

## **Effects of Prey Size on Scat Analysis to Determine River Otter *Lontra canadensis* Diet**

Authors: Crimmins, Shawn M., Roberts, Nathan M., and Hamilton, David A.

Source: *Wildlife Biology*, 15(4) : 449-453

Published By: Nordic Board for Wildlife Research

URL: <https://doi.org/10.2981/08-067>

---

BioOne Complete ([complete.BioOne.org](https://complete.BioOne.org)) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at [www.bioone.org/terms-of-use](https://www.bioone.org/terms-of-use).

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

---

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

## Effects of prey size on scat analysis to determine river otter *Lontra canadensis* diet

Shawn M. Crimmins, Nathan M. Roberts & David A. Hamilton†

We conducted a controlled feeding trial using two captive river otters *Lontra canadensis* to determine how prey size may introduce bias into frequency of occurrence analysis using otter scats. Otters were fed specific prey across a range of sizes. We then collected all scats deposited by the otters to determine how many defecation events occurred to remove the prey item from the digestive system. We found a strong, positive relationship between prey item size and the number of scats required to excrete the item. We then examined how the results, of an actual river otter feeding habits study using frequency of occurrence analysis of scats, could be biased towards an over-representation of larger prey items by using a correction factor for prey item size developed from our feeding trials. Frequency of occurrence suggested a strong preference for mid-range size of prey items and a strong avoidance of smaller prey items. Our corrected results indicated that otters exhibit little preferential feeding based on prey item size in the Missouri Ozarks. Our results suggest that bias associated with frequency of occurrence analyses may severely limit the robustness of inferences that can be made from such analyses.

*Key words:* feeding habits, frequency of occurrence, *Lontra canadensis*, prey size, river otter, scat analysis

Shawn M. Crimmins\*, Nathan M. Roberts\*\* & David A. Hamilton†, Missouri Department of Conservation, 1110 South College Avenue, Columbia, Missouri 65201, USA - e-mail addresses: otter\_scat@yahoo.com (Shawn M. Crimmins); nmr25@cornell.edu (Nathan M. Roberts)

†Deceased

*Present addresses:*

\*Department of Forest Management, University of Montana, Missoula, Montana 59812, USA

\*\*Department of Natural Resources, Cornell University, Ithaca, New York 14853, USA

*Corresponding author:* Shawn M. Crimmins

*Received 2 October 2008, accepted 25 June 2009*

*Associate Editor:* Andrew E. Derocher

Dietary studies are critical for understanding animal ecology and conserving animal populations (Martin et al. 1961, Litvaitis et al. 1996, Litvaitis 2000). Such studies are increasingly based on the identification of prey remains found in scats, especially in studies of carnivore diets (Reynolds & Aebischer 1991, Hewitt & Robbins 1996, Browne et al. 2002). Many alternative methods for assessing feeding habits exist including direct observations of foraging (e.g. Bielefeldt et al. 1992), examination of stomach contents (e.g. Perez & Bigg 1986), and stable isotope analysis (e.g. McFadden et al. 2006). Litvaitis (2000)

highlighted many of the advantages and disadvantages for several of these methods. Its non-destructive nature often makes scat analyses preferable to studies of gastrointestinal tracts, and its low cost and logistical ease make it an appealing method to many biologists. Scat analyses are also recommended because of their comparability to previous studies (van Dikj et al. 2007). However, it is important to note that these considerations do not account for accuracy or reliability of the method. Scat analyses have been commonly used to assess food habits in several mustelid species, including mink *Mustela vison* (Fer-

reras & Macdonald 1999, Bartoszewicz & Zalewski 2003), American marten *Martes americana* (Bull 2000), and river otters *Lontra canadensis* (Pardini 1998, Crait & Ben-David 2006).

Most scat-based diet studies quantify dietary composition based on frequency of occurrence, and is expressed as the proportion of scats collected which contain a particular species (Trites & Joy 2005). The issues associated with estimating food habits from frequency of occurrence analyses have been addressed by previous researchers (Litvaitis et al. 1996). Most of this research has focused on the differential digestibility of specific prey items, or the relative importance of certain prey items based on biomass remains (Floyd et al. 1978, Dickman & Huang 1988). Several comparisons of frequency of occurrence to other methods have been made. For example, Mersmann & Buehler (1992) found that frequency of occurrence analysis of bald eagle *Haliaeetus leucocephalus* scats yielded highly biased results compared to direct observations. However, in a study of wolverine *Gulo gulo* diet, van Dijk et al. (2007) found that frequency of occurrence analysis performed better than several other methods in a controlled setting.

