Thomas A. Hanley

USDA, Forest Service
Pacific Northwest Forest and Range Experiment Station
Forestry Sciences Laboratory
P.O. Box 909
Juneau, Alaska 99802

Donald E. Spalinger

Department of Zoology
Washington State University
Pullman, Washington 99164

Kathleen A. Hanley

136 Behrends Avenue
Juneau, Alaska 99801

and

John W. Schoen

Alaska Department of Fish and Game
230 South Franklin Street
Juneau, Alaska 99801

Relationships Between Fecal and Rumen Analyses for Deer Diet Assessments in Southeastern Alaska

Abstract

Rumen and fecal samples obtained from 13 Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) from 21 January through 13 March 1981, were analyzed to determine percentage dry weight composition of plant species and forage classes. Mean percentage similarity of the two types of samples was 65 and 77 percent for plant species and forage classes, respectively. Spearman's rank correlation coefficients were 0.56 and 0.66 ($P<0.05$ for both), respectively. Forbs and ferns were consistently more abundant in rumen than fecal samples, while graminoids, mosses, conifers, and lichens were more abundant in fecal than rumen samples.

Introduction

The composition of diets selected by wild, free-ranging ungulates is difficult to determine. Such a determination is important for evaluating the nutritional quality of diets and for understanding animal-habitat relationships. Direct methods of determining diet composition, such as esophageal fistula (Veteto *et al.* 1972) or bite count (Wallmo and Neff 1970) methods, can be used only with tame, or at least very human-tolerating, animals. Diet determinations for wild, free-ranging ungulates must rely on indirect methods, such as forage site examinations (Cole 1959), stomach analysis (Korschgen 1962, Dirschl 1962), or fecal analysis (Croker 1959, Storr 1961). Forage site examinations suffer from the obvious problems of measuring what has been eaten and the site-specific nature of the data. Stomach and fecal analyses are the most commonly employed methods of determining diet comosition of wild, free-ranging ungulates.

The principal advantage of stomach analysis is that much of the contents consists of macroscopic fragments that can be identified readily with minimal equipment. The principal disadvantages are that animals must be killed or captured to obtain samples and that forages that are readily digested or rapidly passed from the stomach tend to be under-represented while those that are slowly digested and/or passed tend to be over-represented. The latter is a special problem with rumen analysis (Bergerud and Russell 1964, Gaare *et al.* 1977). That technique results in over-estimation of the poorer quality forages and underestimation of the better forages. The principal advantage of fecal analysis is that fecal samples are relatively easy to obtain and do not require handling of animals; hence, it is possible to obtain large sample sizes without disturbing the study population. The principal disadvantages are that plant fragments must be identified microscopically, thus requiring extensive experience, and that highly digestible and/or poorly identifiable forages tend to be under-represented, while poorly digestible and/or highly identifiable forages tend to be over-represented in the diet determination (Adams *et al.* 1962, Slater and Jones 1971, Dearden *et al.* 1975, Havstad and Donart 1978).

The purpose of this study was to compare the results of analyses of rumens and feces obtained from Sitka black-tailed deer (*Odocoileus hemionus sitkensis*) in southeastern Alaska. It was not possible to compare these results with known diets, since such data were not available. Still, it is important to have some understanding of how rumen and fecal results differ to enable better comparisons with results reported for one or the other method in the literature. This study offers a better basis for appraising the results from either method or from their use in combination. No such comparison has been made previously for Sitka black-tailed deer or for the forages of southeastern Alaska or coastal British Columbia.

