Correcting for Differential Digestibility in Microhistological Analyses Involving Common Coastal Forages of the Pacific Northwest

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Abstract

The accuracy of microhistological techniques to describe herbivore diets can be affected by differential digestibility of ingested forages. Correction factors were developed to adjust for those effects in 17 common forages of coastal, forested ranges of the Pacific Northwest. Two ferns, a moss and a sedge were overestimated by microhistological analysis in all seasons, while most shrubs, forbs and a grass were underestimated. Trees were not consistently over- or underestimated. Phenology significantly affected the degree of over- or underestimation of most forages. Failure to correct for differential digestibility will significantly bias results of microhistological techniques such as fecal analyses.

Microtechniques for determining food habits of large herbivores can be biased by differential digestibility of ingested plant species (Holechek et al. 1982). For example, the accuracy of fecal analysis can be affected by the extent of digestion of plant epidermis as it passes through the alimentary tract of a ruminant (Steward 1970, Slater and Jones 1971, McInnis et al. 1983) and by sample preparation techniques (Vavra and Holechek 1980). Yet, fecal analysis is used widely for describing diets of wild and domestic herbivores (e.g., Free et al. 1970, Stewart and Stewart 1980, Hansen and Martin 1973, Hansen et al. 1973, Todd and Hansen 1973, Anthony and Smith 1974). Frequently, it is the only practical method available (Vavra et al. 1978), particularly when dense vegetation and wariness of study animals preclude direct feeding observations and when protection from hunting of some wild and/or rare herbivores eliminates the possibility of collecting ruminal samples. Also, fecal material usually is readily available, which enables the collection of an adequate number of samples at any time of the year.

Results from fecal analyses can be improved by species-specific correction factors that compensate for differential digestibility of ingested forages (Voth and Black 1973, Dearden et al. 1975, Fitzgerald and Waddington 1979, Pulliam and Nelson 1979, Vavra and Holechek 1980). Forbs are usually highly digestible and as a result, underestimated by fecal analyses (Vavra et al. 1978, Vavra and Holechek 1980, McInnis et al. 1983). Some grass and browse species are overestimated by fecal analyses, while others are underestimated (Dearden et al. 1975, Vavra and Holechek 1980). Phenology affects digestibility of most forages (Laycock and Price 1980) and thus, season-specific correction factors may be necessary for individual plant species in the diet (Pulliam and Nelson 1979). Unfortunately, these relationships have been described for relatively few forages.

This report provides correction factors for common forages of coastal, forested ranges of the Pacific Northwest that are important to both wild and domestic ungulates.

Methods

Plant samples were collected as part of a study on the nutritional ecology of Roosevelt elk *(Cervus elaphus roosevelti)* and Columbian black-tailed deer *(Odocoileus hemionus columbianus)* in the Hoh Valley (47°50′ N, 124°′ W) of Olympic National Park, Washington (Leslie 1983). Plant communities of the Hoh Valley were described by Fonda (1974) and are comprised of many forage species typical of coastal, forested ranges of the Pacific Northwest (Franklin and Dryness 1973). For each plant species, a composite sample of approximately 25 grams (dry weight) was collected at random throughout their respective distributions in the study area. Samples of plant parts that were thought to be consumed by cervids were collected in summer (15 July–15 August), fall (15 October–15 November), winter (15 January–February), and spring (15 April–15 May), 1980-1981.

Correction factors were determined by modifying the approach of Dearden et al. (1975) to include a standard forage of known properties in microhistological analyses. Each plant species was part of 5 hand-mixed diets and occurred in various known relative densities (i.e., percentages by weight) in those mixtures. A known percentage of Idaho fescue *(Festuca idahoensis)* was included in each mix as a standard; based on our laboratory observations, it is neither over- or underestimated by microtechniques after digestion. Each mix was digested in vitro (Tilley and Terry 1963) for 48 hours using inoculum from a steer maintained on an orchard grass/alfalfa diet (~10% crude protein, 55% digestible), and analyzed microscopically (Vavra and Holechek 1980). The observed density of each plant species (X_i) was calculated from frequency tabulations of identifiable epidermis (Sparks and Malechek 1968). The actual density (Y_i) was calculated from relative weights and the observed density of the standard (Table 1), assuming the latter equalled its relative weight in the hand-mixed diet. The observed and actual densities were then correlated using a least squares regression forced through the origin (Neter and Wasserman 1974:156). The estimate of β was

$$b = \frac{\Sigma X_i Y_i}{\Sigma X_i^2},$$

where b represented the degree of overestimation ($b<1.0$) or underestimation ($b>1.0$) of a plant species by microhistological analyses. This approach was analogous to Dearden et al. (1975) and provided the same correction factor for a given set of data. However, the actual density in this study was calculated from the relative weights of each species in the hand-mixed diets and then correlated with the observed density (Table 1). Dearden et al.

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Authors thank R.G. Anthony and K.J. Jenkins for helpful comments on earlier drafts of this paper.

Manuscript received November 15, 1982.

Table 1. Procedure for obtaining actual density (Y_i) and observed density (X_i) in determining correction factors for common forages of the Pacific Northwest.

