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Comparison of fecal analysis and rumen evacuation techniques for sampling diet botanical composition of grazing cattle

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Abstract

Fecal samples, evacuated rumen samples, and non-evacuated rumen samples were compared at different seasons as techniques for determining diet botanical composition of cattle. The study was conducted at the New Mexico State University College Ranch near Las Cruces. Six rumen-fistulated steers were used spring (28 May–7 June), summer (19 July–8 August), fall 1989 (1–17 October), winter (8–28 January) 1990; 4 rumen-fistulated steers were used during summer (24 July–4 August) 1990. Sampling techniques differed ($P<0.05$) for the proportion of some plant species in steer diets at certain seasons. In most cases, these differences were observed only for minor forage species. Similarity (%) between fecal samples, evacuated rumen samples, and non-evacuated rumen samples varied with season and with the particular techniques being compared. Similarity was lowest in fall between fecal samples and evacuated rumen samples (74%), and highest in summer (1989) between fecal samples and non-evacuated rumen samples (93%). Differential digestion, sampling procedures, and observer errors may explain these differences. For practical purposes, fecal analysis appears to be one of the best techniques to evaluate diet composition of large herbivores.

Key Words: microhistological technique, diet analysis, fecal analysis

A clear understanding of animal botanical diet composition is essential for efficient range management of rangeland ungulates. Several methods have been developed to evaluate dietary botanical composition of grazing animals, including direct observation of the animal, utilization techniques and ocular estimation. Due to animal selectivity and the limited sampling period, the chance for error is large using these techniques (Lesperance et al. 1960; Stewart 1967; Galt et al. 1969). Therefore, to overcome these problems, other techniques such as microhistological analysis of fecal material, rumen, and esophageal fistula extrusa have been developed. Baumgartner and Martin (1939) first applied histological methods for contents of squirrel stomachs and pioneered this technique for food habits determination. Dusi (1947) later adapted the histological method for fecal analysis of cottontail rabbits.

In much of the research conducted to evaluate botanical diet composition of rangeland ruminants, evacuated rumen, non-evacuated rumen, or fecal sampling techniques have been used (Anthony and Smith 1974, Dearden et al. 1975, Johnson and Person 1981, McInnis et al. 1983, Olson 1991). Similarities between these techniques have been inconsistent. Johnson and Pearson (1981) found using Kulczynski's similarity index, that estimates of cattle diet composition obtained by esophageal and fecal samples were about 90% similar. McInnis et al. (1983) reported that fecal samples had a higher proportion of grasses than non-evacuated rumen samples, but they also found that non-evacuated rumen samples had a higher proportion of grasses than esophageal samples. The objective of this study was to compare analyses of fecal samples, evacuated rumen, and non-evacuated rumen samples for species composition of cattle diets.

Materials and Methods

This study was part of a project dealing with several aspects of beef cattle production under semi-desert conditions. It was conducted at the New Mexico State University College Ranch, 38 km north of Las Cruces. The study pasture covers an area of 1,400 ha with a climate typical of semi-arid grassland. Precipitation on the area is basically bimodal with the major peak in the summer. Long-term precipitation is 229 mm annually, while during the study annual precipitation was nearly 12% above this average (Mohammed 1992). Precipitation from June through September is over 50% of the annual precipitation.

Vegetation of the study pasture is typical of semi-desert grassland (USDA-ARS 1987). Dominant grass species are black grama (*Bouteloua eriopoda* [Torr.] Torr.) and *Sporobolus flexuosus* [Thurb.] Rybd.) on upland sites. Several forb species are scattered throughout the pasture while mesquite (*Prosopis glandulosa*

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Torr.) is the main large shrubby species. Standing crop of grass varied from a high of 664 kg ha^{-1} in Fall 1989 to a low of 202 during the Summer of 1990 (Mohammad 1992). Forb standing crop varied from 220 kg • ha^{-1} to a low of 50.

Six rumen-fistulated crossbred steers (red Angus X [Hereford X Angus]), born in 1988, were used for sample collection during spring (28 May–7 June), and 4 steers during summer (19 July –8 August), fall, 1989 (1–17 October), and winter (8–28 January). Four sample diets were collected from each steer in each seasonal period. The steers were gathered from the pasture at 0800 hours on each of the 4 sampling days and moved to a corral. Rectal grab samples of feces were collected from each steer and placed in separate plastic bags.

