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Soil Ingestion by Cattle on Semiarid Range as Reflected by Titanium Analysis of Feces

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Highlight: *Soil ingestion was determined for cattle grazing a* Bromus tectorum *range in southern Idaho by measuring titanium concentrations in animal feces collected at 2-week intervals during the droughty 1973 grazing season. The experiment was based on the premise that titanium, which is abundant in soils, is contained only in small quantities (less than 1 ppm) in plants not contaminated with soil.*

Fecal-soil values averaged 14%, with values ranging from 3 to 30% of fecal dry matter, increasing as forage availability decreased. Soil ingestion levels were estimated to range from 0.1 to 1.5 kg with a median of 0.5 kg soil/animal-day. This soil was ingested primarily with the roots of Bromus tectorum, *which were often pulled up and consumed with the aboveground plant parts. Dust on leaves and stems accounted for only a small portion of the ingested soil.*

Measurements of acid-insoluble residue concentration in feces overestimated soil ingestion because of the probable presence of SiO_2 of plant origin. Large changes in forage SiO_2 concentrations of the diet reduce the effectiveness of this method compared to the Ti method.

Ingested soil may be a possible source of trace minerals, pesticides, heavy metals, and radionucleides that may be sorbed to surface soil particles.

Ingested soil may be a source of minerals to the grazing ruminant. Its importance depends on the amount of soil ingested, the ratio of the mineral concentration in soil to that in herbage, and the ability of the ruminant to solubilize and absorb the soil-derived minerals.

We were motivated to consider ingested soil as a dietary zinc (Zn) source because we did not find visual Zn deficiency symptoms in cattle whose diet did not otherwise appear to contain adequate Zn. The possibility that ingested soil may be a source of dietary minerals for grazing sheep and cattle has been investigated in New Zealand (Healy, 1967, 1968, 1973). Healy et al. (1970) reported that about 14% of the radioactive ^{65}Zn adsorbed to soil was absorbed by experimental sheep after they were drenched with 100 g of the ^{65}Zn labelled soil.

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The objective of this study was to determine soil ingestion rates for cattle grazing on a semiarid range in southern Idaho.

Field Methods

The study was conducted on the Saylor Creek Experimental Range, 7 miles southwest of Glenns Ferry, Ida. It is a mesic, upland site with a coarse silty, xerollic durorthid soil classified in the Minidoka silt loam soil series. The area receives 130 to 330 mm annual precipitation with a mean of 220 mm. Precipitation during 1973 was 200 mm, with only 80 mm occurring between March 1 and October 31. The native big sagebrush-Thurber needlegrass complex (*Artemisia tridentata-Stipa thurberiana*) has been largely replaced by cheatgrass (*Bromus tectorum*).

In mid-June 1973, four groups of 25 cow-calf pairs each were assigned to individual 32.4 ha (80 acre) pastures (Fig. 1F). After each group utilized an estimated 70% to 80% of the forage in that pasture, it was given access to an additional pasture(s). A fifth group, also having 25 cow-calf pairs, was assigned to a large 150-ha pasture for the entire study (Pasture LP, Fig. 1F). Feces, distinguished as to cow or calf origin, were sampled from the five groups at 2-week intervals from July 3 through November 6. Fecal subsamples were taken from the center of approximately 10 fresh dung pats, carefully avoiding soil and dust contamination; subsamples were composited by group.

Forage, clipped at a 2-cm stubble height, was collected at regular intervals. During the grazing season, six forage samples were pulled in a sweeping motion and shaken to simulate material eaten by cattle. The simulated samples contained attached crowns, roots, and soil. The forage and fecal samples were dried at 65°C for 72 hours and ground in stainless steel equipment to pass a 20-mesh screen.

Soil samples representing less than 0.58 mm material in the 0- to 2-cm depth were collected from Pastures 47, 50, 54, 57, and 61 (Fig. 1F) and air dried.

Laboratory Methods

Titanium Method

The experimental approach was based on the premise that titanium (Ti), which is abundant in soils (1,000 to 3,000 ppm Ti), is contained only in small quantities (less than 1 ppm Ti) in plants not contaminated with soil (Healy, 1968). Soil concentration in fecal and plant material was, therefore, determined by spectrographically measuring the amount of Ti present. Samples were loosely packed in aluminum frames, backed with 0.06 mm mylar film, and subjected to an x-ray fluorescence instrument with a tungsten target tube and a sodium chloride analyzing crystal. Samples and optical path were bathed with a helium atmosphere.