Methods

The data were obtained as paired rumen and fecal samples from 13 deer shot from 21 January through 17 March 1981. All seven males and six females ranging from fawns to very old animals (10+ yrs), were collected in the vicinity of Admiralty Island (Hawk Inlet and Winning Cove) and northeastern Chichagof Island (Tenakee Inlet and Whitestone Harbor), approximately latitude 58° N, longitude 135° W. The winter of 1980-81 was very mild, with little or no snow at sea level during the time deer were collected. Animals were obtained by hunting in old-growth forest, beach-fringe, muskegs, and one recent clearcut. Animals were shot as encountered. From each animal, the rumino-reticulum was excised whole, and approximately 20 fecal pellets were obtained from the rectum. Materials were frozen and returned to the laboratory. Two 100-200 ml samples were obtained from each completely thawed rumen for determination of plant species composition. The samples were collected by thoroughly mixing the rumino-reticular contents and quickly removing a sample with a tubular suction device. Such samples were found to be highly uniform in terms of dry matter content, particle size distribution, and species composition (D. E. Spalinger, unpublished report on file at Forestry Sciences Laboratory, Juneau). The two samples from each rumen were combined and washed through standard soil screens. All material that did not pass through a 2.00 mm screen was retained, oven dried, and separated by plant species. The rumen composition was expressed as percentage oven-dry weight of each plant species. Fecal samples were prepared by mixing in a Waring blender and washing over a 0.074 mm

screen. Five microscope slides per sample were prepared according to procedures described by Sparks and Malechek (1968). Approximately three identifiable plant fragments occurred in each microscope field of view at 100 power magnification. Frequency of occurrence of each plant species in each of 20 microscope fields per slide (100 fields per sample) was determined and converted to percentage relative density (Sparks and Malecheck 1968), which is assumed to be directly proportional to percentage ovendry weight.

The treatment of these data as paired-samples requires the assumption that each deer consumed a constant diet during the approximately one week period preceding its collection. Drastic shifts in the diet could result in very different forages being represented in the upper and lower digestive tracts. This assumption of constant diet detracts from statistically valid paired-sample comparisons; but it permits examination of relationships which would not be possible by treating the data as two independent sets.

The data were analyzed in terms of plant species and forage classes. The overall mean compositions of the rumen and fecal samples were compared by calculating their percentage similarity (PS) by Czekanowski's Index (Feinsinger *et al.* 1981):

$$PS = \sum_i \min (p_i, q_i) \times 100,$$

where p_i is the proportional dry weight of item i in the rumen, and q_i is the proportional dry weight of item i in the feces. Spearman's rank correlation coefficient also was calculated for the two sets of results. Rumen-fecal relationships within forage classes were examined by plotting for each forage class the paired-sample results from each of the 13 deer.

Results

Rumen and fecal methods yielded generally similar results, both in terms of plant species composition and forage class composition (Table 1). The percentage similarities were 65 and 77 percent, respectively. Spearman's rank correlation coefficients were 0.56 and 0.66 ($P<0.05$ for both), respectively. Herb-layer, evergreen half-shrubs, especially *Cornus canadensis*, were the most abundant foods in both rumen and fecal material. Conifers, especially *Chamaecyparis nootkatensis* and *Tsuga* spp., were next most abundant, and graminoids and mosses were least abundant. It also is evident, however, that some forages were consistently over/under-represented in one technique relative to the other. Forbs and ferns were consistently more abundant in rumen than fecal samples, while graminoids, mosses, and to a lesser extent conifers, were more abundant in fecal than rumen samples (Fig. 1).

Among the forbs, *Lysichiton americanum* and *Coptis asplenifolia* were consistently very poorly represented in the fecal samples. Both are highly digestible (*L. americanum* was very young with tender shoots) (Hanley and McKendrick 1983). *Tiarella trifoliata* appeared to be equally well represented in fecal and rumen samples. The only paired sample that had a higher composition of forbs in the feces than the rumen was a sample that was especially high in *T. trifoliata* (17 percent in feces, 12 percent in rumen) and contained no other forbs. In all 12 of the other paired samples, forbs were under-represented in the feces relative to the rumen.

Herb-layer, evergreen half-shrubs, especially *Cornus canadensis*, tended to be under-

TABLE 2. Mean percentage composition, range, and percentage frequency of forage in 13 rumen and fecal samples from Sitka black-tailed deer collected during 21 January through 17 March 1981.