For the rumen samples, rumen contents of each steer were evacuated into an individual plastic container and sides of the rumen were cleaned with sponges, as described by Lesperance et al. (1960). A sample of each steer's rumen contents was placed in a separate plastic bag (rumen non-evacuation samples). After evacuation, steers were returned to a representative area in the pasture where they were allowed to graze with the other cattle for 45 minutes, then returned to the corral. These representative areas were locations within the pasture where other cattle (44 head) used in the overall study (Kattning 1991 and King 1991) were grazing. The steers generally grazed with the larger herd before being gathered and during sample collection.

The ingested samples were removed and placed in individual plastic bags (rumen evacuation samples). All rumen samples were placed on ice in the field and transferred to a freezer in the lab where they were processed and analyzed. Fecal samples were handled in the same manner as the rumen samples.

One composite sample was prepared across the 4 sampling days for each steer within each seasonal period. Botanical composition of each steer's diet obtained by fecal, evacuated rumen, and non-evacuated rumen samples was determined using the microhistological technique described by Sparks and Malechek (1968). Training for slide reading and plant identification was carried out according to procedures described by Holechek and Gross (1982a).

Twenty fields in each slide were selected randomly. Species identified by epidermal characteristics in each field were recorded (Sparks and Malechek 1968). To obtain more accurate results, hairs, trichomes, and small particles were disregarded (Holechek and Gross 1982a), and magnification levels of 100 X were used, with 200 X used when the particle characters were unclear (Holechek and Valdez 1985). Frequency of occurrence of each species was calculated and converted to relative density, which was used as the percentage weight estimate for each species in the diet (Holechek and Gross 1982b).

Dietary overlap between fecal, evacuated rumen, and non-evacuated rumen samples were obtained by utilizing Kulczynski's similarity index (Oosting 1956).

Statistical analysis was conducted using the Statistical Analysis

Table 1. Botanical composition of steer diets (%) obtained by fecal (F), evacuated rumen (Ev), and non-evacuated (No-Ev) rumen samples during different seasons on semidesert rangeland in southern New Mexico.

Plant	Spring 1989		Summer 1989			Fall 1989			Winter 1990			Summer 1990	
species	F	Ev	F	Ev	No-Ev	F	Ev	No-Ev	F	Ev	No-Ev	F	No-Ev
Grasses													
Sporobolus spp.	41	40	30	31	28	5^{a}	2^{b}	3^{b}	3	4	3	1	1
Bouteloua eriopoda	4	4	36	39	37	3	10	2	29	40	35	34	35
Aristida spp.	8	7	3	5	4	22	15	22	8^{a}	1^{b}	6^{a}	17^{b}	24^{a}
Scleropogon brevifolius	3	2	1	2	2	1^{b}	3^{a}	1^{b}	1	2	3	6^{a}	5^{b}
Erioneuron pulchellum	T	3	0	0	0	4	3	3	5	6	8	7	7
Hilaria mutica	0	0	7^{a}	T^{b}	7^{a}	1	1	2	0	T	0	0	1
Muhlenbergia arenacia	0	0	1	1	2	3	1	2	3	3	2	T	T
Total grasses	57	56	78	78	79	39	34	35	49	56	56	65^{b}	72^{a}
Forbs													
Croton pottsii	18	16	7	6	6	6	5	6	5	8	7	6	7
Solanum elaeagnifolium	1	1	0	0	0	1	T	1	3^{a}	T^{b}	1^{b}	3^{a}	1^{b}
Lesquerella fendleri	1	T	0	T	0	0	0	T	2^{a}	T^{b}	1^{b}	T	0
Sphaeralcea spp.	1	0	1	T	1	2	1	1	1	1	1	4^{a}	T^{b}
Psilostrophe tagetinae	4^{b}	13^{a}	0	T	0	1	T	3	0	T	T	T	2
Cassia bauhinoides	4	3	T^{b}	2^{a}	T^{b}	6^{ab}	4^{b}	8^{a}	0	0	0	8	5
Dalea nana	0	0	1	1	0	1	1	1	0	T	0	0	0
Dithyrea wislizenii	3	1	0	0	0	1	T	T	3	1	1	T	T
Euphorbia spp.	0	0	2^{b}	T^{c}	3^{a}	17	16	15	2	1	2	7	9
Salsola australis	0	0	4	5	6	2^{c}	10^{a}	5^{b}	7	5	4	3	1
Machaeranthera spp.	0	0	0	1	T	4^{a}	2^{b}	4^{a}	T	T	1	T	T
Eriogonum trichopes	0	0	1	1	T	T	T	T	0	0	0	0	0
Zinnia spp.	0	0	4	4	3	T	1	T	2	T	1	0^{b}	1^{a}
Others forbs	3	2	1	1	1	7	8	6	5	5	5	T	T
Total forbs	35	35	20	21	20	49	47	53	30	22	23	31^{a}	25^{b}
Shrubs													
Yucca elata	2	2	1	T	1	4	4	4	9^{a}	2^{b}	8^{a}	1	1
Ephedra trifurca	4	5	0	1	T	7	8	6	8	16	9	1	1
Prosopis glandulosa	2	3	1	T	1	2^{b}	7^{a}	3^{b}	5	4	4	2^{a}	1^{b}
Total shrubs	8^{a}	10^{b}	2	1	2	12	19	12	21	22	21	4	3

