Comparison of Two Diet Analysis Techniques Applied to White-tailed Deer

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Abstract: Paired rumen and fecal samples from 89 white-tailed deer (*Odocoileus virginianus*) collected in the South Carolina Coastal Plain were analyzed using standard macro- and micro-techniques, respectively. Compared to fecal analysis, rumen analysis identified fewer plant taxa per sample ($P < 0.05$). A significant correlation among mean percent weights of forage categories ($P < 0.05$) and taxa ($P < 0.05$) was found. Spearman's rank correlation coefficients for percent frequency of detection were also significant for forage categories ($P < 0.05$) and taxa ($P < 0.05$). Estimates of mean percent weight were significantly different between techniques for 7 of 9 forage categories and 16 of 26 taxa found by both. The time needed to analyze the 2 types of samples was not significantly different. Usefulness of fecal analysis in estimating diets of southeastern Coastal Plain deer is discussed.

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Rumen analysis has been the most common method of estimating the food habits of a deer population. However, there are situations where an adequate number of animals cannot be collected for this technique. Such a situation might arise on a preserve or refuge where legal restraints or adverse public reaction might hamper collection efforts. A need exists for a food habits investigative technique that is applicable on an annual cycle basis, minimizes contact with the animal, and is practical in time and labor requirements. Fecal analysis has been proposed as such a technique by Stewart (1967), Todd and Hansen (1973), and Johnson and Pearson (1981).

While rumen analysis has been used extensively in the Southeast (Harlow and Hooper 1971, Sossaman and Weber 1973, Harlow et al. 1975, 1979), fecal analysis has received little attention. Since Harlow and Hooper

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(1971) reported that the forage of southeastern deer consisted mainly of herbage and foliage of woody plants, most of the ingesta should be identifiable by epidermal fragments. The purpose of this study was to compare estimates of diet composition and forage species array size from rumen and fecal analysis for deer collected in the fall-winter season in the South Carolina Coastal Plain.

Study Areas

The South Carolina Coastal Plain encompasses 51,720 km^2 of which 63% is forested and 20% is in agricultural lands (U.S. Department of Agriculture 1980). Some 42% of the forest is in softwoods and 58% is in hardwoods. Principal species types and the percentage of the forest area accounted for by them were: oak-gum-cypress (*Quercus-Nyssa-Taxodium*), 25%; loblolly pine (*Pinus taeda*), 25%; longleaf pine (*P. palustris*), 6%; and pond pine (*P. serotina*), 4% (Craven 1979, Sheffield and Hutchinson 1979).

Specific collection sites were Buist Game Management Area in the northern Coastal Plain, Francis Marion National Forest, Hobcaw Barony, and Alumax Aluminum Plant lands in the central Coastal Plain, and the vicinity of Palachocola Game Management Area in the southern Coastal Plain.

Methods

Animals were collected either by hunters or by researchers by night-lighting. Rumen samples were 0.97 liter in size. Fecal samples were taken from the last 30 to 40 cm section of the colon. Each sample was separately preserved in formalin.

Treatment of rumen samples followed the procedures used by Harlow and Hooper (1971). Separates were dried at 60° to 65° C for a minimum of 24 hours then weighed to the nearest 0.01 mg. The time required to analyze a rumen sample was recorded. Work time began when the rumen material was emptied onto the sieve and ended when the separates were placed in the drying oven. Time needed to weigh the separates was added to the time required for separation to obtain total processing time.

Prior to beginning fecal analysis, a reference collection of photomicrographs was made of tissues of species and plant parts important as forage to white-tailed deer. Mengak (1982) described the modification to the procedures of Storr (1961), Stewart (1967), and Anthony and Smith (1974) which were used in processing the reference plant tissue and fecal samples. Both fecal analysis and rumen analysis in all sample sets were carried out by the senior author.

Percent weight of a species in the diet based on composition of fecal material was estimated according to the method of Sparks and Malechek (1968).