FORAGE CLASS/Species	Feces			Rumens		
	Percentage composition	Range	Percentage frequency[1]	Percentage composition	Range	Percentage frequency[1]
FORBS						
Coptis asplenifolia	1	0-4	69	9	0-19	92
Lysichiton americanum	t[2]	0-1	38	4	0-19	69
Moneses uniflora	t	0-t	8	0	0	0
Pyrola secunda	t	0-t	38	0	0	0
Tiarella trifoliata	2	0-17	62	2	0-12	85
HERB-LAYER, EVERGREEN HALF-SHRUBS						
Cornus canadensis	24	2-46	100	34	14-54	100
Rubus pedatus	11	1-37	100	7	1-32	100
Vaccinium spp.[3]	t	0-1	46	1	0-3	92
SHRUB LEAVES						
Empetrum nigrum	t	0-3	23	t	0-t	15
Ledum palustre	9	0-42	62	3	0-19	46
Oxycoccus microcarpus	t	0-1	31	0	0	0
Phyllodocae spp.	0	0	0	t	0-6	8
Vaccinium vitis-idaea	0	0	0	t	0-2	38
unknown	t	0-2	46	4	0-23	46
SHRUB STEMS						
Alnus spp.	t	0-t	8	0	0	0
Vaccinium spp.	5	t-16	100	4	0-10	92
unknown	1	0-5	69	6	0-17	92
CONIFERS						
Chamaecyparis nootkatensis	14	0-51	69	11	0-47	54
Picea sitchensis	0	0	0	t	0-t	23
Pinus contorta	t	0-3	15	0	0	0
Tsuga spp.	15	1-67	100	7	t-26	100
GRAMINOIDS[4]	2	0-7	85	t	0-t	38
FERNS[5]	2	0-18	31	4	0-38	38
LICHENS						
Lobaria spp.	5	0-44	85	0	0	0
Ushea spp./**Alectoria** spp.	t	0-1	38	1	0-3	77
other lichens	0	0	0	2	0-14	77
MOSSES						
Hylocomium spp./ **Rhytidiadelphus** spp.	4	0-16	100	t	0-1	69
Sphagnum spp.	1	0-1	69	t	0-t	15
ALGA (**Fucus furcatus**)	3	0-25	69	3	0-17	77

[1]Presence or absence in 13 samples.

[2]t=trace=<0.5 percent

[3]decumbent, evergreen variety.

[4]primarily **Elymus** spp. and **Carex** spp.

[5]primarily **Dryopteris dilatata.**

represented in the fecal samples relative to the rumen samples when their abundance was low in both fecal and rumen samples. Shrub leaves consisted primarily of *Ledum palustre*, which tended to be over-represented in the fecal samples relative to rumen samples. A high proportion of unknown leaves (23 percent) in one rumen sample was responsible for the anomolously high data point for shrub leaves in Figure 1. No clear relationships were evident in the comparison involving shrub stems.

Conifers, graminoids, lichens, and mosses tended to be over-represented in the fecal samples relative to rumen samples. Among the conifers, only *Chamaecyparis nootkatensis* and *Tsuga* spp. were represented to any important degree. Ferns were under-represented