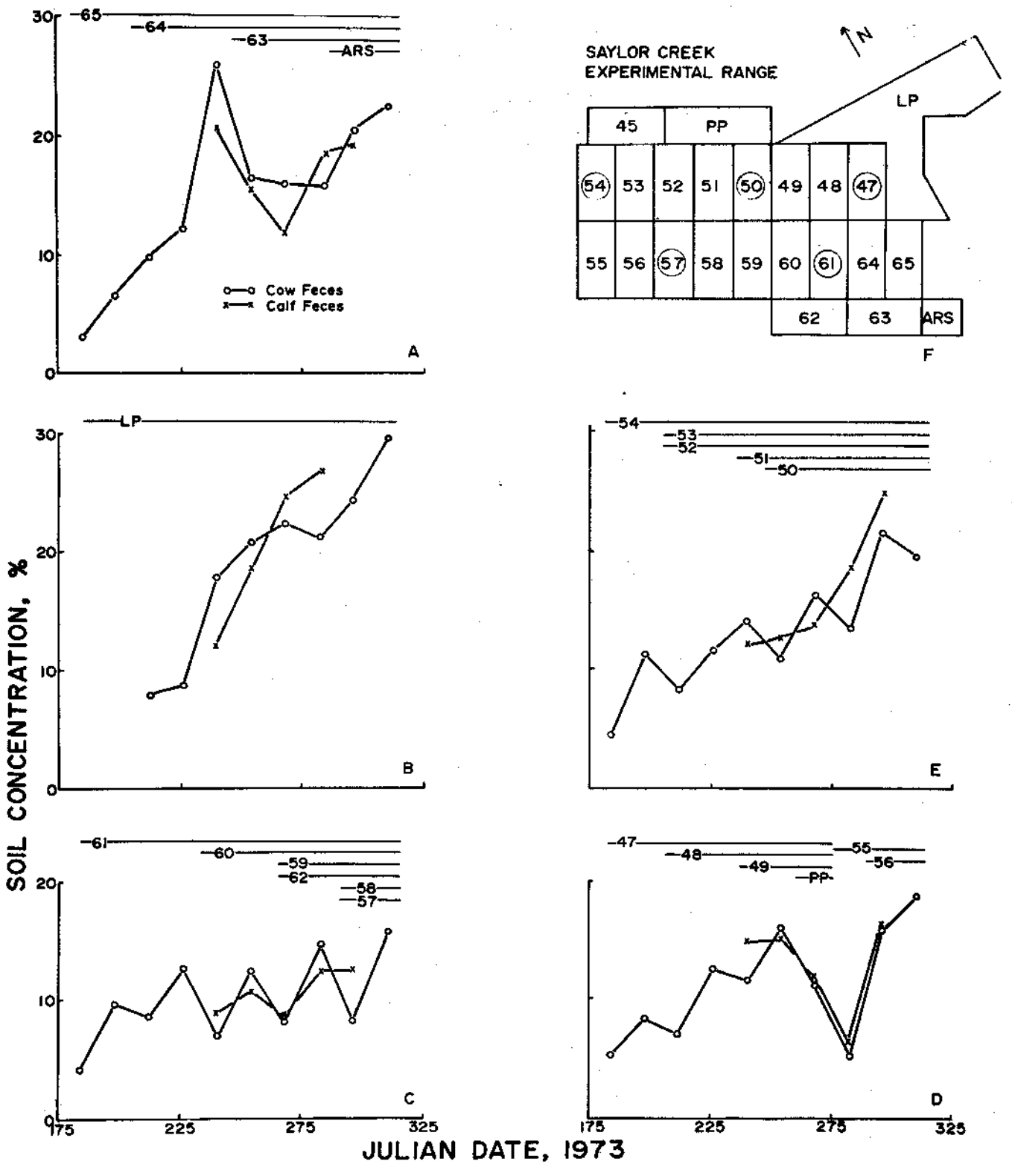

Fig. 1. *Fecal-soil concentration of five cow-calf groups as related to Julian date and pasture accessibility. The horizontal line or lines on the top of each sub-figure indicate the time duration during which that cow-calf group had access to the designated pastures. The experimental pasture arrangement is shown in Figure 1F. All pastures are 32 ha (80 acres), except LP = 150 ha (375 acres) and ARS = 16 ha (40 acres).*

The ratio F/S, where F is the counting rate at the Ti Kα emission line (λ = 2.750 Å, $2\theta = 58.34°$), and S is the counting rate at the background (λ = 3.267 Å, $2\theta = 71.00°$) was used as a measure of the Ti concentrations in fecal, plant, and soil samples. In previous studies, this ratio was found to be a better measure of the concentrations of elements in the parts per million range than either the counting rate at the Ti Kα line less rounting rate at the background (F − S), or the counting rate at the Ti Kα line (F) by itself (Kubota and Lazar, 1971).

Calibration for Titanium Method

The Ti concentration in soils was determined by the method of additions. The spectrographic parameter F/S was