River otters are the apex predator in many aquatic systems in North America, therefore understanding their functional role in these systems is critical for proper management (Melquist et al. 2003). Studies of otter feeding habits have been conducted throughout North America, yielding great regional variation (Gilbert & Nancekivell 1982, Anderson & Woolf 1987, Reid et al. 1994). Many studies that have assessed river otter feeding habits have been based on frequency of occurrence analysis of scats (e.g. Crait & Ben-David 2006, Roberts et al. 2009). However, little information exists on biases that may be associated with frequency of occurrence analyses for river otter diets derived from scat samples. Our objectives were to determine: 1) if the size of a prey item affects the number of scats in which it could be found, and 2) how this relationship could affect the results in the frequency of occurrence analysis of food habits in river otters.

## Material and methods

### Feeding trials

We used two captive river otters legally owned by a private citizen to conduct controlled feeding trials. Both river otters were adult animals in good physical

condition which were primarily used for public outreach events sponsored by the Missouri Department of Conservation. Both otters were housed in a small (< 100 m<sup>2</sup>) semi-natural enclosure. One day prior to each feeding trial, their normal ground-beef based diet was withheld and their enclosures were cleaned of all remnant scat. On five occasions, each otter was fed one smallmouth bass *Micropterus dolomieu* of known length (10-18 cm) and allowed to completely digest and excrete the fish (N = 10 trials). We recorded the number of scats excreted by each otter for 24 hours after consuming the fish that contained identifiable remains, during which time the study animals were not given any additional food. The small size of the enclosures facilitated the collection of all scats with minimal probability that any scats were not located.

### Example data

In order to assess how prey item size may influence the results of feeding habits studies, we used an existing data set containing 4,750 river otter scats collected in southern Missouri during 2001-2002 (Roberts et al. 2009). Scats were collected from the Big Piney River and Osage Fork of the Gasconade River in the winter (January-March) and summer (June-August), along 30 randomly selected 0.4 km survey sections of each river. Frequency of occurrence analysis was conducted using diagnostic materials extracted from scats (e.g. fish scales, reptile bones and bird feathers), and these materials were used to identify prey species. Once located, fish scales were pressed on acetate plates and the impressions were viewed using a microfiche reader. Scale morphometric characteristics were used to determine species (Roberts et al. 2007). Fish age was determined using annulus counts. For this study, we focused only on the frequency of occurrence and age estimates for smallmouth bass remains.

### Data analysis

We examined the relationship between smallmouth bass length and the number of scats in which remains were found during our feeding trials using simple regression analysis. This model allowed us to predict the number of scats in which a smallmouth bass of known mass could be found (Fig. 1). We then used standard growth models developed by Jackson et al. (2008) to estimate the length of smallmouth bass recovered in otter scats as a function of age, which were based on samples collected throughout North America, and thus represented a general yet plau-

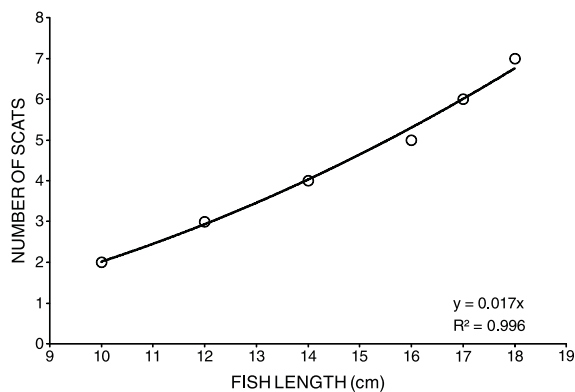


Figure 1. Regression model estimating number of river otter scats deposited as a function of fish length (in cm). Points at length 10 cm and 12 cm each represent three points with the same value (N = 10 total).

sible relationship between smallmouth bass age and length in our study area. We then combined the standard growth equation of Jackson et al. (2008), which allowed us to estimate mass of smallmouth bass based on age, with our regression model. This allowed us to estimate the number of otter scats in which we could expect to find remains of a smallmouth bass of a known age using the following equation:

$$N_i = \frac{n_i}{0.0177 \times (498.6 \times [1 - e^{-0.229(i-0.141)}])^{2.0566}},$$

where  $N_i$  is the actual number of smallmouth bass consumed in age class  $i$ , and  $n_i$  is the number of scats containing smallmouth bass remains of age class  $i$ .

