# Mineral dynamics in beef cattle diets from a southern mixed-grass prairie

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**Abstract**

**Acute and chronic dietary deficiencies in macro and micro minerals have significant impacts on production efficiency on rangelands throughout the world. However, limited information is available on the mineral quality of diets primarily because salivary and soil mineral contamination of esophageal extrusa precludes quantitative recovery of dietary minerals. Mineral profiles of diets can be estimated indirectly, however, if forage species composition of diets and mineral concentrations of selected forages are known. The objective of this study was to utilize this approach to estimate seasonal dynamics of phosphorus (P), calcium (Ca), potassium (K), and magnesium (Mg) in cattle diets' relative requirements. Two diet selection scenarios were developed: the first, maximum mineral intake, assumed cattle consumed only live plant tissue of a forage if it was available; the second, considered minimum mineral intake, assumed cattle consumed live and dead tissue in direct proportion to their availability. Calculated concentrations of P and Ca in diets showed P concentrations were below and Ca concentrations were above their respective requirements for spring calving cows regardless of selection scenario or season of the year. However, K and Mg concentrations varied as a function of selection scenario and season of year and ranged from adequate during periods of rapid vegetation growth to marginally inadequate during periods of water (drought) or temperature (winter) induced dormancy.**

**Key Words: phosphorus, potassium, calcium, magnesium, diet quality**

Livestock production from rangeland is a function primarily of the quantity and quality of forage consumed and subsequent efficiency of conversion into animal fiber. While deficiencies or imbalances in dietary protein and energy and their effects on range livestock production are well established, less is known about the temporal and spatial distribution of acute and chronic mineral deficiencies on most rangelands. Realistic estimates of dietary mineral status are essential for development of mineral supplementation programs. Although numerous studies have focused on quantifying relationships between forage nitrogen, fiber, and energy profiles and associated diets, few have attempted to quantify mineral profiles of diets (Kalmbacher et al. 1984). This information void exists because esophageal extrusa is generally considered sufficiently adulterated by salivary and soil minerals (Little 1975, Kirby and Stuth 1980) to preclude quantitative recovery of dietary minerals. Hand squeezing (Lesperance et al. 1974) and rinsing extrusa (Hart 1983) with distilled water are generally unacceptable alternatives because leaching of soluble fractions from the forage and differential removal of salivary minerals may occur. Hence, although the mineral dynamics in available forage are quantifiable (Rauzi et al. 1969, Everitt et al. 1980, Huston et al. 1981, Kalmbacher 1983, Green et al. 1987), the absolute concentrations of minerals in the diets of grazing animals cannot be assayed using esophageal extrusa. However, concentrations of dietary minerals can be estimated indirectly if mineral concentrations in the forages consumed are known. The objective of this note is to utilize this technique to ascertain the probable maximum and minimum concentrations of phosphorus (P), calcium (Ca), potassium (K), and magnesium (Mg) in cattle diets relative to the NRC (1984) requirements for spring calving cows.

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## Materials and Methods

Research was conducted at the Texas Experimental Ranch located on the eastern edge of the Rolling Plains Resource Region. The study was one of a series of studies designed to examine the effects of a 16-paddock, 1-herd rotational grazing treatment on quantity and quality of forage produced and consumed.

Quantity of forage produced was estimated by clipping aboveground standing crop in 4 paddocks immediately before and after each grazing period during the 2-year study period. Standing crop was clipped by species and/or functional group. Species/functional groups were annual grasses, Texas wintergrass (*Stipa leucotricha* Trin. and Rupr.), sideoats grama (*Bouteloua curtipendula* Michx.), other warm-season grasses, and forbs. Following drying and weighing, subsamples were separated by hand into live and dead tissue for laboratory analyses of mineral concentrations. For a detailed description of field sampling procedures and associated results, see Heitschmidt et al. (1987a, 1987b, and 1987c). For a detailed description of laboratory procedures and study results relative to mineral concentrations in the various forage species/-functional groups, see Greene et al. (1987).

On 8 dates over the 2-year period, diet samples were collected in the same paddocks as forage samples, utilizing 3–6 esophageally fistulated Hereford-Angus × Jersey cross bred steers per paddock. Botanical composition of diets was determined by species/functional group using the microscopic frequency technique as described by Kothmann (1968). For a detailed description of sampling procedures and study results, see Walker et al. (1989).

Mineral concentration in diets within date were estimated utilizing the forage mineral concentrations from Greene et al. (1987) and the botanical composition of diet data summarized by Walker et al. (1989). Because esophageal extrusa was not separated into physiologic age of tissue (live vs. dead) by species or functional group, mineral concentrations in diets were estimated in 2 scenarios. First, it was assumed that selection for live tissue was nonexistent. In this instance, whole-plant mineral concentrations (Greene et al. 1987) were multiplied by estimates of diet composition by species/functional group. Products were then summed across species. For example, in October 1982, estimated diet composition was 13% Texas wintergrass, 1% annual grasses, 19% sideoats grama, 55% other warm season grasses, and 12% forbs. Estimated whole plant P concentrations for the 5 species/functional groups were 0.056, 0.040, and 0.046, 0.058, and 0.46%, respectively. Thus, estimated percentage concentration of P in the diet was 0.054%. For the second method, concentrations of minerals in the diet were calculated in the same manner except it was assumed diets con-

