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SOIL INGESTION BY UNGULATES GRAZING A SAGEBRUSH-BUNCHGRASS RANGE IN EASTERN OREGON

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Ingested soil by the grazing animal not only contributes to the wear of the animal's teeth, but may also be a source of dietary minerals. Thus, an estimate of soil intake is a necessary factor in the determination of the amount of minerals entering the animal via the soil.

Titanium (Ti), a rare earth element, is relatively abundant in soils, but is found only in small quantities (1 part per million) in plants not contaminated with soil (Healy, 1968). Thus, its presence in the feces of grazing animals is a reflection of: (1) eating soil-contaminated forage; (2) ingesting soil directly; (3) drinking soil-contaminated water. Mayland et al. (1975) investigated the Ti method in Idaho and found it useful for estimating soil ingestion by cattle grazing a semiarid range. Recently, Mayland and Sneva (in press) discuss the Ti method's usefulness to range investigations.

This paper presents Ti values determined in the soil and in feces of five ungulates grazing a sagebrush-bunchgrass range over a two-year period. From those findings the annual mean soil intake per ungulate was estimated and discussed relative to the variability in the data.

PROCEDURE

Sagehen Summit, an elevated plateau of about 65 square miles, lies about 4,501 feet above sea level 13 miles west of Burns, Oregon. It is a mule deer winter range which is also grazed by sheep and cattle in spring, summer, and fall under a Bureau of Land Management permit. It is also grazed all year by about 200 antelope and 25 to 35 wild horses.

Vegetation on the plateau is a mosaic of western juniper (Juniperus occidentalis), big and low sagebrush (Artemisia tridentata and arbuscula), rabbitbrush (Chrysothamnus spp.), and bitterbrush (Purshia tridentata). The associated grasses are bluebunch wheatgrass (Agropyron spicatum), needlegrass (Stipa spp.), bottlebrush squirreltail (Sitanion hystrix), Idaho fescue (Festuca idahoensis), Junegrass (Koeleria cristata), and bluegrass (Poa sandbergii and cusikii). Broadleaf plants contribute less than 10 percent of the total understory and are dominated by the phloxes (Phlox spp.) and locoweeds (Astragalus spp.). Cheatgrass (Bromus tectorum) is present in some areas.

Fecal samples were collected periodically over the two-year period from May 1975 to April 1977. Animals first were located and observed in the field and the area then was searched for fresh feces. The goal was to obtain five fecal samples from each animal class per date, but this was not always achieved. Field sampling attempted to minimize obtaining soil contaminated feces. Samples were immediately frozen and stored in a freezer until analyzed.

Soil samples from the surface two inches were taken in four locations to provide an estimate of soil Ti concentration. Preparation of soil and feces for subsequent colormetric determination of Ti followed that described by Mayland et al. (1975).

RESULTS AND DISCUSSION

Titanium concentration was 5,300, 5,900, 9,400, and 13,900 parts per million (ppm) for soil associated with low sagebrush, big sagebrush, rabbitbrush and buckwheat (Eriogonum) sites, respectively. Such a wide range in Ti concentration was unexpected and created difficulty in interpreting results. The mean of those values, 8,525 ppm, was used in subsequent computations; but the reader is cautioned that the Ti concentrations varied greatly and computed results could be from 62 percent less to 58 percent more than the concentrations estimated from the mean.

Mean Ti concentration in the feces by animal species per sampling date is presented in Table 1. Fecal samples visually observed to be contaminated with soil at time of sample preparation in the laboratory were so noted--all had exceedingly high Ti values and were excluded from the data presented in Table 1. Six percent of the 232 samples were so excluded. Standard errors averaged 48, 23, 31, and 38 percent of the mean for mule deer, antelope, cattle, and horses, respectively. Tests to determine significant mean differences between and among animal species on dates on raw or on transformed data all produced nonsignificant differences. This is not surprising in light of Ti variability encountered in the soil and feces. Also, because of complex patterning of the soil-vegetation type, the free-roaming nature of the animals, and the delayed time interval between foraging and defecation, the opportunity for variability is great. Thus, we were hampered statistically in discussing Table 1; yet, there were some overall trends, differences, and incidences which can be pointed out and perhaps are real.

Mule deer feces had the lowest Ti concentrations, averaging 442 ppm. Forage selectivity by deer was strongly oriented towards sagebrush, juniper, and bitterbrush, which all present an elevated browsing surface, thereby minimizing soil contamination except for dust via air turbulence. Most deer samples were from late fall, winter, and spring periods when soil surfaces were most apt to be moist or snow-covered, further minimizing soil contamination. Elevated Ti values in deer feces in February, March, April and December of 1976 were associated with increased intake of Sandberg bluegrass and fall germinated cheatgrass. Both grasses are low-growing and grazing them would increase the susceptability to soil intake.

Sheep grazed the area for only a short time in the spring of each year. Diets were primarily the large bunchgrasses. Mean Ti concentration of 702 ppm was similar to that for cattle (720 ppm), which selected similar forage for those months.

