Soil-Ingestion Rates of Steers Following Brush Management in Central Texas

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Abstract

Fecal soil concentrations and soil-ingestion rates were estimated for steers grazing pastures treated 1 year prior with herbicide or bulldozing and stacking. Mean fecal soil concentration was higher on mechanically treated, 16.6%, than those chemically treated, 12.5%, or untreated, 10.9%, under similar forage utilization levels (50%). With one exception, fecal soil concentration decreased over the study period on treated pastures. Fecal soil concentration was correlated with forb availability (r = 0.72) and percentage bare ground (r = 0.85) on treated pastures. At the forage utilization level of this study, no relationship between fecal soil concentration and stocking pressure was apparent.

Minerals essential in ruminant animal nutrition are usually assessed through plant analyses, which may not reflect actual mineral intake for grazing animals. Where plants are studied under grazed conditions, soil ingested with herbage may be of considerable importance in animal health and nutrition. Ingestion of soil may increase tooth wear (Healy and Ludwig 1965; Healy et al. 1967), and cause colic which can lead to death in young calves and lambs (Mayland et al. 1977). However, ingested soil may increase trace element intake (Healy 1973). Trace elements ingested in substantial amounts in soil include cobalt (Andrews et al. 1958), copper (Suttle 1974), and zinc (Healy et al. 1970).

The amount of soil ingested has been related to management (Healy 1973), season (Healy and Ludwig 1965), soil and plant types (Healy 1968a; Mayland et al. 1975), and individual animal behavior (Healy 1968b). These variables may explain some observations that only a portion of animals in any given herd show mineral deficiency symptoms, and also that animals on certain soil types, may be affected. No information is available on the effects of range improvement practices on livestock soil-ingestion rates.

The purpose of this study was to estimate soil-ingestion rates following two brush management methods in the Claypan Savannah Resource area of central Texas.

Study Area and Procedures

The study area was located approximately 3 km west of College Station, Texas, on sandy loam soil. Annual average rainfall is 99 cm, most of which falls in May and September.

Treatments, each applied to two 1.5 to 2.5-ha pastures in May and June 1977, included bulldozing and stacking brush, aerial application of pelleted tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N*, N′-dimethylurea) at 2.24 kg/ha active ingredient, and no treatment.

June 14, 1978, a group of eight steers (150 to 200 kg) was allocated to each pasture of one replication. By July 10 all groups had utilized approximately 50% of the little bluestem and were moved to the corresponding treatment in the second replication. Grazing period two terminated August 21, 1978. Prior to the first collection, all steers were preconditioned for 2 weeks on pastures similar in vegetative composition to the study pastures.

Available forage by herbaceous class was determined at the beginning and end of each grazing period. Fifteen 0.25-m^2 plots were randomly selected and clipped for each pasture. Forage disappearance was determined at the termination of each grazing period by clipping 15 pairs of protected and grazed 0.25-m^2 plots and calculating the percent difference (Klingman et al. 1943). Basal area, mulch, and bare ground in each pasture were determined from reading 500 points using a 10-point inclined frame spaced equidistantly along a diagonal across each pasture.

Soil samples were collected to 4-cm deep, sifted to pass a 0.5-mm screen, and composited by pasture and replication. Weight losses from acid-soluble residues were determined on each soil sample.

Daily dry-matter intake (DMI) of the steers, necessary for estimating soil-ingestion (SI) levels, was calculated by determining forage dry-matter digestibility and fecal output. Forage samples were collected by grazing four 450-kg, esophageally fistulated cows 1 hr twice daily on each fecal collection date. A forage subsample was used for in vitro dry-matter digestibility (IVDMD) determinations by the fermentation stage of Tilley and Terry (1963) followed by extraction in neutral detergent solution (Van Soest and Wine 1968).

Dietary intake of forage acid-insoluble residue (A.I.R.) was determined by analyzing a subsample of the forage collected by grazing esophageally fistulated cows for A.I.R. Prior to analysis the forage subsample was thoroughly rinsed with distilled water to remove soil or dust inadvertently or directly ingested by the grazing animal. Therefore only ingested forage acid-insoluble residues or biogenic silica remained.

Dry-matter excretion was determined by total fecal collection. Two preconditioned, 150 to 200-kg steers were maintained on similar adjacent native pastures for 3 days. Stocking pressure was roughly equivalent to that where steers were grazing treated pastures. Feces were collected twice daily, weighed, and a subsample removed and oven-dried for fecal dry-matter output (FDM) calculations.

