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David G. Hewitt and Charles T. Robbins

Abstract We fed 27 different food items to captive grizzly bears (*Ursus arctos*) to investigate the need for correction factors (CF's) when estimating grizzly bear food habits from fecal residue. The amount of food necessary to produce 1 ml of fecal residue ranged from 0.16 to 40.8 g dry matter, suggesting that uncorrected fecal analysis are rarely equivalent to food habits. We propose CF's that relate the volume of residue in the feces to the mass of dry matter ingested. The ranges of these CF's were 0.16–0.35 for vegetation, 0.51–1.84 for berries, 0.35–1.40 for roots, 0.91–1.25 for insects, 1.54 for pine nuts, 1.54–12.5 for mammals, and 40.8 for fish. The CF for large mammals depends upon how much skin, hair, bones, or other poorly digested components are consumed.

Key words correction factor, fecal analysis, food habits, grizzly bear, *Ursus arctos*

Reproductive rates of bears are strongly influenced by nutritional status, which in turn is a function of available food resources (Jonkel and Cowan 1971, Rogers 1976, Bunnell and Tait 1981, Rogers 1987). Thus, food resources are an important parameter in habitat analyses, carrying capacity estimates, and conservation plans for grizzly bears (*Ursus arctos*; Craighead et al. 1982, U.S. Fish and Wildl. Serv. 1993). The importance of various food resources for a population of bears is often determined by fecal analysis. Fecal analysis, however, may result in biased estimates of food habits because of differences in the amount of recognizable fecal residue produced by different foods. These differences will cause an underestimate in the diet of highly digestible or easily fragmented foods and an overestimate of less digestible items. To reduce this bias, correction factors (CF's) may be used to relate the amount of residue in the feces to the amount of a diet item ingested. Such CF's have been reported for carnivores (Lockie 1959, Floyd et al. 1978, Johnson and Hansen 1979, Liberg 1982, Ackerman et al. 1984) and herbivores (Pulliam and Nelson 1979), but have rarely been derived for omnivores (Greenwood 1979). The highly varied diets of omnivorous bears are likely to have the most substantial differences in the amount of recognizable fecal residue between food items.

The objective of our study was to relate the amount of food items eaten by grizzly bears to the volume of residue produced in the feces for a variety of bear foods. These relationships were used to investigate the need for correcting bear fecal analysis in food-habit studies and are proposed as CF's.

Methods

Two male and 2 female grizzly bears housed at Washington State University were used in feeding trials between March and October. Females and males were 1 and 2 years old and weighed 80-140 and 135-210 kg, respectively. Throughout the study, the bears were kept in concrete-floored, indoor-outdoor pens (7 x 3 m) and maintained on commercial bear chow. Water was supplied ad libitum. All trials were conducted with 2 randomly selected bears. Prior to each trial, food was withheld from each bear for 24

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Table 1. Fecal analysis correction factors (g dry matter consumed/ml residue in feces) (mean and range for 2 bears/food item) for foods fed to captive grizzly bears. Three foods were given in each of 9 trails.

