, equines and rabbits given timothy (Phleum pratense) hay. Br. J. Nutr. 48:329-339.

VAN SOEST, P. J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fiber and lignin. J. Assoc. Off. Agric. Chem. 46:829-835.

VAN SOEST, P. J., and R. H. WINE. 1967. Use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell-wall constituents. J. Assoc. Off. Anal. Chem. 50:50-55.