A Comparison of Esophageal Fistula and Fecal Material to Determine Steer Diets

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Highlight: Cattle diets were determined by esophageal fistula and fecal material collection procedures from yearling cattle grazing shortgrass range in northeastern Colorado. Diets were quantified by microhistological procedures from samples collected in June, July, August, and December of 1969; and June, July, and August of 1970. Total grasses occurred significantly less in esophageal samples, while total forbs were significantly lower in fecal samples. Individual grass species did not appear to follow a set pattern of variation from esophageal to fecal sampling; some were greater in fecal samples while others were greater in fistula samples. Forbs occurred at greater percentages in fistula samples, with the exception of burning bush (*Kochia scoparia*) in 1969. Correlation and regression analysis revealed little relationship in botanical composition determined on fecal and esophageal samples. However, an importance value ranking revealed esophageal and fecal samples were similar when individual species were ranked from the most common to the least common in the diet.

Microhistological examination of fecal material or esophageal fistula extrusa are two common techniques for estimating the botanical composition of the diets of herbivores. Esophageal fistulation has been primarily used with domestic animals (Vavra et al. 1973) while fecal examination has been used with wildlife (Hansen et al. 1975) and where several herbivores graze in common (Hansen et al. 1973). Reviews of each method exist (esophageal fistulation, Van Dyne and Torrell 1964; fecal collection, Ward 1970). The microhistological examination method of Sparks and Malechek (1968) appears to be the most common technique used in recent years and applies to material collected by both procedures. Anthony and Smith (1974) compared dietary residues collected from the rumen and feces and raised several questions about the fecal analysis technique. Higher estimates of evergreen species and lower estimates of some forbs resulted from fecal analysis as compared to rumen analysis. Also, the authors stated that quantification of food items such as flowers, tubers or acorns would not be possible with fecal analysis. Use of the esophageal fistula has been restricted to domestic animals because a tractable animal amenable to frequent handling is essential. Additional problems include: (1) associated surgery, McManus (1961); (2) incomplete collection, Campbell et al. (1968); (3) fistulated animals can only be grazed for short time periods, Van Dyne and Torrell (1964).

This study was conducted to determine if diet determinations differed when esophageal fistula extrusa or fecal material was used as the sampling medium. Additionally, simple correlations and regressions were calculated to determine: (1) the relationship between data collected by esophageal fistula and fecal material and (2) regression equations to be used to adjust fecal data should differences exist.

Materials and Methods

The study was conducted on the Pawnee Site of the U.S. International Biological Program Grassland Biome. This area was located on the Central Plains Experimental Range, approximately 57 km north of Greeley, Colo. The range is administered by the USDA/Agricultural Research Service. A more complete description of the pastures, area and cattle grazing formulae can be found in Vavra et al. (1973).

Samples were collected on heavy, moderate, and light grazing intensities in June, July, and August of 1969; and on heavy and light intensities in December of 1969 and during June, July, and August of 1970. Four animals were used per pasture treatment during both years. Esophageal and fecal samples came from the same animals. Fecal material used was from a 24-hour total collection, which began directly after the esophageal fistula collection. Samples were then paired by animal and by sample day for analysis.

Microhistological examination of material followed the method of Sparks and Malechek (1968). Forty microscope fields were examined at 100× for each sample. Frequency of occurrence was recorded and converted to density; then relative density was calculated as an estimate of percent composition by dry weight.

Statistical analysis followed Steel and Torrie (1960). Selected plant species which made up the major diet constituents (>5% of total diet) and plant groupings of warm-season grasses, cool-season grasses, total grasses, total forbs, and total shrubs were compared between sampling techniques. The least squares analysis of variance was used to determine significant differences due to technique. Main effects (technique, pasture, collection month) and first order interactions were tested. Data were pooled by year for the analysis to remove any variability due to year. Simple correlation and regression analyses were run on data pooled by month, by year, and over the entire study. All references to statistical significance imply differences at the 0.05 level of probability.

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Table 1. Mean percent weight of diet constituents of cattle.