The time required to analyse a fecal sample was recorded. Time began with preparation of the first slide and continued to completion of the examination of the tenth slide. All data for both rumen and fecal analysis were converted to aggregate percent weight (Martin et al. 1946) and data analysis was conducted on the paired samples.

Prior to statistical testing, the percent weight was transformed using the arc sine transformation. Similarity of the diet as determined by each technique was compared using Kulczynski's formula (Oosting 1956). Paired *t*-tests were used to compare the mean percent weight of ingesta by forage category. Plant names follow Scott and Wasser (1980). Except where noted, values are reported as mean and standard deviation and statistical significance was accepted at the 0.05 level.

Results

Seventy-seven deer were collected from August to December 1979. An additional 12 deer were collected in February 1981.

Fecal analysis placed 3.6 times more woody plant leaves and 18.6 times more herbs in a genus or species than did rumen analysis. On the other hand, rumen analysis placed 1.2 times more fruits from woody plants in a genus or species than did fecal analysis. The 2 procedures were about equal in effectiveness in identification of woody twigs.

Leaves of woody plants accounted for 45% of the diet by rumen analysis and 40% of these were dead when ingested. Twenty-four percent of all green and 15% of all dead leaves of woody plants were identified to genus or species with the remainder being unidentifiable beyond category. Fecal analysis estimated that woody plant leaves made up 63% of the diet by fecal analysis and 40% of these were identifiable to genus or species. Green leaves could not be separated from dead leaves by this technique.

Paired *t*-tests were used to compare the mean percent weight of ingesta by forage category (Table 1). Fecal analysis estimates of percentage weight values were significantly higher than those of rumen analysis for woody plant leaves, twigs, and ferns. Rumen analysis estimated significantly larger weight amounts of fruit, herbaceous plants, fungi, and grass than did fecal analysis. Estimates for the lichen and moss category and agricultural crops category were not significantly different between the techniques.

A total of 49 taxa were identified by the combined methods of analysis. Rumen analysis detected 9 taxa individually accounting for more than 1% of the identifiable ingesta, while fecal analysis detected 15 (Table 2). Among the 28 taxa common to both techniques, rumen analysis estimates of mean percent weight were significantly lower than fecal analysis estimates in 14 cases but never significantly exceeded them.

Among woody plant species identified, 2 were found only by rumen analysis and 9 only by fecal analysis. Among the identified species of herbs,

Table 1. Mean percent weight ± standard error and percent frequency of detection of the major categories of fall-winter forage as estimated by rumen and fecal analyses of 89 white-tailed deer collected in the South Carolina Coastal Plain.

Category	Rumen analysis		Fecal analysis	
	Mean % weight	% frequency of detection	Mean % weight	% frequency of detection
Woody plant leaves[a]	44.9 ± 3.1	99	63.4 ± 2.4	97
Woody twigs[a]	10.8 ± 1.2	96	17.0 ± 1.0	100
Woody plant fruit[a]	22.8 ± 3.7	51	14.1 ± 2.3	79
Herbs[a]	6.0 ± 1.5	67	1.4 ± 0.3	36
Fungi[a]	7.9 ± 1.5	69	1.7 ± 0.4	36
Grass[a]	3.1 ± 1.1	82	0.3 ± 0.1	13
Lichens & mosses	0.6 ± 0.4	7	0.0	0
Ferns[a]	0.1 ± 0.1	9	0.8 ± 0.1	31
Agricultural crops	3.9 ± 1.9	8	0.2 ± 0.2	3

[a] Mean percent weights are statistically different ($P < 0.05$).

grasses, and ferns, 6, 0, and 0, respectively, were unique to rumen analysis while 2, 1, and 2, respectively, were unique to fecal analysis.

Except for woody plant leaves and twigs, there are substantial differences in the percent frequency of detection of forage categories (Table 1) by the different techniques. For all categories except woody plant leaves and fruit, categories with the highest percent weight by 1 analysis also had the highest percent frequency of detection.