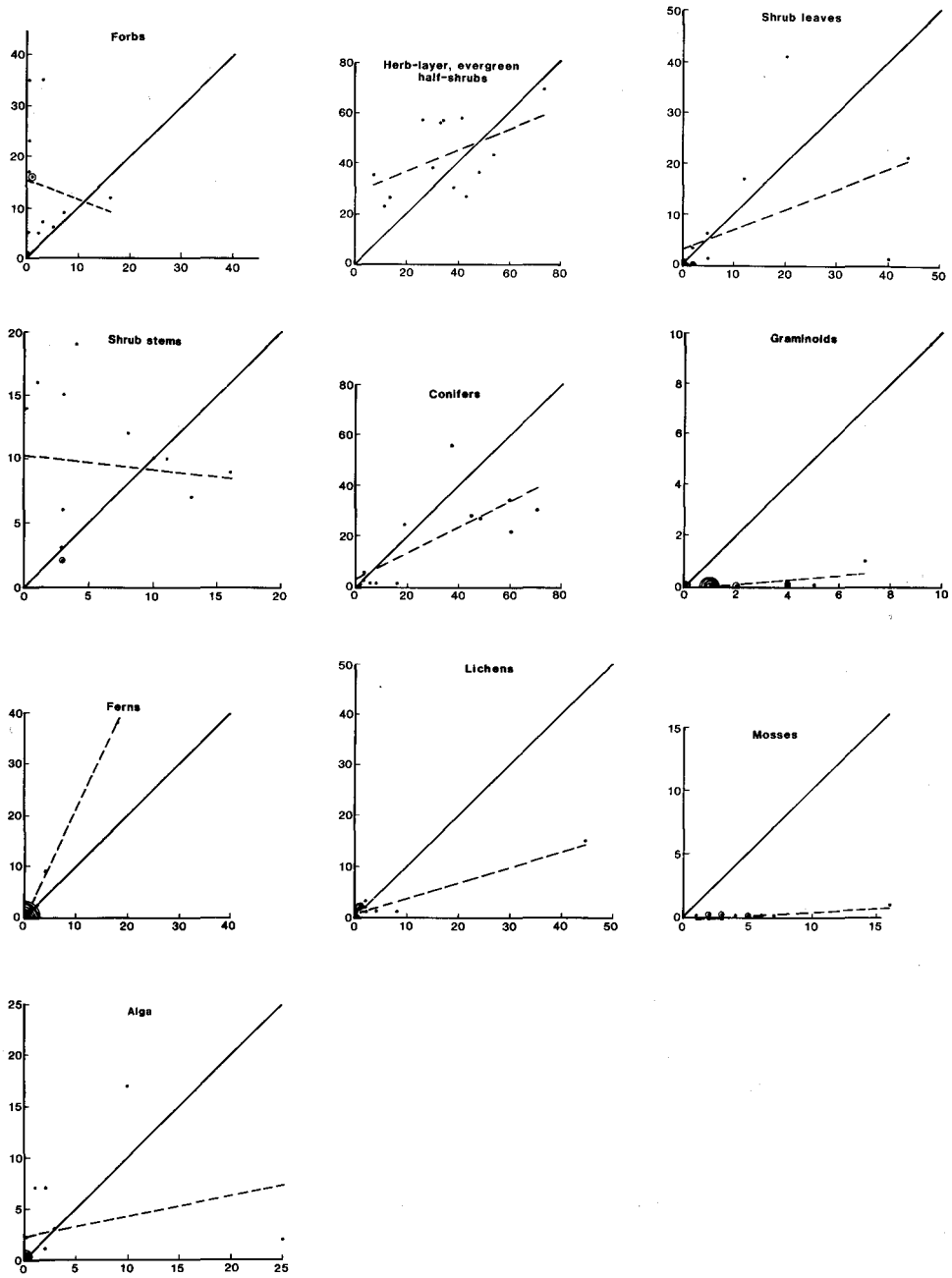

Figure 1. Percentage composition of 13 paired rumen and fecal samples (solid circles), plotted for each of 10 forage classes. Solid line indicates 1:1 relationship; broken line indicates linear regression best-fit relationship. Horizontal axis is percentage composition in feces; vertical axis is percentage composition in rumens.

in the feces relative to rumens, probably due to very high digestibility (ferns were primarily *Dryopteris dilatata* and were in the tender, young, fiddle-head stage at the

time they were eaten). No clear relationships were evident in the comparison involving rockweed alga (*Fucus furcatus*).

Discussion

Several general relationships are evident and provide valuable insight into the relative merits of rumen and fecal analyses for deer diet assessments in southeastern Alaska in winter and early spring. Forbs and ferns were under-represented, while graminoids, mosses, and conifers were over-represented in fecal analysis relative to rumen analysis. Similar results have been observed by other investigators (Anthony and Smith 1974, Dearden *et al.* 1975, Kessler *et al.* 1981) and have been related to differential digestibility and identifiability of forages. Highly digestible forages also are under-represented in rumen analysis relative to actual diet composition (Gaare *et al.* 1977). Both techniques tend to over-estimate diet constituents of poorer quality (i.e., digestibility) and underestimate those of higher quality.