We used this equation as a correction factor in our frequency of occurrence analysis. We based our frequency of occurrence analysis on the assumption that each sample containing smallmouth bass remains represented a single fish. Such assumptions are common in frequency of occurrence analyses. Of the 4,750 scats collected, 261 contained remains of smallmouth bass that could be assigned to a specific age class (Table 1), thus we assumed this to represent 261 fish consumed. We then applied our correction

Table 1. Total numbers (N) of river otter scats containing smallmouth bass remains according to age class.

Age	N	% of total
0	3	1.2
1	45	17.2
2	71	27.2
3	94	36.0
4	37	14.2
5	8	3.1
6	3	1.2

factor to these results to create a size-adjusted estimate of the minimum number of fish consumed in each age class. We then compared the resulting estimated smallmouth bass age class distributions from the frequency of occurrence analysis and our size-corrected estimate to the observed age class distribution in our study area (Missouri Department of Conservation, unpubl. data). In this case, the age class distributions from frequency of occurrence and our size correction represented estimated age distributions of consumed fish, whereas the observed distribution represented the true age class distribution of the prey population. We calculated Pearson's correlation coefficient between estimated and observed age distributions as an overall measure of departure between age distributions of consumed and available fish.

## Results

There was a very strong relationship between fish length and the number of scats deposited during our feeding trials despite our relatively small sample size (see Fig. 1). There was minimal variability in the results of our feeding trials, indicating a stable relationship between prey item size and digestive capabilities. The number of scats required to excrete a prey item increased by approximately 250% for every 50% increase in prey item length (see Fig. 1). When correcting for size-based bias using our correction factor, the estimated age distribution of smallmouth

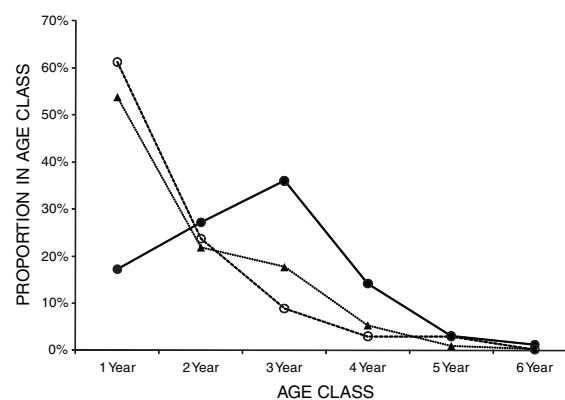


Figure 2. Observed age class distribution (--- ▲ ---), estimated age class distributions from frequency of occurrence analysis (—●—), and size-corrected scat analysis (···○···). Estimated distributions from scat analyses represent percentages of prey consumed in each age class. Observed distribution represents age class distribution of available prey population from electrofishing surveys.

bass consumed by otters closely matched their availability. Conversely, estimated age distributions of smallmouth bass consumed based on frequency of occurrence analysis indicated that otters consumed a much higher number of 3-5 year old fish than available (Fig. 2). Correlation was substantially higher between corrected age distributions and observed age distributions ( $r = 0.983$ ) than between age distributions estimated from frequency of occurrence and observed age distributions ( $r = 0.287$ ).

## Discussion

Dietary investigations of carnivores are often prompted by interest in the potential predation of a single taxa of interest; examples include river otter predation of sportfish (Roberts et al. 2009), coyotes *Canis latrans* predation of deer *Odocoileus* spp. (S. Crimmins, unpubl. data), and wolf *Canis lupus* predation of livestock (Chavez & Gese 2005). Scats provide a convenient and relatively assessable sampling unit from which to characterize the diet of a given species. Diets are often analyzed using frequency of occurrence analyses due to an uncomplicated methodology, computational ease and simple interpretation (Litvaitis 2000). However, this method is recognized as being subject to several sources of bias that can influence its results (van Dijk et al. 2007). Despite this, little research has been conducted to identify potential solutions to these sources of bias. Fundamental to describing an organism's diet from indirect observations, such as scats, is appreciating and quantifying sources of sampling bias.