The 6 taxa which accounted for at least 1.0% of the estimated diet by both the rumen and fecal analysis had a mean percent frequency of detection of 36.7 ± 16.9 in the rumen analysis and 59.2 ± 19.3 in the fecal analysis. Chi-square analysis revealed that distribution of the percent frequencies of detection were not significantly different between techniques. The 9 taxa accounting for at least 1.0% or more of the diet estimated by rumen analysis and 15 taxa of the same importance in the fecal analysis had mean frequencies of detection of 27.0 ± 19.7 and 48.6 ± 22.5, respectively.

The number of genera or species identified per sample differed significantly between techniques. An average of 12.8 ± 4.3 taxa per sample were identified from fecal samples, while 3.8 ± 2.2 taxa per sample were identified from rumen analysis.

Spearman's rank correlation test showed a significant correlation among the forage categories and taxa was found when ranking by mean percent weight. Similarly, Spearman's test showed the ranking of forage category and taxa by percent frequency of detection was significantly correlated. For the forage category data (Table 1), the index of similarity (IS) was 73.5%. For the taxa data (Table 2), the IS was 55.3%.

Table 2. Mean percent weight ± standard error and frequency of detection of taxa estimated by rumen and fecal analyses to account for 1.0% or more of the fall-winter diet of 89 white-tailed deer collected in the South Carolina Coastal Plain.

Taxa	Rumen analysis		Fecal analysis	
	Mean % weight	% frequency of detection	Mean % weight	% frequency of detection
Quercus spp.	16.4 ± 3.4	44	13.7 ± 1.6	27
Ilex glabra	3.1 ± 1.0	31	4.9 ± 0.7	58
Gelsemium sempervirens[a]	2.3 ± 0.7	31	4.5 ± 0.5	79
Sabal spp.	2.1 ± 1.1	7	0.2 ± 0.1	12
Ilex spp.[a]	1.7 ± 0.5	37	4.5 ± 0.6	72
Lonicera japonica[a]	1.5 ± 0.6	13	3.9 ± 0.6	71
Smilax bona-nox	1.3 ± 1.1	8	0.1 ± 0.1	8
Pinus spp.[a]	1.0 ± 0.2	64	1.9 ± 0.3	48
Rubus spp.[a]	0.8 ± 0.3	24	2.1 ± 0.3	65
Berchemia scandens[a]	0.5 ± 0.3	8	2.0 ± 0.4	38
Smilax spp.[a]	0.4 ± 0.2	13	3.5 ± 0.6	55
Ilex coriacea[a]	0.3 ± 0.2	8	2.2 ± 0.3	52
Vaccinium spp.[a]	0.1 ± 0.1	9	4.0 ± 0.5	66
Ilex vomitoria[a]	0.1 ± 0.1	6	2.4 ± 0.4	53
Juniperus virginiana[a]	0.1 ± 0.03	6	1.9 ± 0.3	52
Liquidambar styraciflua[a]	0.04 ± 0.04	1	2.4 ± 0.3	64
Rhus spp.	0.0	0	0.5 ± 0.2	23
Vitis spp.	0.0	0	2.2 ± 0.4	52
Glycine max	3.9 ± 1.80	8	0.2 ± 0.2	3
Total	33.3		56.1	

[a] Mean percent weights are statistically different ($P < 0.05$).

The time required to analyze a rumen sample averaged 80.0 ± 38.4 min. The time required to analyze a fecal sample was 83.6 ± 36.0 min. This difference was not significant.

Discussion

The accuracy of free-ranging animal intake estimates has been difficult to determine. Usually, researchers are limited to comparing new techniques with those believed to be reliable or at least traditionally accepted. To minimize the bias against a new technique, it probably should be evaluated primarily on demonstrated strengths and weaknesses, and secondarily on ability to duplicate the results of another method.

This study is unique in the comparison of diet composition percent weight estimates by rumen analysis using a macro-technique with microscopic fecal analysis using percent weight estimates based on relative densities. Anthony and Smith (1974) compared relative volume estimates of rumen contents with percent composition estimates by fecal analysis. All other simi-

lar studies have ground the ingesta and fecal material to the same fineness and conducted microscopic analyses of both (Smith and Shandruk 1979, Vavra et al. 1978, Johnson and Pearson 1981). Of these 5 investigations, only Johnson and Pearson (1981) failed to raise reservations about fecal analysis as a good estimate of diet composition.