	1969		1970	
	Esoph	Fecal	Esoph	Fecal
Western wheatgrass (*Agropyron smithii*) Agsm	10	9	6	7
Red threeawn (*Aristida longiseta*) Arlo	4^a	8^b	6	5
Blue grama (*Bouteloua gracilis*) Bogr	29^a	41^b	45^a	73^b
Buffalograss (*Buchloe dactyloides*) Buda	4^a	1^b	1	< 1
Sun sedge (*Carex heliophila*) Cahe	6	8	12^a	7^b
Sand dropseed (*Sporobolus cryptandrus*) Spcr	1^a	< 1^b	3	2
Needleandthread (*Stipa comata*) Stco	1	1	8^a	2^b
Total warm season grasses	40^a	49^b	57^a	81^b
Total cool season grasses	16	17	21^a	14^b
Total grasses	55^a	67^b	74^a	92^b
Astragalus sp. Astr	1	< 1	3	1
Spreading wildbuckwheat (*Eriogonum effusum*) Eref	5^a	11^b	< 1	< 1
Burning bush (*Kochia scoparia*) Kosc	2^a	6^b	2	< 1
Scarlet globemallow (*Sphaeralcea coccinea*) Spco	12	11	6^a	2^b
Evening primrose (*Oenothera coronopifolia*) Oeco	3	4	2	2
Spreading fleabane (*Erigeron divergens*) Erdi	0	0	4	< 1
Wavyleaf thistle (*Cirsium undulatum*) Ciun	5	3	1	< 1
Slimflower scrufpea (*Psoralea tenuiflora*) Pste	1	1	4^a	< 1^b
Total forbs	37^a	29^b	23^a	7^b
Fringed sagewort (*Artemisia frigida*) Arfr	6	5	2	< 1
Total shrubs	7	5	1^a	< 1^b

$^{a, b}$ Means with different superscripts within year and between technique differ significantly at the .05 level.

Additionally, individual species were ranked as to "importance value": sequentially from greatest to least amount in the diet for the two techniques. Importance value was a ranking used to compare the occurrence of plant species in the diet as estimated by each method. "Important" dietary constituents would be those that occurred most often in the diet. Scientific names of all plants mentioned in the text are listed in Table 1.

Results

The percent composition by weight of selected dietary constituents as determined by the two methods is presented in Table 1. Of individual grass species, significant differences due to technique occurred for red threeawn, blue grama, buffalograss, and sand dropseed during 1969 and blue grama, sun sedge, and needleandthread during 1970. Definite trends within species between techniques for the two study years were not evident. More western wheatgrass occurred in esophageal samples than in fecal samples in 1969, while the reverse was true in 1970. More red threeawn and sun sedge occurred in esophageal samples in 1969 but again the reverse was true in 1970. Esophageal samples contained more blue grama and needleandthread during both years. The lack of a definite trend among individual species was responsible for the lack of year to year trend when the grasses were pooled into cool- or warm-season categories. Significantly less total grasses occurred in esophageal samples during both years of the study.

With the exception of burning bush in 1969, greater percentages of individual forb species were present in esophageal than in fecal samples. Differences were significant in 1969 for spreading wildbuckwheat and in 1970 for scarlet globemallow and slimflower scurfpea. Significantly less total forbs occurred in fecal samples during both years. Shrubs (primarily fringed sagewort) made up a small portion of the diets but appeared in greater percentages in esophageal samples.

Generally, correlation and regression coefficients were quite low (rarely exceeding $r = 0.50$) regardless of how the data were pooled. An example of a typical esophageal-fecal relationship is presented in Figure 1.

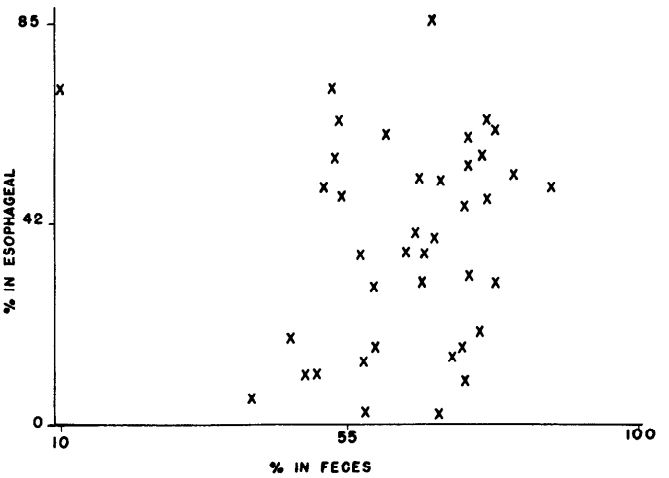

Fig. 1. *The relationship between feces and esophageal fistula extrusa analyses for the determination of percent blue grama in steer diets.*

Individual species were ranked from the most common to the least common in the diet on a percent weight basis (Table 2). In both years four of the top five ranked plants were common to both sampling techniques. The five most common species in the diets made up 64.6% and 75.6% in 1969; and 76.4% and 93.5% of the diets in 1970 for esophageal and fecal sampling, respectively. The average change in rank (ACR) of grasses and forbs between sampling techniques and within a year was calculated by dividing the total number of changes by the total number of species represented. Shrub species were not considered. This calculation should give an indication of the degree of variation of each class of plants in the diets. Grasses had ACR values of 1 and 2 for 1969 and 1970, respectively. Forbs were more variable having ACR values of 2 and 2.5 for the respective sampling years.

