Are MOOSE on the Menu for Northwestern Montana Wolves?

Seeking Answers in Scats and Stable Isotopes

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It all started during an informal lunch with a member of my graduate committee. "How about using stable isotopes to examine wolf diet?" asked Mark Hebblewhite. "You might be able to get at how important moose are to wolves in northwestern Montana." Thus began my journey on a fascinating path of discovery.

I had just enrolled in the University of Montana's wildlife biology program as a Boone and Crockett Fellow under B&C Professor Paul Krausman. Since 2005 I had worked seasonally for the Montana Fish, Wildlife and Parks (FWP) Wolf Program, and before that for the Nez Perce Tribe on the Idaho Wolf Recovery Program, and the USGS Minnesota Wolf Project. This was good preparation for launching a Master of Science study on the wolves of northwestern Montana. Montana's FWP Region 1 (Northwestern Montana) Wildlife Manager Jim Williams was happy to provide logistical assistance and the use of vehicles, and the agency's wolf management specialist for the region, Kent Laudon, was also in full support. Kent and I had worked together since my 2004 summer on the Nez Perce project, and we recognized the value of information sharing while trying to figure out where wolves were and what they were up to. We knew roughly how many wolf packs there were and had a general sense of home ranges; however, other basic information on the area's 300 or so wolves was lacking. I realized that the big questions about ecosystem effects of a recolonizing top predator were beyond the scope of my master's degree time frame. Still, I wanted to add something original to the state of wolf knowledge and provide results that managers and resource users would find helpful.

Dr. Hebblewhite was widely published in the science of wolf ecology but new to the literature on how stable isotope analysis (SIA) can be used to investigate the diets of carnivores. He was interested in the evidence suggesting that wolves seek out moose (*Alces alces*) as prey whenever they are available. However, few studies had used SIA to determine what wolves may be eating in an ecosystem offering a good variety of wild ungulate species on the menu. Northwestern Montana certainly fit that description. And because managers here knew that some populations of Shiras moose (*Alces alces shirasi*) were in decline, a wolf diet study had real potential to provide useful management information.

Two Ways of Looking at Wolf Diets

In wildlife research, the SIA approach was best known for detecting the presence of unusual diet items. Could it be used more broadly

Few studies had used SIA (stable isotope analysis) to determine what wolves may be eating in an ecosystem offering a good variety of wild ungulate species on the menu. Northwestern Montana certainly fit that description.

LEFT: The areas of matted down vegetation are wolf rendezvous sites where hair and scat are collected.

to study carnivore diets? At a conference during my first semester I got lucky and met just the expert to help me explore this idea. Canadian researcher Chris Darimont, of the University of California-Santa Cruz and Raincoast Conservation Foundation, had been publishing SIA work on wolves since 2002. He strongly encouraged me to pursue the project; he continued to provide support throughout my master's program and coauthored the soon-to-be published peer-reviewed paper on the study. We agreed it would also be worth comparing the SIA method with the more traditional method of scat analysis. Several of Dr. Krausman's former graduate students had conducted scat studies on wolves, and my years of wolf work in Montana, Idaho, and Minnesota meant I already had a good nose for wolf scat, so it seemed like a good plan.

I delved into the scientific literature to develop my understanding of how stable isotopes can be used. Then it was time to head out into the mountainous wilds of northwestern Montana to find some wolves. On paper the plan was relatively simple: collect samples needed for the two different methods, analyze them and compare the results, and assess their relative costs. If successful, I could provide wildlife managers with information about the prey wolves were eating, how much diet varied among wolf packs, and recommend which analysis method to use in future research.

Lacking data to the contrary, most biologists assumed that wolves primarily consumed the abundant white-tailed deer (*Odocoileus virginianus*), which comprises about 70 percent of ungulate biomass in northwestern Montana. The scientific literature offered no clear consensus on what wolves consume in ecosystems containing a range of large ungulates. Thus the whitetail hypothesis seemed the safest, and I anticipated that my study would support it.

In scat studies, what one is able to say about a wolf pack's diet is limited by the number of scats collected. The goal is to gather as many as possible and identify them as belonging to one pack and not another. Scats are then sterilized and broken apart to see what undigested remains lurk within. The typical wolf scat contains remains from a single species because wolves usually kill a wild ungulate, consume it, and defecate all undigested remains before the next meal. Most scats contain some hairs and these have characteristic coloration, banding, and scale patterns at the microscopic level that can be used to identify the species or possibly only the genus of prey. For example, I could use hairs to distinguish between elk (*Cervus Canadensis*), moose, and deer, but not between mule deer (*Odocoileus hemionus*) and white-tailed deer.

