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METHODS OF ESTIMATING DRY-WEIGHT COMPOSITION IN DIETS OF STEERS [1]

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THE species of plants in the diets of grazing animals must be accurately determined in order to efficiently manage the grazing animal and, hence, the range ecosystem. Since animals select forage from a variety of species of plants and parts of plants, procuring estimates of the quantity and quality of plants in the diets of herbivores has been a difficult sampling problem. However, this information is essential for devising optimal grazing and supplementation plans (Cook and Harris, 1950).

The intent of this study was to compare the "microscope technique" and the "bite-count method" for estimating dry-weight composition of plant species in the diets of steers grazing sandhill range in eastern Colorado. Sparks and Malechek (1968) showed that dry-weight percentages of individual species of plants could be estimated in mixtures of grasses, forbs, and grass-forb combinations by a microscopic examination of histological characteristics of plant tissue. They accurately estimated the dry-weight composition of known mixtures of plants commonly found in the diets of herbivores (r^2=.98). The microscopic technique, therefore, appears to be a reliable criteria for comparison to the observational "bite-count" method.

Materials and Methods

Diet samples were collected from eight esophageal-fistulated Hereford steers for 3-day periods in mid-June, late-July, early-September and mid-December, 1967. Samples were taken about 1 hr. after sunrise and 1 hr. before sunset. The esophageal samples were dried in an oven at 55 C for 24 hours. Esophageal fistula samples for all steers were composited for each of the three morning and three evening samples. A subsample of each of the six composite samples was obtained by the quartering procedure. The subsamples were ground through a 40-mesh screen to reduce all plant fragments to a uniform size and then washed with water over a 200-mesh screen to remove soil and plant debris. The washing procedure makes particles easier to identify on the microscope slide. This cleaning procedure does not apparently alter the calculated plant species composition of the original sample. The finely ground material was used to make three microscope slides from each collection period according to the procedure of Sparks and Malechek (1968).

The dry-weight composition of plant in the diets of steers was determined by observing 20 systematically located fields on each of the three slides with a compound binocular microscope at 125-power magnification. The presence of each species of plant in each field was recorded. Average frequency percentages were computed for all species of plants present in the samples. The relative density was calculated for each item in the diet (Curtis and McIntosh, 1950). Relative density was used as an estimate of the dry weight composition of each species in the diet (Sparks and Malechek, 1968). The procedure of practicing on known dry-weight mixtures was used in this study to learn to accurately identify the material on the microscope slides.

Concurrently with esophageal-fistula collections, bite-counts of the plants consumed by the steers were recorded according to the procedure of Reppert (1960). The number of bites of each species of plant consumed was observed from a vehicle at a distance of from three to 10 ft. from the animal. The observer had prior training in plant identification and the animals were accustomed to the observer and the vehicle. Both techniques were done by the same observer.

To convert the number of bites of a species of plant to relative percentage dry weight, the mean dry weight for all species combined and for each of the three important grasses was determined. The average dry weight per bite for all species combined was determined on July 6, July 25, August 22, August 25, September 11 and December 25, 1967. The

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weight per bite for each of the three important grasses in the diet, blue grama (*Bouteloua gracilis*), prairie sandreed (*Calamovilfa longifolia*), and needle-and-thread (*Stipa comata*), was determined only in the autumn and winter. These three species, blue grama, prairie sandreed and needle-and-thread, represented relative "bite size categories"—small, medium and large, respectively. Other plants in the diets of steers were placed into one of these categories according to their estimated bite-quantity similarity. All other individual species were placed into different bite-size categories by estimating their bite-size relative to the measured species. This was necessary because most of the species did not occur in pure stands so that the actual bite sizes could be measured.

To obtain the various dry-weights per bite a sample consisting of 500 to 1,000 bites was collected with esophageal fistulated steers. The samples obtained were oven dried and the dry weight per bite was computed by dividing the total dry weight of the sample by the number of bites.

Results and Discussion

The bite-count method and the microscope technique were not significantly different ($P<.05$) for estimating the percent of blue grama, prairie sandreed, needle-and-thread, other grasses, and total forbs in the diets of steers (table 1). Significant correlations ($P<.05$) were found between the estimated mean dry-weight percentages of species of plants in the diets of steers for the two methods at all four collection periods. The correlation coefficients between the bite-count and microscopic methods were .81, .86, .88 and .95 for the spring, summer, autumn and winter collections, respectively. As the season advanced, fewer species occurred in the diet and individual species accounted for a larger proportion of the intake. Approximately 17, 18, 13 and 10 plant species were observed in the diet for the spring, summer, autumn and winter seasons, respectively.

Individual grass species, included in the Other grasses categories, did present some problems with the two methods of diet determination. During the first three collection periods, the dry weight of western wheatgrass (*Agropyron smithii*) was 6 to 7% less for the bite-count estimates than for the microscopic estimate (table 1). This difference was probably due to an underestimation of the number of bites taken of western wheatgrass. This plant is difficult for an observer to distinguish among other plants due to its gregarious growth form until seedhead formation when it becomes more easily distinguishable.

