Influence of Frequency of Drinking on Particulate Passage Rate and Dry Matter Disappearance in Grazing Zebu Cattle

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Abstract

Three ruminally cannulated zebu steers were used in a water restriction study. Three drinking frequencies were imposed on the steers: watered daily, once in 2 days, and once in 3 days. Particulate rate of passage was estimated by dosing steers with Yb-labeled forage and collecting fecal grab samples for a 5-day period. Steers were grazed from 0700 h to 1800 h, then brought back to drink, and penned overnight. Particulate passage rate decreased ($P<0.05$) from 3.8 to 2.5 and 2.1 %/h, while total mean retention time increased ($P<0.01$) from 54.0 to 65.2 and 80.2 h for steers watered once daily, once in 2 days, and once in 3 days, respectively. In situ dry matter disappearance in the rumen was increased ($P<0.01$) and dry matter intake decreased by one-third to two-thirds ($P<0.01$) by water restriction.

Key Words: intake, particulate passage rate

Retention time of digesta and associated rate of passage are highly related to forage intake and digestibility in ruminants (Robles et al. 1981, Hendricksen et al. 1981, Mudgal et al. 1982, Varga and Prigge 1982). Increased passage rate may reduce fiber digestion; however, it may increase intake, enabling the animal to assimilate the same or greater amounts of energy. Robles et al. (1981) reported decreased dry matter and cell wall intake of various forage hays was accompanied by increased digesta retention time. Increases in both fluid and particulate turnover rate in sheep were associated with higher intakes of alfalfa and orchardgrass (Varga and Prigge 1982).

Previous work has shown zebu cattle *(Bos indicus)* are more efficient in water utilization than temperate breeds *(Bos taurus).* Zebu cattle have lower water turnover rates, lower water intakes, and are better adapted to water stress than temperate breeds (McFarlane and Howard 1966). These characteristics may be associated with ruminal digesta kinetics and gastrointestinal tract functions whereby rate of passage of both fluid and particulate portions of digesta are decreased with water stress. Such changes may alter digestibility, because digestibility of fibrous feeds is somewhat increased under conditions of reduced water and feed consumption (Johnson et al. 1966, Singh et al. 1976, Thornton and Yates 1968).

This study was conducted to test the hypothesis that alterations in frequency of watering affect particulate digesta kinetics of grazing zebu cattle. Forage intake and in situ dry matter disappearance were also evaluated.

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Experimental Procedure

Three esophageal-fistulated and 3 ruminally cannulated zebu steers of similar ages and weighing between 300 to 360 kg, were used in the study. Esophageal-fistulated steers were used to collect esophageal masticate samples from a 50-ha plot being grazed by all experimental steers in July, 1984, when forage was dry and dormant. A complete description of the study area and vegetation has been provided by Musimba et al. (1987). Briefly, the study was conducted at the National Range Research Station, Kiboko, Kenya. Minimum and maximum temperatures during the study period were 20 and 25° C, respectively. Precipitation was less than 5 mm during the trial. Botanical composition of esophageal masticate during the trial (Musimba 1986) indicated perennial grasses comprised 84.7% of the diet, annual grasses 3.3%, and browse 12%. The ruminally cannulated steers were subjected to 3 watering regimens of once daily (1/1), once every 2 days (1/2), and once every 3 days (1/3). Because of the minimal number of ruminally cannulated steers, a completely random design was adopted such that the 3 steers were put into each treatment at the same time for 5 days, then to the next treatment, and so on, with a 1-wk interval for adaptation to treatments. Steers were allowed to drink for 1 h only in the evenings and penned overnight.

Masticate samples were collected from esophageal-fistulated steers on 3 consecutive days for .5 h daily, composited across days for each animal, and subsampled for chemical analysis. A batch of 20 kg wet weight of esophageal masticate was weighed and labled with Yb, a particulate phase marker, by the procedure described by McCollum and Galyean (1985). Briefly, the procedure involved washing forage once with distilled water to remove soil or salivary contamination. Forage was labeled with a solution containing 2.5 g $YbCl_3 \, xH_2O$ in proportions of 50 g dry matter/liter for 24 h with occasional stirring. Labeled forage was washed 6 times with distilled water at 1-h intervals to remove unbound Yb. After labeling the forage, portions of 800 g wet weight were weighed into plastic bags and refrigerated before dosing into the steers. Another portion of about 1,000 g wet labeled forage was dried at 50° C, ground through a 2-mm screen in a Wiley mill, and stored for Yb analysis.

