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Soil Ingestion by Cattle Grazing Crested Wheatgrass

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Highlight: Soil ingestion rates were determined using four 350-kg esophageal fistulated heifers. Soil concentrations in feces, as determined indirectly by titanium analysis, averaged 14 and 20% in June and August, respectively. Calculated soil ingestion rates were 0.73 and 0.99 kg/animal-day for the two respective periods.

Although grazing animals may deliberately ingest soils, generally they consume soil inadvertently with the forage. This ingested soil may serve as a source of essential minerals (Healy et al. 1970, and Suttle 1974) like copper (Cu). For example, Stoszek (1976) observed that while three grass-fed cattle became severely Cu depleted, a fourth animal, which had the habit of eating soil, accumulated Cu. Stoszek concluded that the ingested soil contributed to the dietary Cu intake.

However, soil ingestion may be detrimental because of increased tooth wear, physical impaction in the digestive tract, or because of indirect effects of harmful chemicals adsorbed to soil particles. A. L. Lesperance (University of Nevada, Reno, personal communication) reported that 4- and 6-liter volumes of washed sand were removed periodically from the reticula of 210 kg rumen-fistulated cattle grazing a desert shrub range in southern Nevada. Even small pebbles have been retrieved from cow feces during rectal palpations for pregnancy tests (J. H. Lowery, DVM, Twin Falls, Idaho, personal communication). Young calves and lambs often directly ingest soil, which occasionally leads to colic and death. Sand colic or soil impaction is also found in horses, especially when deprived of adequate feed, or when they are fed on sandy paddocks.

The effect of soil ingestion on tooth wear is of economic importance to livestockmen. Dr. Lowery (personal communication) noted that 7-year-old cows on northern Nevada range had teeth like 12-year-old cows on southern Idaho range where soil ingestion levels and mineral hardness values may be lower. Soil particles harder than tooth enamel will gradually grind the teeth down to a level where they are no longer effective during mastication, therefore decreasing animal performance. The degree of tooth wear will depend not only on the amount of soil ingested, but on the soil type or mineral. Apatite (a mineral similar to tooth enamel), opal (like that found in plant-absorbed silica phytoliths), and quartz have hardness values of 5, 4-6, and 7 Mhos, respectively, as compared with 10 Mhos for diamond. Thus, many soil particles have no effective abrasive action when ground against tooth enamel. However, it is readily apparent that the effect of soil ingestion on animal performance will depend on the soil type and amount ingested.

A technique using titanium (Ti) as an external marker is available to quantify soil ingestion levels. Titanium is abundant in soils, is not taken up by plants (Healy 1968), and is not absorbed by animals (Miller et al. 1975). Thus, soil and fecal Ti concentrations can be determined and then soil intake rates can be calculated or estimated from dry matter intake and digestibility data or from the amount of total dry matter excreted.

In this paper, we report soil ingestion rates for cattle grazing a crested wheatgrass range in southern Idaho.

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Methods and Procedures

The study was conducted on pasture No. 04 of the Point Springs Experimental Range, 19 km (12 miles) east of Malta, Ida., on a mesic, alluvial fan with a calcareous sandy loam soil supporting a good stand of crested wheatgrass (*Agropyron desertorum*) and some annual forbs. The annual precipitation ranges from 150 to 450 mm.

In 1974, four 350-kg esophageal fistulated Hereford heifers were preconditioned for 2 weeks on the 32-ha crested wheatgrass pasture before the first test period (June 9 to 22), and continued on that same pasture through the second period (August 4 to 16).

During each test period, 10 g of an external marker (5 g Cr_2O_3 + 5 g purified cellulose formulated in gelatin capsules) was administered twice daily. The mass of dry matter excreted was calculated from the dilution of Cr_2O_3 (determined by atomic absorption in fecal grab samples taken at 0600 and 1800 hours (Lesperance and Bohman 1963). Dry matter intake was calculated from fecal mass and changes in acid detergent lignin (Van Soest 1964) concentrations between esophageal-forage samples and the fecal samples. The esophageal-forage samples were collected in bags (with screen bottoms for saliva drainage) attached to grazing animals from 0600 to 0700 hours on each of the last four days of the two test periods.