Controlled feeding studies of captive animals have been used to assess accuracy of dietary analyses for a variety of carnivorous and piscivorous species including wolverine (van Dijk et al. 2007) and harbour seals *Phoca vitulina* (Cottrell et al. 1996). Our study is, to our knowledge, the only study to conduct controlled feeding trials of captive river otters. Although our feeding trials did not account for scat deposition rates when multiple prey items were consumed, the observed positive relationship between prey item size and the number of scats in which it could be detected would likely remain. Our results indicate a clear prey-size specific bias associated with the frequency of occurrence analysis of river otter scat. By applying a correction weight to account for the observed bias to the results of a previous study (Roberts et al. 2009), we demonstrated that the interpretation of results regarding prey selectivity can be

dramatically different from naïve estimates based on frequency of occurrence. In fact, the limited range of prey sizes used in our feeding trials indicates that bias from frequency of occurrence analysis would be even greater in situations where larger prey items were consumed. Although the scats used in our frequency of occurrence analysis were collected across multiple seasons, the age ratios of smallmouth bass remains were similar across seasons and sites, meaning that the trend in estimated age ratios across seasons would be similar. Most carnivores consume a variety of prey that range considerably in size. Given this, it is reasonable to assume that the inherent difficulties with frequency of occurrence analysis are not limited by prey taxa. If researchers desire to more accurately quantify overall dietary patterns using scat analysis, correction factors would need to be developed for several prey species (Rühe et al. 2008). We suggest that researchers should acknowledge the potential of prey-size specific bias when employing frequency of occurrence derived diet analysis and, preferably, attempt to quantify and correct for these biases. Previous research has indicated that other factors can influence the results of scat-based dietary studies including total meal size (Marcus et al. 1998), specific prey remains recovered (Cottrell et al. 1996), level of digestion (Tollit et al. 1997), and specific analysis technique (van Dijk et al. 2007). When considered along with our results, studies such as these suggest that caution should be used when conducting frequency of occurrence analysis to determine dietary composition.

*Acknowledgements* - we are grateful to G. Chambers for providing access to his animals. Support for this project was provided by the Missouri Department of Conservation. Comments from two anonymous reviewers greatly improved the quality of the manuscript.

## References

- Anderson, A.A. & Woolf, A. 1987: River otter food habits in northwestern Illinois. - Transactions of the Illinois Academy of Science 80: 115-118.
- Bartoszewicz, M. & Zalewski, A. 2003: American mink, *Mustela vison* diet and predation on waterfowl in the Slonsk Reserve, western Poland. - Folia Zoologica 52: 225-238.
- Bielefeldt, J., Rosenfield, R.N. & Papp, J.M. 1992: Unfounded assumptions about the diet of the Cooper's hawk. - Condor 94: 427-436.
- Browne, P., Laake, J. & De Long, R.L. 2002: Improving pinniped diet analysis through identification of