For each treatment, the 3 ruminally cannulated steers were dosed with one 800-g portion of labeled forage at 0600 h. The ruminal cannula plug was removed, a portion of the ruminal fluid squeezed into a container, and the labeled forage pushed into the rumen and mixed with other ruminal contents, after which the plug was put back in place.

Rectal grab samples were obtained from each steer at prescribed times as follows: 4-h intervals for the first 1 1/2 days (0, 4, 8, 12, 16, 20, 24, 28, 32, 36 h); 6-h intervals for the next 1 1/2 days (42, 48, 54, 60, 66, 72 h); and 12-h intervals at 84, 96, 108, 120 h postdosing. Grab samples were separately dried (50° C) for each steer per sampling time, ground through a 2-mm screen, and saved for determination of Yb. For both fecal grab samples and the originally labeled forage, Yb was extracted by the method of Hart and Polan (1983) and determined by atomic absorption with a nitrous oxide/acetylene flame. Standards for Yb analysis were made in 0 h collections of extracted feces. Rate of passage measurements of the particulate phase of digesta in the gastrointestinal tract were calculated using Yb excretion curves fitted to a one-compartment model (Ellis et al. 1979). Estimates included particulate flow rate, transit time (TAU), and total mean retention time. Fecal output estimates were also derived from one-compartment model by the method described by Krysl et al. (1985).

A portion of the unlabeled esophageal masticate was air dried and ground through a 2-mm screen before being used to estimate dry matter disappearance by a nylon bag (in situ) digestion procedure. Nylon bags were 5 × 10 cm in size with 50 threads/cm and openings that could not be seen under 400 × magnification. Dry, pre-weighed bags with 2.0 g esophageal forage were secured to a 60-cm nylon cord with a small metal chain and placed in the ventral sacs of the rumens of the 3 ruminally cannulated steers for 48 h. Ten samples bags were suspended in the rumen of each steer. Upon removal, bags were thoroughly washed, dried to constant weight and reweighed. Dry matter disappearance was calculated according to the procedure of Whittington and Hansen (1985).

Dry matter intake was calculated from the estimated fecal output and in situ digestibility of each steer by the equation of Van Dyne (1968) as

$$\text{Forage intake (kg/d)} = \frac{\text{Fecal output (kg/d)}}{100 - \text{\% In Situ Digestibility}} \times 100$$

Chemical analyses of the unlabled masticate (Table 1) was carried out to determine ash and Kjeldahl nitrogen content (AOAC 1980) and dietary fiber components (neutral detergent fiber, acid detergent fiber and lignin) according to Goering and Van Soest (1970).

Data from various measurements were subjected to statistical analysis using general linear models procedure of the Statistical Analysis System (SAS 1982). Treatment means were compared for statistical differences by the least significant difference method.

Table 1. Chemical composition of the forage grazed by steers in July, 1984.

Item[a]	%	SE[b]
Neutral detergent fiber	72.0	.38
Acid detergent fiber	49.0	.83
Acid detergent lignin	8.9	.27
Cellulose[c]	40.2	.81
Hemicellulose[c]	23.0	.63
Crude protein (N × 6.25)	6.1	.24
Ash	11.0	.14

[a]Organic matter basis except ash which is expressed on a dry matter basis.
[b]Standard error of the mean.
[c]Calculated from detergent fiber analyses.

Results and Discussion

Restricted watering regimens of (1/2) or (1/3) decreased particle passage rate ($P<0.05$) compared with daily drinking; however, differences between the (1/2) or (1/3) regimens were not significant (Table 2). The decrease in particle flow rate would in this case be associated with reduced water and dry matter intake because water content of digesta does not change appeciably until water is reabsorbed in the lower gut, thus producing dry feces in cattle and sheep (Thornton and Yates 1968, Grovum and Hecker 1973). This results in conservation of water because of reduced particulate water flow rate. Transit time (TAU), or time of first appearance of marker in feces, did not differ among treatments, although it was slightly increased with the (1/3) water drinking frequency. Total mean retention time of particulate digesta throughout the gastrointestinal tract increased ($P<0.01$) from 54 h at (1/1) to 80.2 h at (1/3) drinking frequency, respectively, with the (1/2) drinking frequency intermediate at 65.2 h.