Dry matter intake, excretion, and apparent digestibility were calculated using the following equations:

$$\text{Fecal DM output (g/day)} = \frac{Cr_2O_3 \text{ consumed (g/day)}}{Cr_2O_3 \text{ concentration in feces (g/g)}}$$

$$\text{Dry matter intake (g/day)} = \frac{[\text{fecal DM output (g)}]\,[\text{lignin in feces (\%)}]}{\text{lignin in esophageal forage sample (\%)}}$$

$$\text{Apparent digestibility (\%)} = \frac{[\text{DM intake (g)}] - [\text{fecal DM (g)}] \times 100}{\text{DM intake (g)}}$$

Composite forage samples were obtained during the June and August test periods by clipping wheatgrass to a 2-cm stubble height. Forage dry-matter yield for June 29 was 360 kg/ha, as compared with a long-term average of 560 kg/ha. Forage, esophageal, and fecal samples were dried at 50°C for 48 hours and ground to pass a 1-mm screen. Samples used to determine digestibility and intake were composited into one sample for each animal and each test period.

The soil concentration in feces was determined indirectly by measuring the Ti concentration in both feces and soil by x-ray fluorescence spectrophotometry (Mayland et al. 1975). A set of reference samples was prepared by adding known amounts of soil to a fecal sample, which did not contain soil. The added soil represented the < 480 μm portion of a composite series taken from the 0.1-cm depth of pasture No. 04 and was found by the method of TiO additions to contain 3,100 ppm Ti.

A second approach to estimating soil ingestion is to measure acid-insoluble residue (A.I.R.). The forage and fecal A.I.R. includes the acid-insoluble portions of soil and biogenic silica (the Si absorbed by the plant to the transpiration stream) present in the sample. The A.I.R. was determined as the oven-dried residue remaining after dry-ashing clipped forage, esophageal, fecal, and soil samples at 550°C for 6 hours, followed by leaching samples with 50-ml 2*N* nitric acid and 100 ml H_2O (Mayland et al. 1975).

Results and Discussion

Fecal soil concentrations determined by the Ti method were 14 and 20% of total dry matter excretions in June and August, respectively (Table 1). The amounts of ingested soil calculated from forage intake and digestibility data were 0.73 and 0.99 kg/animal-day for the two test periods. These soil ingestion rates for grazing cattle are similar to the 0.5 to 0.87 kg/animal-day reported in New Zealand (Healy 1968); 0.46 to 0.78 kg/animal-day in southwestern England (Thornton 1974); and 0.1 to 1.5 (median of 0.5) kg/animal-day on semidesert rangeland in Idaho (Mayland et al. 1975).

The A.I.R. values of clipped forage were calculated as 0.36 and 0.39 kg/animal-day for the June and August periods, respectively. The respective esophageal A.I.R. values were 0.46 and 0.45 kg, which were greater than those for the clipped forage because animals were ingesting more soil than that found on the clipped forage. The esophageal A.I.R. values were not as great as the respective 0.68 and 0.90 kg/animal-day values calculated from fecal material, because some soil was likely leached from the esophageal sample and lost with the saliva through the screened collection bag. These fecal A.I.R. values resemble soil A.I.R. values of 0.67 and 0.91 kg/animal-day for the June and August periods, respectively. Soil A.I.R. equaled soil excretion levels determined by the Ti method after correcting for the 8% loss in weight when subjected to the A.I.R. procedure. Assuming that the amount of biogenic silica remaining in the fecal A.I.R. is small or negligible, we can be quite confident in these soil ingestion measurements.

Table 1. Number of samples; mean dry matter-intake, -excretion, and -digestibility; acid-insoluble residues (A.I.R.) of various components; and mean fecal soil levels determined by the Ti method.

	Sampling date	
Component	June 16–22	August 6–15
Number of samples		
Clipped forage	2	2
Esophageal	10	10
Fecal samples	30	39
Dry matter		
Intake (kg/animal-day)	10.4	8.6
Excreted (kg/animal-day)	5.3	5.0
Digestibility (%)	49	42
A.I.R. in daily dietary intake or equivalent		
Clipped forage (kg/animal-day)	0.36	0.39
Esophageal (kg/animal-day)	0.46	0.45
Fecal (kg/animal-day)	0.68	0.90
Soil (kg/animal-day)[1]	0.67	0.91
Fecal soil by Ti method		
Concentration (%)	14	20
Amount (kg/animal-day)	0.73 ± .02[2]	0.99 ± .03[2]

[1] Ingested soil mass as determined by the Ti method and corrected for 8% loss in mass when soil is subjected to acid-insoluble residue procedure.

[2] Error associated with soil determination only and does not include errors associated with forage intake and digestibility determinations.

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