1978

RELATING WOLF SCAT CONTENT TO PREY CONSUMED

Theodore J. Floyd
University of Minnesota

L. David Mech
USGS Northern Prairie Wildlife Research Center, david_mech@usgs.gov

Peter A. Jordan
University of Minnesota

RELATING WOLF SCAT CONTENT TO PREY CONSUMED

THEODORE J. FLOYD, Department of Entomology, Fisheries, and Wildlife, University of Minnesota, St. Paul 55108
L. DAVID MECH, U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, Maryland 20811[1]
PETER A. JORDAN, Department of Entomology, Fisheries, and Wildlife, University of Minnesota, St. Paul 55108

Abstract: In 9 trials, captive wolves (*Canis lupus*) were fed prey varying in size from snowshoe hares (*Lepus americanus*) to adult deer (*Odocoileus virginianus*), and the resulting scats were counted. Field-collectible scats were distinguished from liquid, noncollectible stools. In collectible scats, the remains of small prey occurred in greater proportion relative to the prey's weight, and in lesser proportion relative to the prey's numbers, than did the remains of larger prey. A regression equation with an excellent fit to the data (r^2 = 0.97) was derived to estimate the weight of prey eaten per collectible scat for any prey. With this information and average prey weights, the relative numbers of different prey eaten also can be calculated.

J. WILDL. MANAGE. 42(3):528–532

Scat analyses are widely used for determining food habits of carnivores. However, the degree to which the relative frequencies of identifiable remains represent the actual proportion of prey types eaten is not known. Scott (1941) and Lockie (1959) considered this problem with red fox (*Vulpes vulpes*) scat analyses and derived correction factors for converting weights of scats to actual weights of food eaten.

Wolf scat analyses present more of a problem because of the great disparity in sizes and weight of prey eaten by wolves. Mech (1966, 1970) suggested that the occurrence of remains of relatively small animals in wolf scats might overrepresent the proportion of those animals eaten compared with the remains of large mammals. This is because smaller animals, having a relatively high surface: volume ratio, would be covered with relatively more hair (the primary identifiable item in scats) per weight of flesh than would larger ones. Thus, a sample of wolf scats, 50 percent of which contained beaver (*Castor canadensis*) remains and 50 percent moose (*Alces alces*) remains, might actually mean that moose composed a higher proportion of the diet, in terms of weight, than did beavers.

Pimlott et al. (1969) believed that wolf scat content accurately represented proportions of prey consumed, and Voigt et al. (1976) concurred, at least for deer fawns and beavers. Shelton (1966) agreed with Mech. Halverson (1969) thought that young animals were underrepresented in scats compared to adults. Carbyn (1975) again stated the need for experimentation on this subject.

The present study was conducted to test Mech's hypothesis and to establish criteria for interpreting from wolf scat data the relative ratios of prey types eaten. The study was supported by the USDA North Central Forest Experiment Station, the USDI Fish and Wildlife Service, the Ober Charitable Foundation, and the Agriculture Experiment Station, University of Minnesota. We also wish to thank B. Norton of the Duluth Zoo, J. Fletcher of the Como Zoo, St. Paul, and the Minnesota Department of Natural Resources for their cooperation, and T. Biebighauser for assisting with the data collection. T. Meier offered valuable suggestions for improving the presentation.

[1] Mailing address: North Central Forest Experiment Station, 1992 Folwell Avenue, St. Paul, Minnesota 55108.

METHODS

Carcasses of several species and sizes of prey were weighed and fed whole to groups of 3 to 5 captive yearling and adult wolves in 9 feeding trials from November 1975 to July 1976. The following prey types were used: snowshoe hares, woodchucks (*Marmota monax*), beaver kit, beaver adult, whitetail deer fawn (4 types: 9.30 kg, 10.89 kg, 22.00 kg, and 39.01 kg), and adult white-tailed deer. Before each trial, the wolves were fasted for 36 to 48 h to clear their digestive systems, and all scats were removed from their pens. All wolves within a group consumed a single prey type in each trial.

During each trial, scats were collected twice daily to minimize trampling and scattering. No further food was provided until scat production ceased. Uneaten remains, consisting mostly of hide and bone, were removed 36 to 48 h after the wolves ceased feeding on them and were weighed. Scats were classified as collectible (firm feces which would retain their form, endure weathering, and most likely would be collected in the field) and noncollectible (loose, liquid feces containing little identifiable material and unlikely to persist long enough to be collected in the field).

For each prey type, we divided the weight of the prey eaten by the number of field-collectible scats that resulted. We then plotted the weight of prey per field-collectible scat against the weight of the prey type (Fig. 1). We also performed a regression analysis with these data and derived an equation describing the relationship between the 2 parameters.