Fecal samples were collected for 2 consecutive days beginning 5 days after steers entered a pasture and at the termination of each grazing period. Approximately 50 g were collected from eight fresh dung piles, avoiding any plant or soil contamination.

Fecal, soil, and rinsed esophageal samples were analyzed by a modification of the acid-insoluble residue (A.I.R.) technique (Mayland et al. 1975). After dry ashing at 550° C for 4 hr, 5 g samples were leached with 20 ml concentrated hydrochloric acid, 50 ml 2N nitric acid, and 100 ml distilled water in gooch crucibles. The remaining oven-dried residue was used for estimating soil-ingestion rates. Estimated dry-matter intake and ingested soil were calculated using the following formulae.

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[1] $$\text{DMI est.} = \frac{\text{FDM}}{1 - \text{Forage IVDMD}}$$

where:

DMI est. = estimated dry matter intake of a steer (kg/steer/day),

FDM = fecal dry matter output (kg/steer/day)

[2] $$\text{Fecal A.I.R. adj. (\%)} = [\text{Fecal A.I.R. (\%)} - \text{Forage A.I.R. (\%)} + \text{Soil A.S.R. (\%)}]$$

where:

Fecal A.I.R. adj. (%) = Fecal A.I.R. (%) corrected for Forage A.I.R. (%) and Soil A.S.R. (%),

Fecal A.I.R. (%) = acid insoluble residue of feces,

Forage A.I.R. (%) = acid insoluble residue of forage rinsed with distilled water,

Soil A.S.R. (%) = acid soluble residue of soil.

[3] $$\text{SI est.} = [\text{Fecal A.I.R. adj. (\%)}][\text{DMI est. (kg)}]$$

where:

SI est. = estimated kg of soil ingested per steer per day.

Analyses of variance (Steel and Torrie 1960) were applied to forage availability, disappearance of forage, percentage fecal A.I.R., and estimated soil-ingestion data. Means were separated using Duncan's multiple range test at $P \leq 0.05$. Regressions were computed in an attempt to predict fecal A.I.R. from soil cover and forage class availabilities.

Results

Grass and total herbaceous availability was significantly greater on tebuthiuron-treated pastures than on mechanically treated or untreated pastures. (Fig. 1). Forb availability was highest on mechanically treated pastures as would be expected following severe ground disturbance. Tebuthiuron-treated pastures supported the fewest forbs.

Herbaceous disappearance varied greatly between treated pastures (Fig. 1). Grazing was terminated when 50% of the little bluestem had disappeared. Less than 50% of all forage classes disappeared during Trial I (June 14 to July 10) of the study. Apparently, little bluestem was the most frequently grazed species, and grazing Trial I was terminated prior to 50% usage of other herbaceous species. Over 50% of the total herbaceous standing crop disappeared during Trial II (July 10 to August 21) on tebuthiuron-treated and untreated pastures. During the dry, hot weather of Trial II, little bluestem was less preferred than during Trial I and more succulent herbaceous vegetation such as brownseed paspalum *Paspalum plicatulum),* dicanthelium's (*Dicanthelium* sp.) and sedges were grazed more heavily. Total herbaceous forage disappearance from the mechanically treated pasture during Trial II was less than 50% because of the presence of a large quantity of nonpalatable forbs such as common broomweed *(Xanthocephalum dracunculoides)* and bitter sneezeweed *(Helenium amarum).*

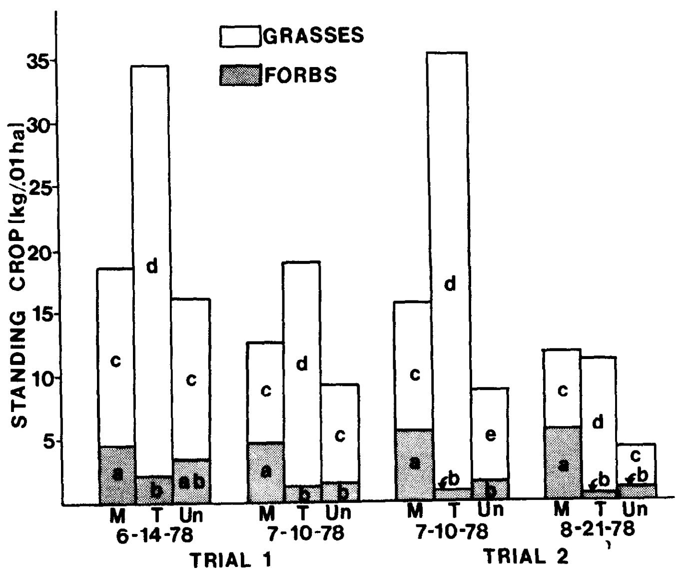


Fig. 1. *Herbaceous composition (%) by weight, forage availability (kg/ha), and disappearance (%) during grazing trials 1 year after brush management treatments were applied to study pastures. Bar sections within herbaceous class and date having similar letters are not significantly different at the 0.05 level.*