Stable isotope analysis is more complicated. Whereas scat studies reveal what has not been eaten (absence) as an aid to determining what was eaten, stable isotope

studies use the chemical composition of the predator's tissues to determine the proportional contributions of distinct diet sources (the "building blocks") that built those tissues. The phrase, "you are what you eat," contains enough truth to make stable isotopes useful for diet analysis.

What, exactly, are stable isotopes? Isotopes are just forms of an element that differ in their atomic weights, specifically in the number of neutrons in a nucleus. So for example carbon-13 and carbon-12 are carbon isotopes with 13 and 12 neutrons, respectively. Most isotopes are unstable, decaying and ultimately becoming a different element; these are the radioisotopes. The decay rates of some unstable isotopes are used to date the formation of rocks and fossils; for example, the use of potassium-40 in geology and paleontology. Others that decay more rapidly are used to date more recent events, such as carbon-14 employed in archaeology. A relatively small number of isotopes are stable, remaining unchanged for vast periods of time, and this stability allows them to be used as ecological tracers.

The tissues of any organism contain some relative proportion of the stable isotopes carbon-13 and carbon-12, and also nitrogen-15 and nitrogen-14. These isotope values differ between species because of their different life histories, including different strategies for deriving nutrition. Thus the tissues of a species that consumes some combination of other species will contain an isotopic record of those dietary choices. For a study on predator diet, the investigator must know two things. First, what prey species are available? Second, what distinct stable isotope values do these prey species have? Once these facts are established, the researcher must collect sufficient samples of prey and consumer to determine mean isotope values, and then use appropriate statistical analysis to estimate diet composition.

Hands and Knees Science

Once I understood the basics, it seemed obvious that the two methods would represent diet very differently. A wolf scat would provide information about a single recent meal, but a tissue sample would provide a complete record of diet information during the growth period of the tissue sample. Thus, unless scats could be collected for every kill made by a pack (impossible in a practical sense), tissue samples for SIA had the potential to be a much more powerful technique. So, what tissues would I collect for SIA?

Hairs are commonly used in SIA for diets of mammalian carnivores because they can be collected non-invasively and relatively easily. Wolves grow guard hairs from around May until October, so these hairs represent summer diet. I decided on an approach to locate wolf home sites and collect hairs shed in the spring molt. My field strategy would include the collection of scats during the summer of year one, and the collection of shed hairs in the following spring/summer. The logic was this: for a given wolf pack, the year-one scats should contain evidence of diet that would match up with the isotope values contained in the year-two hair samples.

In summer of 2008 I spent my scat field season covering many miles of northwestern Montana, using my experience and current information from Kent and his crew of technicians to determine the whereabouts of wolves. Whenever I found concentrations of wolf sign such as multiple sets of tracks and numerous scats of different ages, I focused on finding the den or rendezvous site. There I collected as many scats as possible during repeated visits. By the end of that season, I had enough scats from four packs to start diet analysis.

The stable isotope portion of my study required that I determine the isotope values of prey species as well as wolves. I relied on help from Montana FWP and big game hunters to obtain sufficient samples of prey tissue. Biologists at check stations during the 2008 hunting season collected hairs from white-tailed deer, mule deer, elk, and moose. Successful hunters were happy to part with a few hairs to help improve knowledge about what northwestern Montana wolves were eating.

In summer 2009 I returned to the same wolf pack home sites I had located in 2008, plus some new ones, to find hairs shed by pack members. My most successful approach was to wait until wolves had moved on to a different site, and then very carefully, on hands and knees, scour the ground for clumps of shed hair. In most cases, home sites contained areas of flattened vegetation or circular depressions in the dirt where a wolf had been lying. By targeting these sites I was usually able to find wolf hairs. A less successful but interesting approach was to construct

FROM LEFT TO RIGHT: Jonathan on his hands and knees scouring the ground for clumps of shed hair. ■ In the summer of 2008 enough scat samples from four packs of wolves had been collected to start diet analysis. ■ Along with the help of undergraduates, Jonathan analyzed approximately 200 wolf scats and 150 hair samples for SIA to obtain their data.

hair snares from wooden boards affixed with wire bristles (similar to gun barrel cleaners). I set half-buried snares near home sites and applied trapping lures with the intent of eliciting the canine urge to roll in stinky stuff, thereby leaving hairs on the bristles. A colleague had found this technique useful for collecting hair samples for DNA work. Although I did collect some hairs this way, it did not always provide the number of hairs (30 or more) needed for SIA. As well, it was very time-consuming to set and check a hair snare trapline.

Ultimately, my collections and others provided by Montana's ever-supportive FWP wolf program personnel yielded enough samples to analyze diets of 12 packs. Given that my intensity of field effort was about equal in 2008 and 2009, I had a strong hunch that that SIA might win out in terms of bang for buck. However, a long process of analysis and techniques comparison was required before results would be known.