- multiple skeletal structures in fecal samples. - Fisheries Bulletin 100: 423-433.
- Bull, E.L. 2000: Seasonal and sexual differences in American marten diet in northeastern Oregon. - Northwest Science 74: 186-191.
- Chavez, A.S. & Gese, E.M. 2005: Food habits of wolves in relation to livestock depredations in northwestern Minnesota. - American Midland Naturalist 154: 253-263.
- Cottrell, P.E., Trites, A.W. & Miller, E.H. 1996: Assessing the use of hard parts in faeces to identify harbour seal prey: results of captivefeeding trials. - Canadian Journal of Zoology 74: 875-880.
- Crait, J.R. & BenDavid, M. 2006: River otters in Yellowstone Lake depend on a declining cutthroat trout population. - Journal of Mammalogy 87(3): 485-494.
- Dickman, C.R. & Huang, C. 1988: The reliability of fecal analysis as a method for determining the diet of insectivorous mammals. - Journal of Mammalogy 69: 108-113.
- Ferreras, P. & Macdonald, D.W. 1999: The impact of American mink *Mustela vison* on water birds in the upper Thames. - Journal of Applied Ecology 36: 701-708.
- Floyd, T.J., Mech, L.D. & Jordan, P.A. 1978: Relating wolf scat content to prey consumed. - Journal of Wildlife Management 42: 528-532.
- Gilbert, F.F. & Nancekivell, E.G. 1982: Food habits of mink (*Mustela vison*) and otter (*Lutra canadensis*) in northeastern Alberta. - Canadian Journal of Zoology 60: 1282-1288.
- Hewitt, D.G. & Robbins, C.T. 1996: Estimating grizzly bear food habits from fecal analysis. - Wildlife Society Bulletin 24: 547-550.
- Jackson, Z.J., Quist, M.C. & Larscheid, J.G. 2008: Growth standards for nine North American fish species. - Fisheries Management and Ecology 15(2): 107-118.
- Litvaitis, J.A. 2000: Investigating Food Habits of Terrestrial Vertebrates. - In: Boitani, L. & Fuller, T.K. (Eds.); Research Techniques in Animal Ecology: Controversies and Consequences. Columbia University Press, New York, pp. 165-190.
- Litvaitis, J.A., Titus, K. & Anderson, E.M. 1996: Measuring vertebrate use of terrestrial habitats and foods. - In: Bookhout, T.A. (Ed.); Research and Management Techniques for Wildlife and Habitats. The Wildlife Society, Bethesda, pp. 254-274.
- Marcus, J., Don Bowen, W. & Eddington, J.D. 1998: Effects of meal size on otolith recovery from fecal samples of gray and harbor seals. Marine Mammal Science 14: 789-802.
- Martin, A.C., Zim, H.S. & Nelson, A.L. 1961: American wildlife and plants: a guide to wildlife food habits. - Dover Publishers, New York, 484 pp.
- McFadden, K.W., Sambrotto, R.N., Medellin, R.A. & Gompper, M.E. 2006: Feeding habits of endangered pygmy raccoons *Procyon pygmaeus* based on stable isotope and fecal analysis. - Journal of Mammalogy 87(3): 501-509.
- Melquist, W.E., Polechla, P.J., Jr. & Toweill, D. 2003: River otter: *Lontra canadensis*. - In: Feldhammer, G.A., Thompson, B.C. & Chapman, J.A. (Eds.); Wild Mammals of North America: Biology, Management, and Conservation. Johns Hopkins University Press, Baltimore, pp. 708-734.
- Mersmann, T.J. & Buehler, D.A. 1992: Assessing bias in studies of bald eagle food habits. - Journal of Wildlife Management 56: 73-78.
- Pardini, R. 1998: Feeding ecology of the neotropical river otter *Lontra longicaudis* in an Atlantic forest stream, southeastern Brazil. - Journal of Zoology (London) 245: 385-391.
- Perez, M.A. & Bigg, M.A. 1986: Diet of northern fur seals *Callorhinus ursinus* off western North America. - Fishery Bulletin 84: 957-971.
- Reid, D.G., Code, T.E., Reid, A.C.H. & Herrero, S.M. 1994: Food habits of the river otter in a boreal ecosystem. - Canadian Journal of Zoology 72: 1306-1313.
- Reynolds, J.C. & Aebischer, N.J. 1991: Comparison and qualification of carnivore diet by faecal analysis: a critique, with recommendations based on a study of the fox *Vulpes vulpes*. - Mammal Review 21: 97-122.
- Roberts, N.M., Rabeni, C.F. & Stanovick, J.S. 2007: Distinguishing centrarchid genera by use of lateral line scales. - North American Journal of Fisheries Management 27: 215-219.
- Roberts, N.M., Rabeni, C.F. & Stanovick, J.S. 2009: River otter food habits in the Missouri Ozarks. - Canadian Field-Naturalist 123: in press.
- Rühe, F., Ksinsik, M. & Kiffner, C. 2008: Conversion factors in carnivore scat analysis: sources of bias. - Wildlife Biology 14(4): 500-506.
- Tollit, D.L., Steward, M.J., Thompson, P.M., Pierce, G.J., Santos, M.B. & Hughes, S. 1997: Species and size differences in the digestion of otoliths and beaks: implications for estimates of pinniped diet composition. - Canadian Journal of Fisheries and Aquatic Sciences 54: 105-119.
- Trites, A.W. & Joy, R. 2005: Dietary analysis from fecal samples: how many scats are enough? - Journal of Mammalogy 86(4): 704-712.
- van Dijk, J., Hauge, K., Landa, A., Andersen, R. & May, R. 2007: Evaluating scat analysis methods to assess wolverine *Gulo gulo* diet. - Wildlife Biology 13(2): 62-67.