Herbaceous basal area did not differ greatly between treated pastures, 7 ± 2%. Mulch cover was similar on tebuthiuron-treated and untreated pastures, 75 ± 6%, and greater than on mechanically treated pastures, 51 ± 3%. Bare ground on the mechanically treated pastures, 41%, was more than twice that of the other pastures, 17%.

Estimated dry-matter intake for the 150 to 200-kg steers was determined from fecal dry-matter output and forage dry-matter digestibility. Fecal dry-matter output was 1.2 ± 0.1 kg/steer/day; and initial and final forage dry-matter digestibilities (%) during Trial I and Trial II were 77, 66, and 71, 56, respectively. Estimated initial and final dry-matter intakes (kg/steer/day) during Trial I and Trial II were 5.2, 3.5 and 4.1, 2.7, respectively.

Adjusted fecal A.I.R., hereafter expressed as fecal A.I.R., ranged from nine to more than 20% for steers grazing treated pastures (Table 1). Initial collections of feces from treated pastures were generally greater in A.I.R. than final collections. With one exception, steers grazing mechanically treated pastures had greater fecal A.I.R. Final fecal collections of Trial I, though not significantly different, indicated that steers grazing the mechanically treated pasture had the higest fecal A.I.R. Generally, steers grazing tebuthiuron-treated and untreated pastures did not differ in fecal A.I.R.

Estimated soil-ingestion rates (Table 1), hereafter expressed as soil-ingestion rates, were calculated utilizing estimated forage intake and fecal A.I.R. Soil-ingestion rates

Table 1. Means and standard deviations for adjusted acid insoluble residue (%) in feces and estimated soil ingestion (kg/steer/day) by steers grazing brush-managed pastures in Claypan Savannah Resource area, College Station, Texas.

		Pasture treatment		
Trial[a]	Collection	Bulldozing and stacking	Tebuthiuron	No treatment
Adjusted acid-insoluble residue				
I	Initial	16.02 ± 0.80a[b]	12.90 ± 0.49b	11.67 ± 1.21b
	Final	11.63 ± 0.69a	10.96 ± 0.89a	8.93 ± 0.74b
II	Initial	18.01 ± 1.56a	13.33 ± 0.38b	12.70 ± 0.49b
	Final	20.52 ± 1.49a	12.67 ± 0.67b	10.38 ± 0.40c
Estimated soil ingestion				
I	Initial	0.84 ± 0.04a	0.67 ± 0.03b	0.61 ± 0.06b
	Final	0.41 ± 0.02a	0.38 ± 0.03a	0.31 ± 0.03b
II	Initial	0.74 ± 0.06a	0.55 ± 0.02b	0.52 ± 0.02b
	Final	0.55 ± 0.04a	0.34 ± 0.02b	0.28 ± 0.01c

[a]Trial I was conducted June 14 to July 10, 1978, followed by Trial II July 10 to August 21, 1978.
[b]Means within a row followed by the same letter are not significantly different at the .05 level.

ranged from 0.28 to 0.84 kg/steer/day. As with fecal A.I.R., soil-ingestion rates of steers decreased from initiation to termination of the grazing trials. Steers grazing mechanically treated pastures, with one exception, had greater soil-ingestion rates than on other pastures ($P \leq 0.05$). Estimated soil-ingestion rates of steers grazing the mechanically-treated pasture during Trial I at the final collection date also tended to be higher than on other pastures. Overall, soil-ingestion rates of steers grazing tebuthiuron-treated and untreated pastures did not significantly differ.