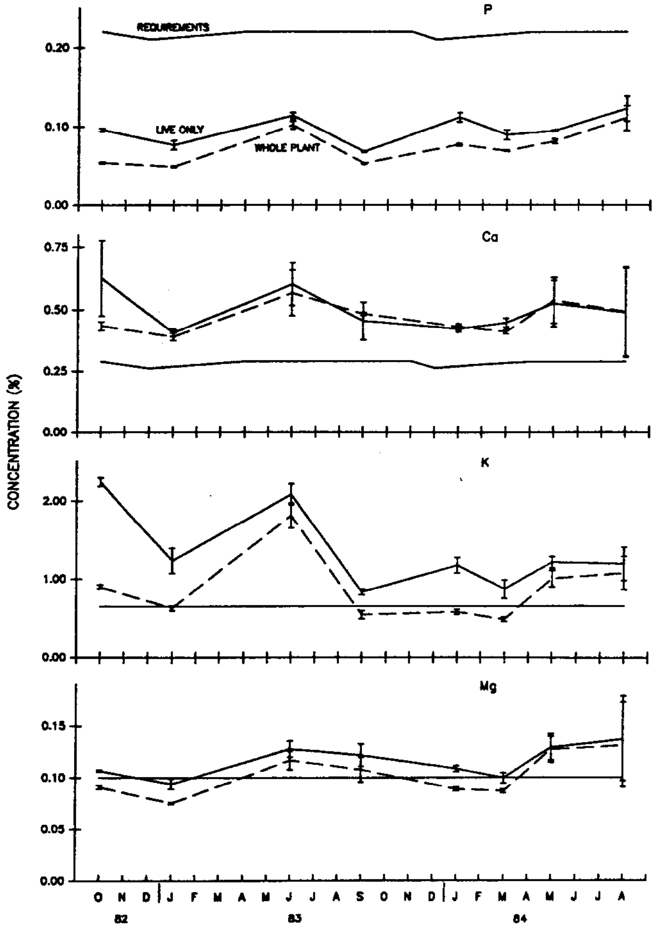


**Fig. 1.** *Estimated mineral concentrations (%) in diets of beef cattle grazing north Texas native rangeland on 8 dates over a 2-year period. Mineral concentrations in diets are based on botanical composition (Walker et al. 1989) and forage mineral concentration data (Greene et al. 1987). "Live only" and "whole plant" estimates represent concentrations based on assumption that cows either selectively consumed only live tissue or nonselectively consumed only whole plants. Nutrient requirements are based on NRC (1984) recommendations.*

sisted of only live tissue if available. Thus, it can be assumed the 2 methods provide estimates of minimum and maximum mineral concentrations in the diets.

Many sources of variation exist in estimating the nutrient content of livestock diets. Animal variation (sample units) in terms of selectivity for particular plants and plant parts, the variation in availability of these food items among pastures (experimental units), and variation in composition among samples of live portions and whole plants are primary sources of variation. The first 2 sources are addressed by Walker et al. (1989), and the third by Greene et al. (1987). Our results are presented in terms of potential variation in selectivity (live tisue only or maximum selectivity vs. whole plant or minimum selectivity). The maximum-minimum approach allows biological interpretable upper and lower limits to be placed upon the estimated concentration of a mineral in the diet. The variance of these limits can only be approximated from the variances and the distributions (if known) of the plant and animal parameters from which they are calculated. The standard deviations presented in Figure 1 arise from the variance in species composition of diets among paddocks within scenarios and trials (n=4).

## Results and Conclusions

Estimated P concentrations in the diets showed a critical need for P supplementation yearlong, regardless of diet selected relative to live/dead tissue composition. This deficiency was directly attributed to low P concentrations in all available forages. The maximum concentration of P in any species/functional group during the study was 0.212% (forbs–Jan. 1983, Greene et al. 1987).

Estimated Ca concentrations in diets indicated Ca requirements for cows with average milking ability (5.0 kg milk/d) were exceeded throughout the study period. The abundance of Ca in the diets, regardless of method of calculation, reflected the effect of consistently high Ca concentrations in all available forages. The lowest concentration of Ca found in any forage during the study was 0.22% (warm-season grasses–Sept. 1983, Greene et al. 1987). The data did not show, however, that Ca supplementation would be appropriate during the first 4 months postpartum if cows of superior milking ability (10 kg milk/d) were grazing these forages. During this period, NRC (1984) recommendations for diet Ca concentrations for 400 kg cows is 0.49%.

Potassium concentrations in diets met requirements if it was assumed only live tissue was consumed. However, whole-plant diet calculations indicated minor deficiencies could occur during periods of extended dormancy. This deficiency resulted because K concentrations in live tissue averaged across species/functional group were about 3.5 times as much as concentrations in dead tissue (Greene et al. 1987).

Trends in Mg concentrations in diets were similar to K trends, but when Mg concentrations exceeded requirements the excess was smaller. This is cause for concern because the NRC (1984) requirements of 0.10% Mg in the diet is probably a minimum. O'Kelly and Fontenot (1969, 1973) have reported that magnesium requirements of cows double from late gestation to early parturition (0.1 vs. 0.2%).

Based upon the results of this study and NRC (1984) nutrient requirements for beef cows, we conclude mineral concentrations in these diets did: (1) not meet P requirements; (2) meet Ca requirements; (3) generally meet K requirements for nonlactating cows except during periods of dormancy; and (4) generally meet Mg requirements for nonlactating cows except during periods of dormancy. The described approach allows for biologically realistic bounds to be placed upon the dietary mineral status of free-ranging livestock facilitates the formulation of complete mineral supplements, and interpretation of mineral supplementation experiments on rangeland.

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