Food item	Correction factor $\bar{x}$	Correction factor Range	Notes	Trial
Vegetation				
Horsetail (*Equisetum arvense*)	0.16	0.14, 0.19	Early summer collection	5
Sedge (*Carex* sp.)	0.18	0.16, 0.20	Leaves only, flowering	6
Dandelion leaves (*Taraxacum officinale*)	0.20	0.19, 0.21	Late summer collection	8
Elk thistle stalks (*Cirsium scariosum*)	0.24	0.19, 0.29	Leaves/flowers removed	6
Bluegrass leaves (*Poa pratensis*)	0.24	0.23, 0.25	Preflower	1
Cow parsnip leaves (*Heracleum lanatum*)	0.24	0.24, 0.24	Petioles removed	7
Winter wheat leaves (*Triticum aestivum*)	0.28	0.27, 0.30	Preflower	2
Dandelion flowers (*Taraxacum officinale*)	0.32	0.29, 0.36	Stalks removed	3
Clover leaves (*Trifolium repens*)	0.33	0.29, 0.38	Petiole removed	4
Canada thistle stalks (*Circium arvense*)	0.34	0.26, 0.43	Leaves/flowers removed	5
Cow parsnip stalks (*Heracleum lanatum*)	0.35	0.31, 0.39	Leaves removed	7
Roots and bulbs				
Hedysarum roots (*Hedysarum* sp.)	0.35	0.32, 0.38	Fall collection	9
Biscuit-root (*Lomatium* sp.)	0.65	0.64, 0.65	Root, summer collection	8
Glacier lily bulb (*Erythronium grandiflorum*)	1.40	1.27, 1.53	Summer collection	7
Fruits and berries				
Apples (*Malus domestica*)	0.51	0.50, 0.53	Fruit fed whole	4
Blueberry (*Vaccinium* sp.)	0.54	0.54, 0.54	Berries fed whole	1
Blackberry (*Rubus* sp.)	0.87	0.83, 0.91	Berries fed whole	8
Buffalo-berry (*Shepherdia canadensis*)	1.84	1.44, 2.24	Berries fed whole	9
Invertebrates				
Crickets (*Acheta domesticus*)	0.91	0.88, 0.94	2.5 cm feeder cricket	5
Maggots (*Calliphoridae, Sarcophagidae*)	1.25	1.06, 1.44	0.5–1.5 cm long	3
Nuts				
Pinyon pine nuts (*Pinus edulis*)	1.54	1.23, 1.85	Fed whole, without cone	2
Vertebrates, ungulates				
White-tailed deer (*Odocoileus virginianus*)	1.55	1.37, 1.73	Fed whole, 7 days of age	6
Mule deer (*O. hemionus*)	1.54	1.42, 1.64	Meat:hide (winter coat) in a 19:1 ratio (fresh mass)	3
Vertebrates, small mammals				
Voles (*Microtus* sp.)	4.4	3.8, 5.0	Fed whole	1
Ground squirrel (*Spermophilus columbianus*)	12.5	12.5,[a]	Fed whole	4
Fish				
Cutthroat trout (*Salmo clarkii*)	40.8	39.5, 42.3	Fed whole, 25–30 cm long	2
Steelhead (*Salmo gairdnerii*)	[a]	[a]	Fed whole	9

[a] A correction factor was not calculated because too little recognizable material was found.

hours to clear the gastro-intestinal tract and encourage ingestion of the test diet. During each of the following 2 days, we fed the bears a meal consisting of 3 of 27 diet items (Table 1) chosen to represent a variety of grizzly bear foods. Mixed diets were fed to increase the number of foods for which we could develop CF's and were justified because associative effects between diet items during digestion in bears are minimal (Pritchard and Robbins 1990). All plant items were refrigerated after collection and fed within 5 days except blueberries (*Vaccinium* sp.) and pine nuts (*Pinus edulis*), which were bought commercially. All animal foods had been frozen and were thawed prior to feeding. Diet items used in each test were those that could be distinguished in fecal analyses. Each meal contained 150 g dry matter of each of the 3 diet items, except steelhead (*Salmo gairdnerii*) which were fed as whole fish. Dry matter content was determined by drying a subsample of the diet item at 100°C for 24 hours just before the trial. All feces and uneaten food were collected. To ensure total collection of feces produced from the test diet, a commercial bear chow was fed 24 hours after the last meal and all feces from the test diet were collected until the chow passed. The first feces containing bear chow were collected separately and rinsed over a 2.00-mm screen to retrieve recognizable fragments of the test diet. To sample the feces for analysis, all feces produced by a given bear were thoroughly mixed and spread evenly on a tray. Several randomly located 5- x 5-cm sections were cut out until 10-33% of the total mass of collected feces was sampled.

We washed each fecal sample over 4.00-mm and 2.36-mm soil screens with hot tap water for 3-5 minutes and cold water for an additional 3-5 minutes. The sample remaining on both screens was then placed in a tray with clear water and manually separated into residues of the 3 diet items. These preparation procedures followed those used by the Interagency Grizzly Bear Study Team (B. Callaghan, Missoula, Mont., pers. commun.). Excess water was squeezed from the residue, and volumes were determined by water displacement in a graduated cylinder. Correction factors were calculated for each diet item as CF = g dry matter ingested/ml residue in the feces. A mean CF of n = 2 bears is reported.