In a more general sense, however, both techniques provided rather similar results. Fecal analysis has a practical advantage over rumen analysis in that animals do not need to be killed or captured to obtain fecal samples. The ability to obtain greater sample sizes with fecal analysis than with rumen analysis and the ability to obtain fecal samples repeatedly from the same study area without disturbing the study population are important considerations to be made when choosing between the two techniques. Neither technique yields actual diet composition data; both techniques have biases. These biases must be kept in mind when designing experiments and evaluating fecal or rumen composition data in terms if diet composition.

Literature Cited

Adams, L., W. G. O'Regan, and D. J. Dunaway. 1962. Analysis of forage consumption by fecal examination. J. Wildl. Manage. 16:108-111.

Anthony, R. G., and N. S. Smith. 1974. Comparison of rumen and fecal analysis to describe deer diets. J. Wildl. Manage. 38:535-540.

Bergerud, A. T., and L. Russell. 1964. Evaluation of rumen food analysis for Newfoundland caribou. J. Wildl. Manage. 28:809-814.

Cole, G. F. 1959. Key browse survey method. Proc. Ann. Conf. of the Western Assoc. State Fish and Game Comm. 39:181-185.

Croker, B. H. 1959. A method of estimating the botanical composition of the diet of sheep. New Zealand J. of Agric. Res. 1:72-85.

Dearden, B. L., R. E. Pegau, and R. M. Hansen. 1975. Precision of microhistological estimates of ruminant food habits. J. Wildl. Manage. 39:402-407.

Dirschel, H. J. 1962. Sieve mesh size related to analysis of antelope rumen contents. J. Wildl. Manage. 26:327-328.

Feinsinger, P. E., E. Spears, and R. W. Poole. 1981. A simple measure of niche breadth. Ecology 62:27-32.

Gaare, E., A. Sorensen, and R. G. White. 1977. Are rumen samples representative of the diet? Oikos 29:390-395.

Hanley, T. A., and J. D. McKendrick. 1983. Seasonal changes in chemical composition and nutritive value of native forages in a spruce-hemlock forest, southeastern Alaska. U.S. Dept. Agric., Forest Serv. Res. Pap. PNW-312. 41 pp.

Havstad, K. M., and G. B. Donart. 1978. The microhistological technique: testing two central assumptions in south-central New Mexico. J. Range Manage. 32:469-470.

Kessler, W. B., W. F. Kasworm, and W. L. Brodie. 1981. Three methods compared for analysis of pronghorn diets. J. Wildl. Manage. 45:612-619.

Korschgen, L. J. 1962. Foods of Missouri deer, with some management implications. J. Wildl. Manage. 26:164-172.

Slater, J., and R. J. Jones. 1971. Estimation of the diets selected by grazing animals from microscopic analysis of the feces—a warning. J. Australian Inst. of Agric. Science 1971:238-240.

Sparks, D. R., and J. C. Malechek. 1968. Estimating percentage dry weight in diets using a microscope technique. J. Range Manage. 21:264-265.

Storr, G. M. 1961. Microscopic analysis of faeces, a technique for ascertaining the diets of herbivorous mammals. Australian J. Biol. Science 14:157-165.
Veteto, G., C. E. Davis, R. Hart, and R. M. Robinson. 1972. An esophageal cannula for white-tailed deer. J. Wildl. Manage. 36:906-912.
Wallmo, O. C., and D. J. Neff. 1970. Direct observation of tamed deer to measure their consumption of natural forage. *In* Range and wildlife habitat evaluation—a research symposium. U.S. Dept. Agric. Forest Serv. Misc. Publ. No. 1147. Pp. 105-109.

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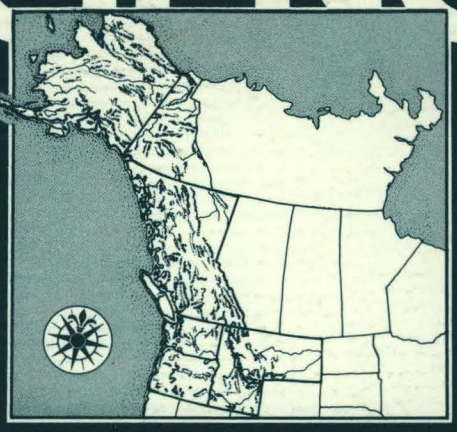

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