An analysis of variance showed that main effects and statistical interactions between methods (bite-count *vs.* microscopic), collection periods (spring, summer, autumn and winter), and time of day (am or pm) were nonsignificant ($P<.05$) for blue grama, prairie sandreed, needle-and-thread, other grasses and total forbs (table 1).

The portion of the sample that cannot be identified or classified affects the results of diet determinations. The unidentifiable portion of the rumen sample by binocular microscope (20 to 80 power magnification) ranged from 11 to 23% with an average of 17% (Galt *et al.*, 1969). In our situation, based on Sparks and Malechek's (1968) previous results, we have assumed that the identifiable and unidentifiable fragments in a "microscope field" are proportional to each other for each plant species. This assumption was made because unidentifiable fragments existed but this did not affect the percentage composition of the practice samples of known composition. This would not be the case if the unidentifiable fragments were not proportional among all species. The unclassified ($\simeq$unknown) percentage by the procedures used in our investigation averaged less than 3%. The "unidentifiable category" in our work consisted of epidermal material recognized as being from "species" whose names were not known to the microscope technician. This can occur when reference plant material is lacking or when the technician has not learned to recognize the histological characteristics of all plants present in a sample. The use of identifying characteristics such as cork cells, silica cells, silica-suberose couples, asperities and trichomes alleviates the problem of the destruction of identifying features by mastication encountered by Galt *et al.* (1969).

Other investigators also have encountered difficulty in estimating the species composition in the diets of cattle using visual estimation methods. Galt *et al.* (1969) found that "ocular observation" method differed considerably from a corresponding rumen sample analysis when comparing the quantity of species in the diet. They pointed out that the two animals used in their study were minimal and, further, they calculated that six animals would be needed to obtain an adequate sam-

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TABLE 1. MEAN PERCENT DRY WEIGHT OF PLANTS IN THE SEASONAL DIETS OF STEERS ON SANDHILL RANGE IN EASTERN COLORADO BY THE MICROSCOPE AND BITE-COUNT METHODS

Plant categories	Scientific name[a]	Percent dry weight composition of seasonal diets[b]									
		Spring		Summer		Autumn		Winter		Avg all seasons	
		Micro	Bite	Micro	Bite	Micro	Bite	Micro	Bite	Micro	Bite
Grasses and grasslikes											
Blue grama[c]	*Bouteloua gracilis*	32[d]	38	24	26	42	43	28	31	32	34
Prairie sandreed[c]	*Calamovilfa longifolia*	19	25	38	36	12	18	3	2	18	20
Needle-and-thread[c]	*Stipa comata*	15	14	4	1	15	12	54	52	22	20
Other grasses[e]											
Western wheatgrass	*Agropyron smithii*	15	8	10	4	20	13	14	14	15	10
Sand bluestem	*Andropogon hallii*	3	1	12	16	2	1	<1	<1	4	5
Sand dropseed	*Sporobolus cryptandrus*	1	1	2	6	3	5	<1	..	2	3
Sun sedge	*Carex heliophila*	1	1	<1	1	2	2	<1	<1	1	1
Miscellaneous grasses		<1	..[f]	<1	1	<1	<1	<1	<1	<1	<1
Total grasses		86	89	90	91	96	94	99	99	94	93
Forbs											
Spiderwort	*Tradescantia occidentalis*	4	3	1	1	..	<1	..	<1	1	1
Louisiana sagewort	*Artemisia ludoviciana*	2	1	2	2	1	1	..	<1	1	1
Lambsquarter	*Chenopodium album*	2	2	1	<1	..	..	..	..	1	<1
Wavyleaf thistle	*Cirsium undulatum*	<1	..	1	1	1	1	<1	<1	<1	<1
Scarlet globemallow	*Sphaeralcea coccinea*	<1	..	1	<1	1	<1	..	..	<1	<1
Western ragweed	*Ambrosia psilostachya*	1	1	<1	<1	<1	<1	..	..	<1	<1
Common peppergrass	*Lepidium densiflorum*	1	1	<1	..	..	<1	..	..	<1	<1
Fireweed	*Kochia scoparia*	<1	..	<1	..	..	..	..	..	<1	..
Bush morning glory	*Ipomoea leptophylla*	<1	1	<1	1	..	..	..	..	<1	<1
Marestail	*Conyza canadensis*	..	..	<1	..	..	..	..	..	<1	..
Sand sunflower	*Helianthus petiolaris*	..	<1	<1	<1	..	..	..	..	<1	<1
Miscellaneous forbs		2	1	3	3	1	4	<1	<1	2	2
Total forbs		14	11	10	9	4	6	1	1	6	7

[a] Botanical nomenclature from Harrington, H. D. 1954. Manual of Plants of Colorado. Denver, Colorado. 666 p.
[b] The percent of the total dry weight of the diet as estimated by relative density.
[c] Data for these three grasses are based on actual weight per bite; whereas, the remainder of the data are based on estimated weight per bite.
[d] Each entry is an average of 18 slides (three slides per collection period, two collection
[e] Other grasses were combined for statistical analysis.
[f] Dots indicate that this species was not eaten.