Because the amount of skin and hair consumed by bears from ungulate carcasses varies (Murie 1948), a single CF cannot be used for ungulates. We calculated CF's necessary for ungulate remains when various percentages of hide were consumed by dividing the dry matter ingested, which was all the soft tissue on an ungulate carcass, by the volume of recovered nondigestible fecal residues, which was only hair. For example, 1 unit of hair consumed with 4 or 9 units of meat yields CF's of 5 and 10. In our trials, each g of dry mule deer (*Odocoileus hemionus*) skin and hair consumed produced 6.2 ml (range = 5.7-6.7) of residue in the feces. For these calculations, a representative mule deer carcass was 52.2% consumable meat, fat, and tendons (Field et al. 1973) containing 25% dry matter. Viscera (without digestive contents) were 13.6% of the fresh body mass and 35% dry matter (C. T. Robbins, Washington State Univ., Pullman, unpubl. data). Skin and hair were 5.8% of fresh body mass (Field et al. 1973) and 55% dry matter.

Results and discussion

The mass of a diet item that must be eaten to produce 1 ml of fecal residue varied by more than 250-fold (Table 1). Correction factors were lowest for plant leaves and stems; intermediate for roots, nuts, insects, and fruits; and highest for animal matter. Estimated CF's for large mammals varied widely depending on the ratio of meat:hair-skin consumed (Fig. 1). The proportion of hair ingested is not a concern with small mammals because the entire carcass is generally consumed. However, hair recognition and recovery can be a problem. In our analyses, vole (*Microtus* spp.) hair tended to form floating clumps, making recovery simple. Ground squirrel (*Spermophilus columbianus*) hair was less evident. Isolated hairs were noted floating on the water's surface, but much of the hair adhered to residues of other items in the feces and thus was unrecoverable. A study by Pritchard and Robbins (1990), in which only ground squirrels were fed to bears, yielded a CF of 3.50. Thus, the correction for ground squirrels ranges from 3.5 to 12.5 depending on the efficiency of identifying hair and bone in the feces.

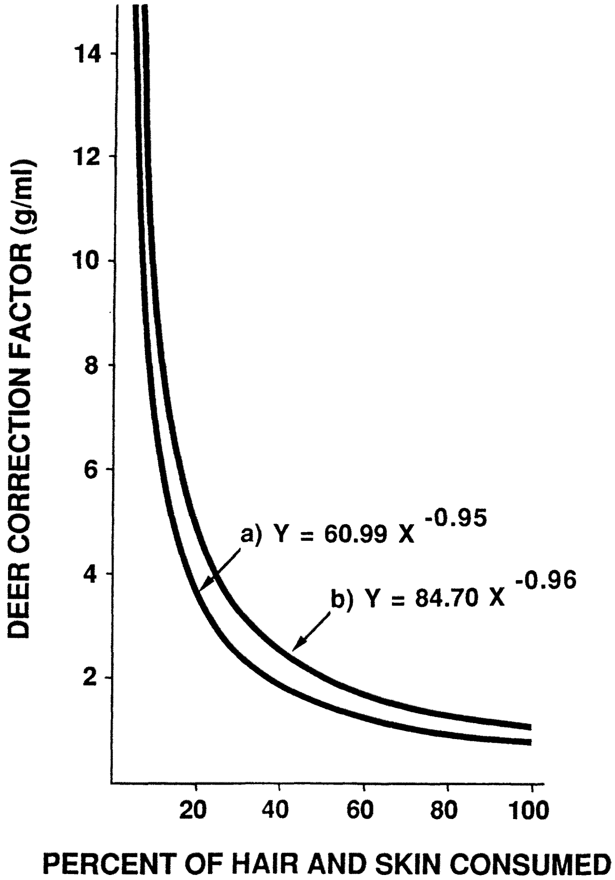

Fig. 1. Calculated grizzly bear fecal correction factors for mule deer as a function of the percent deer hair and skin consumed assuming (a) all the meat on the carcass was ingested, or (b) all the meat and viscera were ingested.

The use of CF's to estimate a grizzly's diet from fecal residue can alter conclusions about the importance of different dietary components. The CF's are employed by multiplying the percent volume of each diet item in the fecal analysis by its corresponding CF. Each of these products is divided by the sum of all the products and multiplied by 100 to express the diet item's percent dry matter contribution to the total diet (Table 2). In the example of Table 2, animal matter was 39% of the

Table 2. Application of fecal correction factors (CF) to hypothetical fecal residues to estimate the diet of a bear.