Titanium levels in cattle feces from March through December varied from 390 to 1721 and averaged 879 ppm. Cattle diets consistently contained 95 percent or more of the dominant bunchgrasses. Variation among dates is not readily explained. Direct soil contamination should have been minimal, as the sample was spooned from the center of the pat. Differences may be the result of Ti level in soil relative to where the animal was grazing, or intake of soil through drinking of muddied surface water.

Table 1. Concentrations of Ti in feces of ungulates grazing sagebrush-bunchgrass range (means of 2 to 5 samples/date[1].

	Cattle	Horse	Mule deer	Antelope	Sheep	Surface condition
			ppm			
May 1975	716[4]	-	-	688[2]	-	dry
June 1975	390	339	212	353	239	dry
Aug. 1975	739[3]	690[4]	-	673[3]	-	dry
Sept. 1975	-	-	122	491[2]	-	dry
Nov. 1975	-	-	-	478	-	dry
Jan. 1976	-	108[2]	337	305[4]	-	5-12 inches snow
Feb. 1976	-	1279	611[4]	-	-	freewater surface
Mar. 1976	-	1128	841	631	-	moist to muddy
April 1976	576	2029[4]	618[2]	2230[4]	936	dry
May 1976	1497	1389	-	2633[2]	700[3]	dry
June 1976	415[2]	846[3]	-	532[2]	758[4]	dry
Aug. 1976	1721	1827	-	1880	-	dry
Sept. 1976	1197	1174[4]	-	-	-	dry
Dec. 1976	796	982	762	1134	-	dry
Jan. 1977	-	1204	286[4]	-	-	4-5 inches snow
Mar. 1977	-	1451[4]	227	610	-	moist to muddy
April 1977	747	1137	405[3]	875[2]	-	dry
Mean	879	1113	442	965	702	

1 Superscripts denote number of individual samples comprising the mean. No superscript denotes 5 sample/mean.

Antelope feces exhibited the widest range of Ti concentration, ranging from 305 to 2,633 and averaging 964 ppm. These estimates may be biased because (1) antelope tended to be most often observed in the buckwheat and rabbitbrush sites which had the highest Ti concentrations in the soil, and (2) it was most difficult to obtain feces from antelope that were not directly contaminated by soil particles. Antelope, like deer, browsed primarily on sagebrush, juniper, and bitterbrush except in early spring when Sandberg bluegrass and forbs made up 50 percent of their diet, and in late fall when that grass and the major bunchgrasses contributed significantly to their diet. Generally, spring and fall samples showed elevated Ti concentrations.

Horse feces contained the highest mean Ti, 1,113 ppm, and ranged among dates from 339 to 2,029 ppm. Forage selected by horses was nearly 100 percent from the major bunchgrasses. The higher concentration of Ti in horse feces compared to cattle feces is perhaps best explain by differences in foraging habit. The horse rolls his lips back and bites the forage off, whereas the bovine wraps the tongue around the forage, binds the forage between teeth and pad, and then tears the forage loose. The horse is apt to have direct soil contact around the grass clump.

Annual amounts of soil ingested by cattle, horses, mule deer, and antelope are shown in Table 2. Mean body weights are those commonly used by management agencies in Oregon. Daily forage intake was computed as 2.5 percent per 100 pounds of live body weight. Sixty percent dry matter digestibility was utilized throughout. Mean fecal Ti are those recorded in Table 1. Calculations for total Ti amount followed procedures set forth by Mayland et al. (1975) with total soil ingestion adjusted by the mean soil Ti concentration of 8,525 ppm.

Table 2. Soil intake estimates for ungulates grazing a sagebrush-bunchgrass range

Species	Body weight[1]	Forage intake[2]	Fecal Ti[3]	Soil intake[4] lbs/yr
	lbs	lbs/day	ppm	
Cattle	1000.9	25.0	879	458.6
Horse	1000.9	25.0	1113	526.5
Antelope	100.0	2.5	965	37.5
Deer	109.1	2.7	442	6.6

1 Mean body weights commonly used.

2 Computed as 2.5% of mean body weight.

3 Obtained from Table 1.

4 Determined by computation using 60% dry matter digestion and 8525 ppm soil Ti.

The annual soil intake of 458 pounds by cattle is approximately 2.9 pounds per day. This mean is about two times the median value reported by Mayland et al. (1975) and is also higher than reported by Healy (1973). Mean body weight used herein is higher than that reported by Mayland et al. (1975) and the forage intake is also higher; thus, some of the difference is explained. However, Mayland et al. (1975) reported very high concentrations of soil due to root pull-up by cheatgrass. Such was probably not a factor in this study, as cheatgrass was only a minor part of cattle diets and pull-up is not a problem with the bunchgrasses.

The estimate of 566 pounds per year for horses is probably conservative, as it is generally recognized that they are "hay burners" and estimates of 2.5 percent body weight for daily intake, and a 60 percent digestion value, may be too low for intake and too high for digestibility.

Because the mean body weights of antelope and mule deer are about one-tenth that used for cattle and horses, the soil intakes are considerably lower. However, only that of deer are notably lower when compared on a per-unit-of-body-weight basis. Part of the difference may be because mule deer samples are primarily from the fall-winter and early spring versus a season-long sample period for antelope.

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