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ple. The small number of animals would affect both the variabilty of the rumen sample and the ocular estimate sample.

Our study shows that the bite-count method provides dry-weight estimates of the diet similar to the microscopic technique if the observer can recognize plants at all growth stages at distances of up to 10 feet. The observer must be experienced and the animals must be accustomed to the observer and the vehicle.

Improvement in the estimated percent dry-weight composition of species in the diet during a certain season can be obtained by adjustment for variations in bite size. Prior utilization, growth habit and density of the plants being grazed affect the weight of the bite.

During the spring and summer, the dry weight per bite of blue grama, prairie sandreed and needle-and-thread appeared to be about equal. The dry-weight percentages of these species in the diet, estimated by the bite-count method, were similar to that obtained from the microscope analysis of a sample from the esophageal fistulas. In the autumn when the forage began to mature, and leaves began to dry and curl, differences in the weight per bite for these species became evident.

The average dry weight per bite changes seasonally. The mean dry weight per bite for steers was .44 g on July 6, .58 g on July 25, .65 g on August 22, .73 g on August 25, .72 g on September 11 and .65 g on December 25 (figure 1). The mean dry weights for the three bite size categories during the autumn and winter were .44 g and .30 g (small bite size category); .74 g and .65 g (medium bite size category); and 1.01 g and 1.00 g (large bite size category), respectively (table 2).

The autumn and winter data (table 1) were adjusted for the respective bite sizes for individual plants (table 2). This adjustment may account for some of the improved correlation coefficients during the two latter sampling periods.

The amount of training time required to obtained samples by the "bite-count" and the microscope technique differ considerably. In our laboratory, we have found that approximately 3 months of concentrated effort by persons not familiar with microscopes and plant histology are required to become proficient in identifying plants by the microscope technique. Training time for the "bite-count" procedure would involve 1 or 2 weeks to learn to identify forage plants. Relatively gentle animals are required for the "bite-count" procedure but they need not be esophageal fistulated as is necessary for obtaining bolus material for microscopic examination.

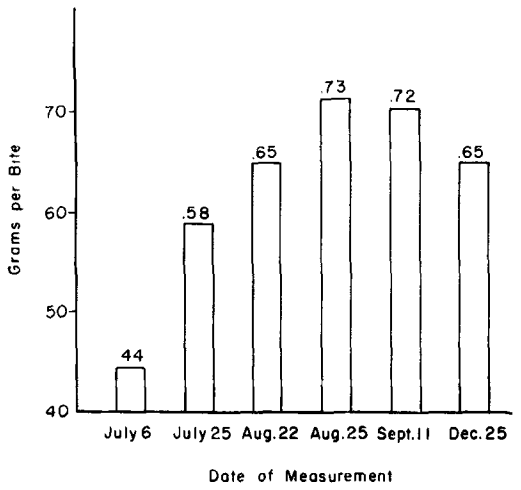

Figure 1. Mean dry weight per bite for steers grazing sandhill range in eastern Colorado, 1967.

Summary

The dry-weight composition of species in diets of steers grazing sandhill range in eastern Colorado was determined during 1967 by the bite-count and the microscope technique. Morning and evening diets were sampled during 3-day intervals in mid-June, late-July, early-September and mid-December. These two techniques produced similar estimates of

TABLE 2. MEAN DRY WEIGHT PER BITE (GRAMS/BITE) OF IMPORTANT PLANT SPECIES AND FOR ALL SPECIES COMBINED FOR STEERS GRAZING SANDHILL RANGE IN EASTERN COLORADO IN THE AUTUMN AND WINTER

Bite size cateory	Species	Autumn	Winter
Small	Blue grama[a]	0.44	0.30
	Sand sedge		
Medium	Prairie sandreed[a]	0.74	0.65
	Western wheatgrass		
	Sand bluestem		
	Sand dropseed		
Large	Needle-and-thread[a]	1.01	1.00
	Forbs		
All species combined		0.73	0.65

[a] Data for these species are based on actual weight per bite. The other species listed in each category were estimated to have a similar bite size.

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the dry-weight composition of the more important species in the diet.

Reliable estimates of the dry-weight species composition of the diets of grazing steers by both methods are highly dependent upon the observer. In the case of the bite-count the observer must be able to identify individual species of plants in all growth stages at distances of up to 10 feet. The microscope procedure entails the identification of finely divided particles of esophageal fistula material by the histological characteristics of specific plants or plant parts.

Consequently, a detailed collection of plants is required to prepare reference slides for individual species and plant parts for the latter technique. The "bite-count" procedure offers advantages in that the time required to become trained is considerably less than for the "microscope" technique. The "bite-count" procedure does not require the use of esophageal fistulated animals but does require relatively gentle animals.

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