^{abc}Means within rows at the same period with different letter differed significantly (P>0.05).
^{T}Species identified in trace (<1%) amounts.

System (SAS) procedure (SAS Institute 1985). A randomized complete-block design with steers used as blocks was used to compare fecal, rumen evacuation, and rumen-non-evacuation sampling techniques by period for each plant component (%). Mean separations for sampling techniques using LSD were conducted where analysis of variance detected a significant difference ($P<0.05$).

Results

Dietary data obtained from fecal samples and evacuated rumen samples during the 1989 spring period differed ($P<0.05$) only in total shrub content (Table 1). Evacuated rumen samples showed slightly higher total shrub content than fecal samples. The only species estimate that differed ($P<0.05$) between the 2 sampling techniques was woolly paper flower (*Psilostrophe tagetinae* [Nutt.] Rydb.). This species comprised 4% in fecal samples and 13% in evacuated rumen samples.

No differences ($P>0.05$) were found between fecal samples, evacuated rumen samples, and non-evacuated rumen samples for any of the forage groups (i.e., grasses, forbs, shrubs) during Summer 1989 (Table 1). At the individual species level, tobosa (*Hilaria mutica* [Buckl.]), two-leaf senna (*Cassia bauhinoides* Gray), and spurge (*Euphorbia* spp.) differed among sampling techniques. Tobosa and spurge were lower and two-leaf senna was higher in evacuated rumen samples than in fecal samples and non-evacuated rumen samples. Only spurge exhibited a smaller proportion ($P<0.05$) in fecal samples than in non-evacuated rumen samples. None of the major forage species showed differences ($P>0.05$) between fecal samples, evacuated rumen samples, and non-evacuated rumen samples.

In Fall 1989 five species differed ($P<0.05$) among fecal samples, evacuated rumen samples, and non-evacuated rumen samples (Table 1). Fecal samples had slightly higher proportions of dropseeds (*Sporobolus* spp.) than evacuated and non-evacuated rumen samples. Higher proportions of two-leaf senna and aster (*Machaeranthera* spp.) were identified in non-evacuated rumen samples than by evacuated rumen samples, but no differences were detected between fecal samples and the other 2 sampling techniques for these plant species. The proportion of Russian thistle (*Salsola australis* R. Brown) was highest in evacuated rumen samples, with non-evacuated rumen samples being intermediate and lowest with the fecal samples. Evacuated rumen samples had a higher proportion of mesquite (*Prosopis glandulosa* Torr.; 7%) species than fecal samples and non-evacuated rumen samples, but fecal samples and non-evacuated rumen samples were not different ($P>0.05$).

In Winter 1990, threeawn (*Aristida* spp.) and soaptree yucca (*Yucca elata* Engelm.) were higher in fecal and non-evacuated rumen samples than in evacuated rumen samples (Table 1). Fecal samples exhibited higher proportions ($P<0.05$) of silverleaf nightshade (*Solanum elaeagnifolium* Cav.) and fendler's bladderpod (*Lesquerella fendleri* [Gray] Wats.) than evacuated, and non-evacuated rumen samples.