Fortunately, I was able to employ a team of motivated and hardworking undergraduates in the University of Montana wildlife biology program to help with lab work. We picked through approximately 200 wolf scats to determine what proportions of deer, elk, moose, and other prey contributed to the diets of four packs. The hair samples for SIA, 150 in all, had to be cleaned, dried, and ground to powder. One milligram samples were placed into tin capsules and sent to a SIA lab for processing in a mass spectrometer. This machine combusts the samples to separate CO_2 and N_2, which then are measured to calculate isotope ratios. The results returned are simply isotope values for each individual wolf or prey animal.

A Taste for Moose

So what did all this reveal about wolf diets in northwestern Montana? The scat samples indicated that moose comprised over 25 percent of summer diet for two of four packs. This was a surprising result considering that moose contributed only about six percent of total ungulate biomass. Pack diets varied significantly; deer were the most common prey for two packs, elk for one pack, and elk and moose tied as the most common prey for the fourth pack. The SIA on 12 packs also revealed that packs vary in the proportions of prey consumed; again, moose featured much more prominently than expected based on the amount of moose available to wolves in northern Montana. Moreover, when we compared results from SIA and scat data for the four packs with matched samples, half of the paired estimates were different.

Was this further evidence for Dr. Hebblewhite's view that wolves like to eat moose whenever they can? Because the comparison of results between analysis methods failed to reveal a consistent match, the answer is somewhat equivocal. This is a little disappointing from the management perspective because I was not able to categorically state what northern Montana summer wolf diets consisted of. Cost-wise, our assessment of the two techniques was overwhelmingly in favor of SIA. Three times as many pack diets were estimated for about half the cost of the scat analysis. It would be premature to promote one technique over the other based on this study alone, however.

The Rest of the Story

There was sufficient evidence of moose in wolf diets to suggest that wolves do consume them more than would be expected based on availability. Also, the lack of certainty may ultimately lead to a more satisfying conclusion for science, because the SIA results revealed a potential weakness in the technique when used for wolf diet. Earlier I mentioned the lack of precision in the "you are what you eat" adage when uttered in a SIA context. The reason is, there is an additional change in isotope values as tissues are converted from being consumed food to becoming tissue of the consumer. Termed

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fractionation, this change must be included in the diet analysis equation to ensure the correct interpretation of consumer isotope values (i.e., how those values are explained in terms of diet contributions).

Researchers choose fractionation values based on what makes sense for their studies, which usually means choosing values that have been determined through experiments on animals most closely related to the species of study. For most SIA wolf diet studies, fractionation values experimentally derived from red foxes (*Vulpes vulpes*) have been used because these carnivores are in the same family, *Canidae*. Several previous studies were primarily interested in detecting use of seasonally available salmon, which have isotope values so different from those of ungulate prey that slightly incorrect fractionation values would not obscure the result of interest. However, when the prey species of interest are all ungulates, only slight changes in fractionation values used can have large consequences for results. It's also possible that wolves fractionate differently enough from red foxes that we ought to use values derived from wolves for SIA studies of wolf diet.

In our case, a different set of values could have resulted in more or less moose being reported for wolf diet in northwestern Montana. The best way to be sure about future results from SIA for wolf diet is to conduct the appropriate experiment to derive wolf fractionation values, and we are working on that now. In collaboration with a captive wolf facility in Minnesota, we are feeding wolves a controlled diet of white-tailed deer for a period of one year. We are taking samples from wolves and deer throughout the period and will be able to establish wolf fractionation values by examining the isotopic differences between the species. This new species-specific value will likely become the standard for future studies and will help eliminate that puzzling source of uncertainty.

As is typical in science, my master's study ended up producing a mix of answers and questions. Although there was some uncertainty, it still indicates that wolves consume more moose than would be expected in an ecosystem where moose numbers are low.

I'm indebted to Dr. Hebblewhite, whose keen interest in wolf ecology drew me into this fascinating investigation of predator-prey dynamics in northwestern Montana. Along the way I completed a Master of Science degree, authored a soon-to-be-published scientific paper, and launched a follow-up study. And when it comes to sniffing out wolf scats and hairs in the wilds, I'm the guy to call. ■

Jonathan Derbridge is working toward a doctorate degree at the University of Arizona. His current work focuses on the ecological interactions between native and introduced species; in particular, the impacts of introduced Abert's squirrels (*Sciurus aberti*) on the endangered Mount Graham red squirrel (*Tamiasciurus hudsonicus grahamensis*) in southeastern Arizona. He plans to pursue an academic career in wildlife ecology and conservation research.