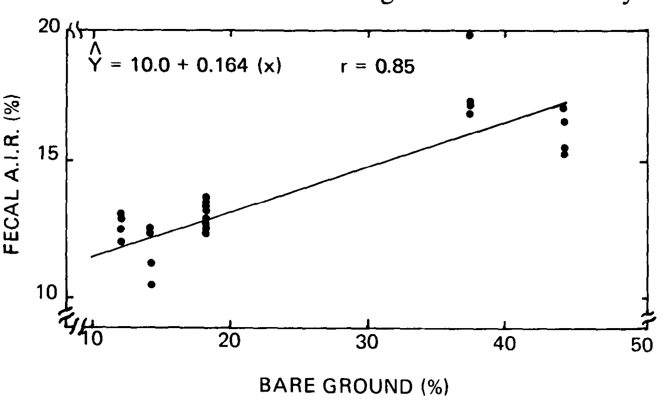
Discussion

Fecal soil concentration determined by the A.I.R. technique ranged from 9 to 20% of steer dry matter excretion in this study. These results agree with values of 14 and 20% reported for summer months by Mayland et al. (1977). Soil-ingestion rates of 0.28 to 0.84 kg/steer/day for this study were similar to those reported by Healy (1968a) (0.52 to 1.73 kg/animal-day); Thornton (1974) (0.46 to 0.78 kg/animal-day); Mayland et al. (1975) (.1 to 1.5 kg/animal-day); and Mayland et al. (1977) (0.73 and 0.99 kg/animal-day).

Fecal soil concentration was highest when steers grazed mechanically treated pastures (Table 1). Mechanically treated pastures supported more forbs than tebuthiuron-treated or untreated pastures. Percentage bare ground and available forbs were the best predictors of fecal soil concentration (Fig. 2). Fecal soil concentration was highly correlated (r = 0.85) with percentage bare ground. The relationship $Y = 10.0 + 0.164x$, accounted for 72% of the variation in fecal soil concentration. Available forbs were also correlated with fecal soil concentration (r = 0.72), and 52% of the variation was explained by the relationship: $\hat{Y} = 10.3 + 0.010x$.

Additional variation in soil ingestion estimates may be explained through a discussion of individual animal variability. Healy (1968b) generally found variability among animal soil-ingestion rates fairly high. Steer feces in our study were collected from the eight freshest dung piles. No attempt was made to collect feces from each steer on treated pastures. Future studies should make an effort to collect fecal samples from all individuals in an experimental unit.

Healy (1968b) also reported that stocking pressure, the ratio of forage availability and stocking density, was directly correlated with soil-ingestion rates of cattle. Our results did not substantiate these findings. Initially, fecal soil concentrations of steers grazing untreated pastures did not significantly differ from those grazing tebuthiuron-treated pastures, although stocking pressure was three times greater for the untreated pastures. Also, the mechanically treated pastures during Trial I with similar initial stocking pressure to the untreated pasture had significantly greater soil-ingestion rates by steers. Grazing increased stocking pressure over the study period; yet, with one exception, fecal soil concentration decreased. A combination of factors may explain this decrease. Forbs and other herbaceous leafy material, which could provide a surface for soil contamination, were being removed by grazing. Secondly, forage intake may have decreased, thereby depressing soil intake. Finally, critical forage disappearance levels, greater than 70%, where fecal soil concentration might be expected to increase, were never attained in this study. Grazing periods were terminated at 50% disappearance of little bluestem, the key summer forage species. Therefore, treatment pastures were never grazed at high levels of stocking pressure that may correspond to greater fecal soil concentrations of livestock.



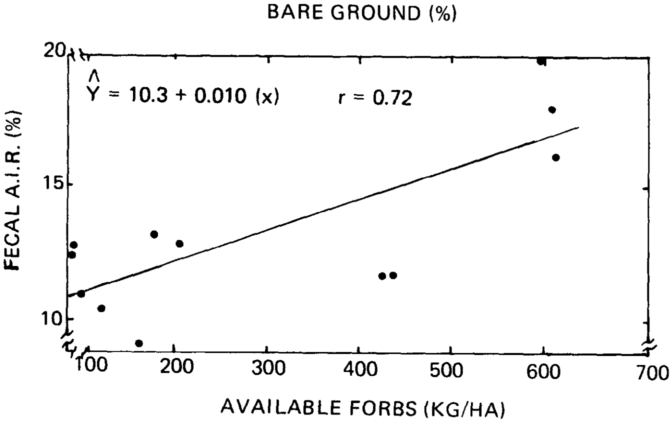


Fig. 2. *Relationship of fecal soil concentration of steers with percent bare ground and forb availability on pastures in the Claypan Savannah Resource area of central Texas.*

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