The latter workers reported that fecal analysis conducted on cattle grazing on longleaf pine-bluestem (*P. palustris-Andropogon* spp.) range gave diet composition estimates that closely approximated exclosure and esophageal fistula results. Kulczynski's similarity index between exclosure and fecal analysis results was 90%. However, *Andropogon* spp. made up 52% to 60% of the diet and *Panicum* spp. made up another 9% to 15% among the 3 methods. Estimators of a simple diet should have a high similarity index if only the major items can be detected with similar accuracy. Logically, as diet complexity increases with type of forager (grazer vs browser-grazer) and type of ecosystem (grassland vs forest), the magnitude of difficulty of diet analysis by any technique increases greatly. Concomitant with this increase will be a decrease in agreement between techniques used to estimate diet composition.

Accurate fecal analysis estimates require that the detection of cutinized epidermal fragments be in proportion to the weight of each species in the total ingesta. This assumption is probably most closely met for grazers in grassland ecosystems. It is probably least met for animals whose diets include woody twigs and leaves, hard and soft mast, fungi, forbs, lichens, and mosses. There are several reasons why fecal analysis may be limited in yielding accurate estimates of forage intake by free-ranging animals with complex diets.

First, the ratios of epidermal cell tissue to the total volume or weight of the plant part ingested obviously must vary greatly between forage categories, e.g., acorns vs leaves. In addition, the degree to which the epidermis is cutinized depends upon the stage of maturity of the plant part and even the conditions under which it was grown (Meyer and Anderson 1952). Croker (1959) found that a thin cuticle could disintegrate in in-vitro digestion. Second, difference in specific gravity between certain types of forages is probably large, e.g., woody twigs vs fungi. Sparks and Malechek (1968) noted the potential for this problem. And third, differential fragmentation and differential digestibility are limitations (Stewart 1967, Vavra et al. 1978, Smith and Shankdruk 1979). Johnson et al. (1983) found that digestion does not alter overall diet composition but does significantly alter detectability of certain plants.

Reports involving the utilization of the microhistological technique commonly site Sparks and Malechek (1968) for validation. However, these workers formulated various compounds of 5 species each of grasses and forbs and demonstrated that they could accurately predict percent weight from relative density of epidermal fragments in a microscope field. Dearden et al. (1975) demonstrated the important effects of differential digestibility and detectibility by developing correction factors which greatly improved their

correlation coefficients for mixtures of 8 plant species tested in 4 ruminants. Brand (1978), however, was unable to develop reliable correction factors for seeds of 3 species ingested by small mammals.

While our data and those previously published indicated that the diet composition of white-tailed deer in the South Carolina Coastal Plain was too complex to be completely characterized by fecal analysis, the procedure can be applied to animals with a complex diet. Stewart (1967), Todd and Hanson (1973) and Vavra et al. (1978) suggested that frequency of detection of forages, irrespective of percent composition estimates, were important food habits data and may be the only data necessary for decision making.

Probably no technique applied to free-ranging animals is without substantial error. In this study, while rumen analysis detected 8 taxa not detected by fecal analysis, the latter detected 14 taxa unique to it. Thus, fecal analysis is likely to yield information on use of a wider array of taxa than the widely accepted rumen analysis technique. Simply knowing those species which are being ingested and detected is important to the wildlife manager so long as he recognizes the limitations of these data. Of great importance is that through fecal analysis this information can be obtained without legal constraint or sacrificing animals and can be done throughout the year.

Conclusions

Substantial differences in results from rumen and fecal analyses used to estimate white-tailed deer diet composition can be expected when both are applied in the South Carolina Coastal Plain forest ecosystem. While fecal analysis identifies more taxa than rumen analysis, it is suspected that differential digestibility and differences in specific gravity may affect composition estimates.

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