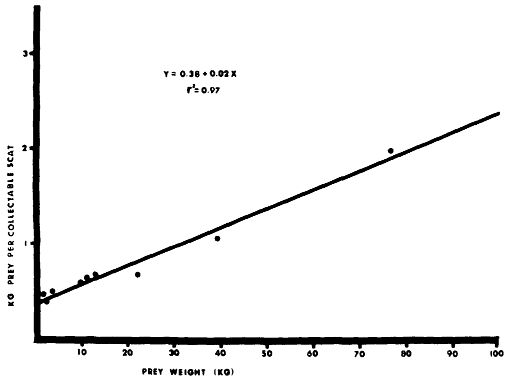

Fig. 1. Relationship between the number of kg of prey per collectible scat (*y*) and the prey weight (*x*).

RESULTS AND DISCUSSION

The wolves completely consumed most of the carcasses except for the 3 heaviest deer, of which the remains ranged from 3.45 to 14.09 kg (Table 1). Scats appeared from 8 h after feeding began until 56 h after it ceased. A high percentage of the first scats deposited after feeding were of the liquid, noncollectible type, but such scats were also deposited sporadically throughout the post-feeding period. Generally the fresh weight of the total scats resulting from a prey type was greater for heavier prey. However, lighter prey resulted in a proportionally greater total weight of feces than did heavier prey (Table 1), demonstrating that small prey is composed of a relatively greater proportion of undigestible matter.

Another factor that became important with prey larger than medium-sized deer fawns was the proportion of uneaten remains of the prey. That increased with carcass weight (Table 1). Thus, with the heaviest carcasses, the lower scat production per kg of carcass eaten was even lower.

The total number of collectible plus noncollectible scats was relatively constant per kg of prey for all carcasses (Table 1), except for the 2 largest, of which substantial portions were left uneaten. However, the number of *collectible* scats per kg of prey eaten decreased as the size

Table 1. Results of feeding trials of captive wolves.

Prey per trial	Weight of prey (kg)		Scats: Fresh weight (kg)			Percent of		No. per kg prey		
	Total	Eaten	Collectible	Non-collectible	Total	Prey weight	Prey eaten	Collectible	Non-collectible	Total
Snowshoe hares (9)	10.44[a]	10.44	1.24	1.05	2.29	21.9	21.9	2.11	1.05	3.16
Woodchucks (2)	2.84[b]	2.84	0.39	0.04	0.43	15.1	15.1	2.47	0.35	2.82
Beaver kit	3.40	3.40	0.48		0.48	14.1	14.1	2.06		2.06
Deer fawn	9.30	9.25	0.95	0.53	1.48	15.9	16.0	1.72	0.41	2.15
Deer fawn	10.89	10.87	1.12	0.06	1.18	10.3	10.9	1.56	0.18	1.74
Adult beaver	12.70	12.58	1.29	0.47	1.76	13.9	14.0	1.50	0.87	2.37
Deer fawn	22.00	18.55	1.67	1.80	3.47	15.8	18.7	1.50	1.14	2.64
Deer fawn	39.01	34.39	2.84	1.95	4.79	12.3	13.9	0.95	0.51	1.46
Adult deer	75.40	61.31	1.50	1.84	3.34	4.4	5.4	0.50	0.29	0.79

[a] Average weight per carcass = 1.16 kg.
[b] Average weight per carcass = 1.42 kg.

or weight of the prey increased (Table 1). This strong inverse relationship (r^2 = 0.97) further indicated that smaller or lighter weight prey was composed of relatively more undigestible matter. This confirmed the hypothesis that, in terms of weight, small prey were overrepresented in frequencies of remains in wolf scats.

So that the results of our feeding trials could be used to convert scat data to relative weight and number of prey consumed, we derived a linear equation to describe the relationship between number of collectible scats and weight of the prey consumed:

$$y = 0.38 + 0.02x,$$

where y is the kg of prey per collectible scat, and x, the average weight of an individual of a given prey type (Fig. 1).

This equation can be used to interpret wolf scat analysis data (Table 2). The process involves (1) estimating the average weight (x) of individuals of each prey type (deer fawn, doe, beaver, etc.), (2) solving the equation for y to determine the number of kg of prey per collectible scat for each prey type, and (3) multiplying each y by the number of scats representing the corresponding prey type in the total scat sample. The product gives the relative total weight of each type of prey fed upon. Then, by dividing these weights by the average weight for individuals of each prey type, one can further derive the relative number of individuals of each type consumed, as represented by the scat sample. A hypothetical example using equal numbers of scats for each prey type demonstrates the use of this method (Table 2).

An example from the literature illustrates the difference the use of this technique makes in interpreting scat data. Van Ballenberghe et al. (1975:12) found remains of adult deer in 219 spring and summer wolf scats, and remains of fawns in 99 (31%) of the total scats with deer. Assuming that adult deer averaged 64 kg, and summer fawns 14 kg, y for adult deer is 1.66 kg per scat and for fawns, 0.66 kg per scat (Table 2). Multiplying these values by the number of scats for each prey type gives 363.5 kg of adult deer consumed, and 65.3 kg of fawns. Thus, fawns

Table 2. Hypothetical sample of wolf scats compared with estimated weight and number of individuals of each prey type eaten.