Dry matter disappearance during 48 h incubation in the rumen increased ($P<0.01$) with water restriction. Differences between (1/2) and (1/3) treatments, however, were not significant. Reasons for the increased in situ digestibility with water restriction are unclear. In situ estimates would not be affected by retention time per se, thus, the data suggest watering regimen had a direct influence on fermentive activity of the microbial population in the rumen.

Dry matter intake decreased ($P<0.01$) by 32% when steers were allowed to drink once in 2 days compared with those drinking daily. There was further decrease in intake ($P<0.01$) when the steers were drinking once in 3 days.

In a companion study conducted with 15 steers per treatment group from February to July, 1984, Musimba et al. (1987) found no effect of watering frequency on steer weight gains. Liveweight changes were not measured in the present trial. Water-restricted steers may be able to compensate for decreased intake by improvements in digestibility, thereby yielding similar weight change patterns among treatments.

Passage rate estimates for zebu steers used in the present experiment were lower than those obtained with temperate breeds of cattle. For example, particulate flow rates and transit times for zebu steers were almost half those of temperate cattle breeds (compare 3.8%/h with 7.5/h particulate flow rate and 21.4 h with 11.8 h transit times reported by Hartnell and Satter 1979). These differences may have partially been the result of breed differences or differences in dry matter intake between the studies. The (1/1) watering regimen may have been insufficient to meet water requirements, thereby imposing a limit on intake. Musimba (1986) reported water intakes by intact steers in a companion grazing study conducted at the same time as the present trial. Daily, water intake (ml/kg body wt) did not differ among steers on the 3 watering regimens but tended to be less for (1/3) steers (49.4) vs (1/1) and (1/2) steers (64.4 and 61.7, respectively). These water intakes are similar to those reported by Phillips (1960) under conditions of unrestricted water intake in zebu steers. Thus, it is unlikely water intake of the (1/1) treatment restricted forage intake to any great extent. Results may reflect the characteristic of zebu cattle for high water use efficiency or water economy (Quartermain et al. 1957).

Similar reductions in intake to those observed in the present study with water restriction were noted by Phillips (1960), who worked with *B. taurus* and *B. indicus* pen-fed steers in Kenya. In the work of Phillips (1960), however, the effect of water restriction on intake was greater in *B. taurus* than *B. indicus*. Total mean retention time was increased by water restriction, which corresponds to the reduction in particulate passage rate. These findings support the suggestion of Campling (1970) that rate of digesta disappearance from the reticulorumen is involved in controlling

Table 2. Particulate passage rate, in situ dry matter disappearance and dry matter intake of Zebu steers under three water drinking frequencies.

	Drinking Frequency[a]			
	1/1	1/2	1/3	SE[b]
Particle passage rate, %/h	3.8[d]	2.5[e]	2.1[e]	0.22
TAU, h[c]	21.4	18.3	23.1	1.27
Total mean retention time, h	54.0[f]	65.2[g]	80.2[h]	1.34
In situ dry matter disappearance, %	68.5[f]	74.7[g]	71.3[fg]	0.22
Dry matter intake g/kg body wt	37[f]	25[g]	13[h]	1.8

[a]Drinking frequencies were: 1/1 (daily), 1/2 (once in two days) and 1/3 (once in three days).
[b]SE = standard error of the mean (3 observations/treatment)
[c]TAU = time of first appearance of marker in feces.
[de]Row means with different superscripts differ ($P<0.05$)
[fgh]Row means with different superscripts differ ($P<0.01$).

voluntary feed intake by ruminants. Also, Robles et al. (1981) and Hartnell and Satter (1979) reported that as retention time increased, intake of dry matter by sheep and cattle decreased. Thus, it can be suggested, under the conditions of this study, water intake played an important role in clearing the gastrointestinal tract of undigested food particles, thus physically influencing intake. The extent to which the effects of water intake are mediated through effects on salivary secretions, fluid digesta passage, and body water turnover merit further study.

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