Fecal samples and non-evacuated rumen samples were different ($P<0.05$) in the proportions of total grasses and total forbs during Summer 1990 (Table 1). Fecal samples were lower in total grasses and higher in total forbs than non-evacuated rumen samples. Threeawns and zinnia (*Zinnia* spp.) had lower proportions ($P<0.05$) in fecal samples than in non-evacuated rumen samples. Burrograss (*Scleropogon brevifolius* Phil.), silverleaf nightshade, globemallow (*Sphaeralcea* spp.) and mesquite had higher proportions ($P<0.05$) in fecal samples than non-evacuated rumen samples.

Kulczynski's similarity indices between fecal samples, evacuated rumen samples, and non-evacuated rumen samples are shown in Table 2. The variations depend largely on season and on the techniques being compared. During summer 1989, the similarity was 87%, 93%, and 88% between fecal samples and evacuated rumen samples, between fecal samples and non-evacuated rumen samples, and between evacuated rumen and non-evacuated rumen samples, respectively. In fall, similarity indexes were lower than summer, and there were 74%, 76%, and 76% similarity between fecal samples and evacuated rumen samples, between fecal samples and non-evacuated rumen samples and between evacuated rumen samples and non-evacuated rumen samples, respectively. During winter, similarity indexes between fecal samples and evacuated rumen samples were lower than between fecal sample and non-evacuated rumen samples or between evacuated rumen samples and non-evacuated rumen samples.

Table 2. Diet similarity (%) between fecal, evacuated rumen, and non-evacuated rumen sampling techniques.

	Sampling techniques		
Period	F vs Ev[1]	F vs Non-Ev[1]	Ev vs Non-Ev[3]
18 May to 7 Jun. 1989 (Spring)	88	-	-
19 Jul. to 8 Aug 1989 (Summer)	87	93	88
1 to 17 Oct 1989 (Fall)	74	76	76
8 Jan. 8 to 28 Jan. 1990 (Winter)	75	84	83
23 Jul. to 4 Aug. 1990 (Summer)	-	84	-

[1]Fecal vs evacuated rumen samples.
[2]Fecal vs non-evacuated rumen samples.
[3]Evacuated vs non-evacuated rumen samples.

Discussion and Conclusions

Differences observed between sampling techniques were mostly among minor forage components. The major reasons for these differences as described by other workers could be differential digestion between forage groups (Anderson et al. 1965, McInnis et al. 1983), sampling procedure (Holechek et al. 1984), or observer errors (Holechek et al. 1982). Differential digestion of different forage species is affected mainly by fiber and lignin contents, which depend on plant form and growth stage of the plants. Therefore, similarity indices among sampling techniques varied according to seasons, reflecting the growth stage of different forage species. The similarity between fecal samples and non-evacuated rumen samples was high during summer. At this early period of growth, succulent grasses form the largest components of steer diets. King (1991) found that organic matter disappearance was highest during summer; therefore differential digestion likely had little effect. In fall when grasses are mature, the similarity between fecal samples and non-evacuated rumen samples was lower.

The other factor that might affect differences between fecal samples, evacuated rumen samples, and non-evacuated rumen

samples is the length of grazing time that the sample represents. Fecal samples represent forage eaten for several feeding periods, and non-evacuated rumen samples represents food eaten for fewer feeding periods (Anthony and Smith 1974), while evacuated rumen samples represent forage eaten for 45 min. only. In addition fecal and non-evacuated rumen samples could represent several feeding stations within a pasture while rumen evacuated samples represent diet selected from a relatively small grazing area. Samuel and Howard (1982) found that diets selected in the morning were different from that selected in the evening. In addition, the heterogeneity of rumen contents makes it difficult to collect a representative sample of diet consumed over several feeding periods. In general, our data showed that all 3 techniques provided similar estimates. The largest differences were between fecal samples and evacuated rumen samples. These differences could be due to different grazing locations within the pasture or differential digestion. We attempted to control variation in grazing locations within the pasture by allowing collecting animals to graze with the larger herd. The growth stage of the plants, seasons of sampling, and length of grazing period that the sample represent should all be considered when diet botanical composition is to be investigated. For practical purposes of sampling without performing surgery to the animal and obtaining samples quickly and easily, fecal analysis might be the most appropriate technique for evaluating cattle diet botanical composition.

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