Prey type in scats	Assumed weight of prey (kg)	Prey per scat (kg)[a] (y)	No. of scats	Kg eaten[b]	Ratios of weight eaten[c]	No. of individuals eaten[d]	Ratios of number of individuals eaten
Adult deer	64.0	1.66	100	166.24	1.00	2.6	1.00
Deer fawn	14.0	0.66	100	65.34	0.39	4.7	1.81
Adult moose	409.0	8.56	100	856.24	5.15	2.1	0.80
Calf moose	91.0	2.20	100	220.24	1.32	2.4	0.93
Beaver	12.5	0.63	100	63.24	0.38	5.1	1.95
Snowshoe hare	1.2	0.41	100	40.64	0.24	33.9	13.03

[a] Calculated from the linear equation in Fig. 1.
[b] Derived from the number of scats in the sample times the kg per scat.
[c] Relative ratios based on the adult deer as the primary unit.
[d] Derived from the number of kg eaten divided by average weight of prey type.

only represented about 15 percent of the total deer eaten. When the weights consumed are divided by the mean weights of adults and fawns, an estimate of 5.7 adult deer and 4.7 fawns eaten results. In terms of numbers of individuals consumed, then, fawns composed 45 percent. Both this and the hypothetical example (Table 2) show that with a direct proportional interpretation of scat analyses, small prey are overrepresented in terms of weight, and underrepresented in numbers. These disparities increase with prey whose sizes differ more than those of fawns and adult deer.

To apply the present technique most accurately, one should use the actual number of scats containing each prey type, rather than the percentage of occurrence, for some scats include remains of more than 1 prey type. Generally wolf scats each contain the remains of a single prey type. Thus, using this technique to convert percentage-of-occurrence data from wolf scats into proportions of prey types consumed will not produce too great an error. Certainly it will provide a more accurate interpretation than will direct projections of percentage-of-occurrence data.

For strictest accuracy, further refinements will often be necessary. Weights used for such rapidly growing prey types as deer fawns or moose calves should be adjusted for different ages, depending on when the wolf scats were deposited. Furthermore, since remains of yearling moose, for example, cannot be distinguished from those of adults in wolf scats, average weights used for non-calves should be adjusted to consider relative proportions of yearlings and adults in the population of moose being killed by wolves.

Application of this technique to scat analyses of smaller carnivores requires a further step because scats of those animals often contain remains of 2 or more prey types. Thus, one must estimate what fraction of a scat contains each prey type. The total of all fractions of each prey type in an entire sample can be compared with that for the other prey types, and the present technique can then be applied.

Neither Scott (1941) nor Lockie (1959) appeared to recognize the surface:volume ratio as a source of error in interpreting fox scat analysis data. However, the correction factors derived by Lockie support the interpretation which our experiment has demonstrated.

LITERATURE CITED

CARBYN, L. N. 1975. A review of methodology and relative merits of techniques used in field studies of wolves. Pages 134–142 *in* Pimlott, D. H. *ed*. IUCN Pub. Supplementary Paper 43. Morges, Switzerland. 145pp.

HALVERSON, P. B. 1969. Certain seasonal food habits of the timber wolf in northeastern Minnesota with reference to wolf predation. Macalaster College Honors Paper. St. Paul, Minn.

LOCKIE, J. D. 1959. The estimation of the food of foxes. J. Wildl. Manage. 23(2):224–227.

MECH, L. D. 1966. The wolves of Isle Royale. U.S. Nat. Park Serv., Fauna Ser. 7:210pp.

———. 1970. The wolf; the ecology and behavior of an endangered species. Nat. Hist. Press, Doubleday, New York. xx + 389pp.

PIMLOTT, D. H., J. A. SHANNON, AND G. B. KOLENOSKY. 1969. The ecology of the timber wolf in Algonquin Provincial Park. Ontario Dept. of Lands and Forests, Res. Rept. (Wildlife 87). 92pp.

SCOTT, T. G. 1941. Methods and computation in fecal analysis with reference to the red fox. Iowa State Coll. J. Sci., 15:279–285.

SHELTON, P. C. 1966. Ecological studies of beaver, moose, and wolf in Isle Royale National Park. Ph.D. Thesis, Purdue Univ., Indiana. 308pp.

VAN BALLENBERGHE, V., A. W. ERICKSON, AND D. BYMAN. 1975. Ecology of the timber wolf in northeastern Minnesota. Wildl. Monogr. 43, 43pp.

VOIGT, D. R., G. B. KOLENOSKY, AND D. H. PIMLOTT. 1976. Changes in summer food habits of wolves in central Ontario. J. Wildl. Manage. 40(4):663–669.

Received 19 January 1977.
Accepted 13 February 1978.