Plant species	Relative weight in hand-mixed diets	Observed density from slides[1] (X_i)	Actual density[2] (Y_i)
Species A	$\%W_a$	$D_{a\text{-}obs}$	$(\%W_a / \%W_{std}) \times D_{std\text{-}obs}$
Species B	$\%W_b$	$D_{b\text{-}obs}$	$(\%W_b / \%W_{std}) \times D_{std\text{-}obs}$
Species C	$\%W_c$	$D_{c\text{-}obs}$	$(\%W_c / \%W_{std}) \times D_{std\text{-}obs}$
Standard[3]	$\%W_{std}$	$D_{std\text{-}obs}$	$D_{std\text{-}obs}$

[1]Calculated from frequency after Sparks and Malechek (1968).
[2]Note that if actual density is made relative to 100 percent, it will equal relative weight in hand-mixed diets.
[3]The standard is neither over- or underestimated (i.e., b = 1.0) in microtechnique after digestion; therefore, observed density from slides equals actual density.

(1975) calculated an observed *relative* density and correlated it with the relative weight in the hand-mixed diets.

Results and Discussion

A total of 29 correction factors was determined for 17 forages (Table 2). Two ferns, a moss and a sedge were overestimated by the microtechnique in all seasons, while most shrubs, forbs, and a grass were consistently underestimated. Trees were less consistent, but only 4 determinations were made. The degree of correction for salmonberry (*Rubus spectabilis)* and bluegrass (*Poa* spp.) was highest in spring and decreased through summer and fall. Other species, such as swordfern *(Polystichum munitum)* and wood-sorrel *(Oxalis oregana),* displayed the opposite trend. Strong inter-seasonal variability of correction factors of some shrubs, forbs, and grasses, suggested that they should be determined for each phenological period in which a diet is being estimated.

The range of correction factors was noticeably greater in our study than those previously reported. Those reported by Dearden et al. (1975) ranged from 0.75 for cotton grass *(Eriophorum vaginatum)* to 1.30 for willow *(Salix pulchra)* and lichen *(Stereocaulon alpinum).* In our study, the lowest factor was 0.20 for fern moss *(Hylocomium splendens)* (Table 2). Similarly, Dearden et al. (1975) noted that mosses were highly overestimated because epidermal tissue fragmented easily in the digestive progress; mosses also are very low in dry matter digestibility (Dearden et al. 1975, Leslie 1983). The highest factor in this study was 6.12 for youth-on-age *(Tolmeia menziesii)* (Table 2). The disparity in ranges in the 2 studies was probably a result of when plant samples were collected relative to phenology. Sampling dates were not reported by Dearden et al. (1975), but if all forages were collected at the same time, correction factors could be less variable than if collections were made during different seasons. Our results and those of Pulliam and Nelson (1979) indicated that phenology of ingested plants significantly affects their degree of over- or underestimation.

The overall effect of these factors on results of fecal analyses, for example, would depend on the relative proportions of each forage species in a given diet. However, one generally would expect uncorrected fecal analyses to overestimate mosses and ferns and underestimate shrubs and forbs. Application of these factors should improve the accuracy of fecal analysis in determining food habits of wild and domestic ruminants in coastal, forested ranges of the Pacific Northwest. Ideally, correction factors should be determined for specific study areas and seasons. Additional research is required to examine the variability of correction factors

Table 2. Seasonal correction factors (≥95% confidence intervals) for common forages in the Pacific Northwest to improve estimates of relative density in fecal analyses.

	Correction factors[1]			
	Spring	Summer	Fall	Winter
Trees:				
Red alder *(Alnus rubra)*	—	—	1.359 (0.311)[6]	—
Western hemlock *(Tsuga heterophylla)*	0.854 (0.152)	—	—	0.759 (0.130)
Western redcedar *(Thuja plicata)*	—	—	—	2.780 (0.431)
Shrubs:				
Huckleberry (*Vaccinium* spp.)[3]	—	1.702 (0.392)	—	—
Salmonberry *(Rubus spectabilis)*	4.263 (1.773)[6]	2.687 (0.816)	—	—
Trailing blackberry *(Rubus ursinus)*	—	—	2.131 (0.426)	—
Vine maple *(Acer circinatum)*	—	1.921 (0.256)	—	—
Willow (*Salix* spp.)[4]	—	1.070 (0.206)	—	—
Ferns:				
Deer fern *(Blechnum spicant)*	—	—	0.684 (0.136)	0.664 (0.295)
Sword fern *(Polystichum munitum)*	0.293 (0.038)	0.664 (0.068)	—	0.663 (0.113)
Forbs:				
Coolwort *(Tiarella trifoliata)*	—	—	1.418 (0.572)	—
Wild strawberry *(Fragaria vesca)*	—	—	1.012 (0.370)	—
Wood-sorrel *(Oxalis oregana)*	1.086 (0.120)	—	2.161 (0.397)	—
Youth-on-age *(Tolmeia menziesii)*	—	—	6.120 (2.690)	—
Grass:				
Bluegrass (*Poa* spp.)[5]	3.720 (0.557)[6]	1.232 (0.214)	1.124 (0.182)	2.264 (0.471)[6]
Sedge:				
Dewey's sedge *(Carex deweyana)*	0.782 (0.171)[6]	—	—	0.602 (0.044)[6]
Moss:				
Fern moss *(Hylocomium splendens)*	0.240 (0.030)	0.208 (0.039)	—	0.200 (0.065)

[1]Each correction factor is the estimate of the slope, *b*, in the regression model Y=bX; all regressions significant at $P<0.05$.
[2]Botanical nomenclature follows Hitchcock and Cronquist (1973).
[3]A composite of *V. parvifolium* and *V. ovalifolium.*
[4]A composite of *S. scouleriana* and *S. sitchensis.*
[5]A composite of mainly *P. pratensis* and *P. trivialis.*
[6]Leaves only.

as they depend on inoculum source (i.e., ruminant species and donor diet). Nevertheless, failure to correct for differential digestibility will significantly bias results of microhistological analyses.

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