Discussion

When one first considers the examination of plant fragments in feces to determine the botanical composition of herbivore

Table 2. Importance ranking of individual plant species occurring in cattle diets as determined by examination of esophageal fistula extrusa and feces.

	1969		1070	
Rank	Esoph	Fecal	Esoph	Fecal
1	Bogr	Bogr	Bogr	Bogr
2	Spco	Spco	Cahe	Agsm
3	Agsm	Agsm	Stco	Cahe
4	Arfr	Arlo	Agsm	Arlo
5	Cahe	Cahe	Spco	Spco
6	Eref	Kosc	Arlo	Spcr
7	Arlo	Arfr	Pste	Stco
8	Ciun	Oeco	Erdi	Oeco
9	Buda	Ciun	Spcr	Astr
10	Oeco	Eref	Astr	Kosc
11	Kosc	Stco	Arfr	Arfr
12	Stco	Buda	Oeco	Pste
13	Pste	Pste	Kosc	Erdi
14	Astr	Astr	Buda	Ciun
15	Spcr	Spcr	Ciun	Eref
16	Erdi	Erdi	Eref	Buda

diets, the obvious shortcoming is the differential digestion of various plant species in the diet. However, data are available in the literature to refute this. Regal (1960) stated that cutinized epidermis passes through the animal's digestive tract undigested. Hanna et al. (1973) reported that the outer portion of the epidermis was more resistant to digestion than other cellular structures because it is cutinized and lignified. Chatterton and Powell (1974) found different rates of digestion of various cellular constituents of orchardgrass (*Dactylis glomerata*); however, the cuticle (cutinized layer over the epidermis) remained intact and was not significantly attacked by microbes.

Wallace and Van Dyne (1970) reviewed lignin digestibility values (lignin is an important constituent of the epidermis that prevents digestion, see above) and found a range of −40 to +64%. Data collected by Wallace and Van Dyne (1970) on lignin digestibility varied from 4% to 46% depending on season of year and plant maturity. The greater the digestibility of lignin the smaller the chance of a discernible epidermal fragment passing through the digestive tract of a ruminant, and the smaller the chance of identification as a diet constituent. Our data indicate that cuticular resistance to digestion is greater in grasses than in forbs because total grasses in esophageal samples were always significantly less than in feces and forbs were significantly higher in esophageal samples than in feces.

Fecal samples in this study were collected for a 24-hour period just after collection of esophageal fistula samples. Diet composition of the fistula sample could not be duplicated in the feces. Fistula samples represent only a portion (1 or 2 hours) of the total grazing period. Actual percentages of plant species in the diet of an animal probably vary with time of day and with exact location of the animal on the pasture (where vegetation exists according to soil type, aspect, etc.).

The forbs and shrubs reported by Taylor (1972) to be highly digestible in the study area were the same ones which Dearden (1973) reported to be less discernible to microscope technicians after digestion than before digestion. Cell wall thickness is the characteristic which probably influences the identification of fragments to a greater extent than any other (Dearden et al. 1972). Estimated percentages in diets are interdependent variables and whenever a technician overestimates or underestimates one plant species the percentages of other species in the sample are adjusted upward or downward by an equivalent amount. Although statistical significance can be demonstrated for the various sources of errors in the microscopic technique of Sparks and Malechek (1968) the importance of plants making up the major portion of a mean diet are in the same general order (Dearden et al. 1975).

If the esophageal fistula method is considered the standard as it often has been (Laycock et al. 1972), then it should be used where resources warrant. However, fecal analysis can be used where the degree of accuracy needed is less, where rare or endangered animal species are studied, where unmanageable animals are studied, or where several herbivores occupy the same range. Actual percentages of a species in the diet are probably less important than the relative value (importance value) of that species. An importance value ranking should identify the most important diet constituents and therefore fulfill the need of most diet investigations.

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