Diet item	Fecal volume (%)	CF	(%)* CF	Food habits (% of diet dry matter)
Ungulates	31	3.0	93.0	54
Rodents	4	4.0	16.0	9
Trout	1	40.0	40.0	23
Insects	3	1.1	3.3	2
Horsetail	3	0.16	0.5	<1
Graminoid foliage	45	0.24	10.3	6
Forbs	5	0.26	1.3	1
Roots	5	1.0	5.0	3
Fleshy fruits	2	1.2	2.4	1
Pine seeds	1	1.5	1.5	1

uncorrected diet and 88% of the corrected diet. Grass, the most prevalent residue in the feces, was 6% of the estimated dietary dry matter after applying the CF's.

If CF's for a specific food item are not available and cannot be developed, we recommend the following CF's: leaves, stalks, and flowers = 0.26; roots, bulbs, and fruit = 0.93; insects = 1.1; hard mast = 1.5; small mammals consumed whole (unless hair recovery is suspect) = 4.0; trout-sized fish consumed whole = 40.0. Neonate ungulates should be corrected by 1.5 if the entire carcass is consumed or 15.0 if skin and hair are not ingested. Ungulate residues should be corrected as in Fig. 1. The use of CF's is likely to elevate the importance of animal matter as a contributor to the nutritional status of many bear populations, which in turn may have implications for bear-habitat management.

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Literature cited

ACKERMAN, B. B., F. G. LINDZEY, AND T. P. HEMKER. 1984. Cougar food habits in southern Utah. J. Wildl. Manage. 48:147-155.

BUNNELL, F. L., AND D. E. N. TAIT. 1981. Population dynamics of bears—implications. Pages 75-98 *in* C. W. Fowler and T. D. Smith, eds. Dynamics of large mammal populations. John Wiley and Sons, New York, N.Y.

CRAIGHEAD, J. J., J. S. SUMNER, AND G. B. SKAGGS. 1982. A definitive system for analysis of grizzly bear habitat and other wilderness resources. West. Wildlands Inst., Univ. Montana Foundation, Monogr. No. 1. 279pp.

FIELD, R. A., F. C. SMITH, AND W. G. HEPWORTH. 1973. The mule deer carcass. Univ. Wyoming Agric. Exp. Stn. Bull. 589. 6pp.

FLOYD, T. J., L. D. MECH, AND P. A. JORDAN. 1978. Relating wolf scat content to prey consumed. J. Wildl. Manage. 42:528-532.

GREENWOOD, R. J. 1979. Relating residue in raccoon feces to food consumed. Am. Midl. Nat. 102:191-193.

JOHNSON, M. E., AND R. M. HANSEN. 1979. Estimating coyote food intake from undigested residue in scats. Am. Midl. Nat. 102:363-367.

JONKEL, C. J., AND I. McT. COWAN. 1971. The black bear in the spruce-fir forest. Wildl. Monogr. 27.

LIBERG, O. 1982. Correction factors for important prey categories in the diet of domestic cats. Acta Theriol. 27:115-122.

LOCKIE, J. D. 1959. The estimation of the food of foxes. J. Wildl. Manage. 23:224-227.

MURIE, A. 1948. Cattle on grizzly bear range. J. Wildl. Manage. 12:57-72.

PRITCHARD, G. T., AND C. T. ROBBINS. 1990. Digestive and metabolic efficiencies of grizzly and black bears. Can. J. Zool. 68:1645-1651.

PULLIAM, D. E., AND J. R. NELSON. 1979. Determination of digestibility coefficients for quantification of fecal analysis with elk. Pages 240-246 *in* M. S. Boyce and L. Hayden-Wing, eds. North American elk: ecology, behavior and management. Univ. Wyoming, Laramie.

ROGERS, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. Trans. North Am. Wildl. Nat. Resour. Conf. 41:431-438.

ROGERS, L. L. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. Wildl. Monogr. 97.

U. S. FISH AND WILDLIFE SERVICE. 1993. Grizzly bear recovery plan. Missoula, Mont. 181pp.

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