Richard Heckmann

Left: Gill filaments (200X mag.) from a cutthroat trout from Yellowstone Lake infested with Trichophrya clarki. *Below: A* Trichodina *sp. from the gills of cutthroat trout (1000X mag.).*

For the modern fisherman who may not care to repeat this experiment, my scoutmaster gave us the right advice when I first ate trout from Yellowstone Lake: they are not harmful to humans as long as the fish are cooked. Dislike of the parasite is purely psychological, and discarding parasitized fish is wasteful. Consider the additional protein you are ingesting when infected fish are eaten.

Flukes: Blindness for Trout

If the lens of a cutthroat trout's eye appears opaque or cloudy, it may be due to a larval stage of a fluke. The larval stage has migrated into the orbit of the eye, causing blindness. Unsuccessful fishing trips may be partially due to this parasite.

The larvae of *Diplostomum* live in the eyes of Yellowstone Lake fishes and remain there until the fish die or the life span of the parasite has been reached. Some fish are probably blinded by Diplostomatosis, the disease caused by the parasite. For fish, this parasite is nonhost-specific (meaning it can live in a variety of hosts rather than in just one species) but has not been considered dangerous to humans. During recent surveys of fish parasites for cutthroat trout from Yellowstone Lake, cutthroat trout had a 100 percent incidence of the eye fluke, with some fish containing more than 100 larvae per eye.

Fish are the most common second intermediate hosts for *Diplostomum*; however, infections in amphibians, reptiles, and mammals have also been reported. Once the larvae are released from their primary host, snails, they penetrate the second intermediate host, lose their forked tails, and migrate to the tissue of the eye, where the metacercariae (or second larval stage) develops in 50-60 days.

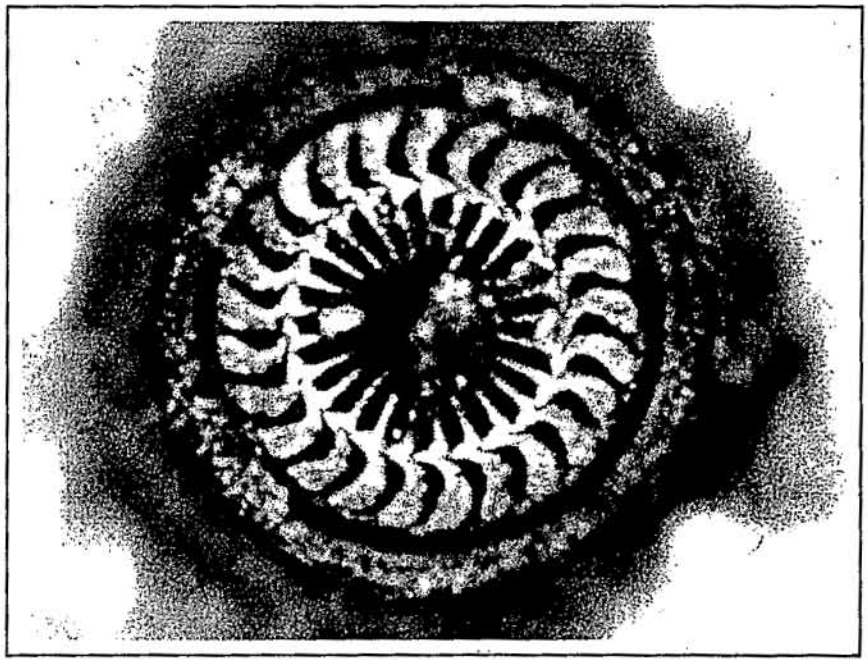
Diplostomatosis can cause cataracts of the lens tissue, due to the presence of the metacercaria stage of this parasite. Visual acuity for infected fish can be slightly hampered or lost, depending on the number of worms present. In addition to visual loss, fish show retarded growth and a change in food habits.

There is a small adult fluke found in many of the fish called *Crepidostomum farionis*. In my 1970 survey, 95 percent of the trout examined were infected with this fluke, which often occupied the lumen of the gall bladder.

Ectoparasites: Fish Louse and Leeches

The fish louse, or parasitic copepod, is a small crustacean usually found attached behind a trout's fins. It is common in June and eventually drops off after the fish has been removed from the water. Minimal damage is caused by the copepod to the host fish. Certain species of copepods, or fish louse, such as the genera *Argulus*, *Lernaea*, and *Ergasilus*, are very serious pests in fish culture and sometimes in nature.

The freshwater leech (*Piscicola salmonsitica*) is dark brown and about one inch long when extended. It attaches to the body of the trout by means



Richard Heckmann

As part of his research, the author captured Yellowstone Lake cutthroat trout and held them briefly in a live well (above) so examinations could be conducted (below). The fish were used for parasite identification and to test new pharmaceuticals against varous parasites.

of a suction-type mouth equipped with rasping mouth parts. The leech is most numerous during the cutthroat's June spawning run. It usually drops off shortly after the fish is removed from water.

Leeches were found on the gills and base of fins of 8 percent of the cutthroat trout checked for parasites during 1985.

Fish Parasites and the 1988 Fires

The last parasite survey of Yellowstone Lake cutthroat trout that I conducted was in 1990, two years after the fires of 1988. I discovered a remarkable drop in the number of tapeworm plerocercoids.

In the 1985 survey, 100 percent of the trout that were six inches or longer were infected. This dropped to 5 to 38 percent infected for the same size group for the 1990 survey, with lower numbers of plerocercoids per infected fish. I have hypothesized that the fires somehow interrupted the life cycle of the cestode so that fewer fish were infected.

Suggested Readings

Heckmann, R.A. 1970. Comparative morphology and host-parasite studies of *Trichophrya clarki* (sp. n.) on cutthroat trout (*Salmo clarki*). Unpublished dissertation, Montana State University, Bozeman. 69 pp.

Heckmann, R.A. 1971. Parasites of cutthroat trout from Yellowstone Lake, Wyoming. *Prog. Fish. Cult.* 33:103-106.

Heckmann, R.A. and T. Carroll. 1985. Host-parasite studies of *Trichophrya* infesting cutthroat trout (*Salmo clarki*) and longnose suckers (*Catostomus catostomus*) from Yellowstone Lake, Wyoming. *Great Basin Nat.* 45:255-265.

Heckmann, R.A. and H.L. Ching. 1987. Parasites of the cutthroat trout, *Salmo clarki*, and longnose suckers, *Catostomus catostomus*, from Yellowstone Lake, Wyoming. *Great Basin Nat.* 47:259-275.

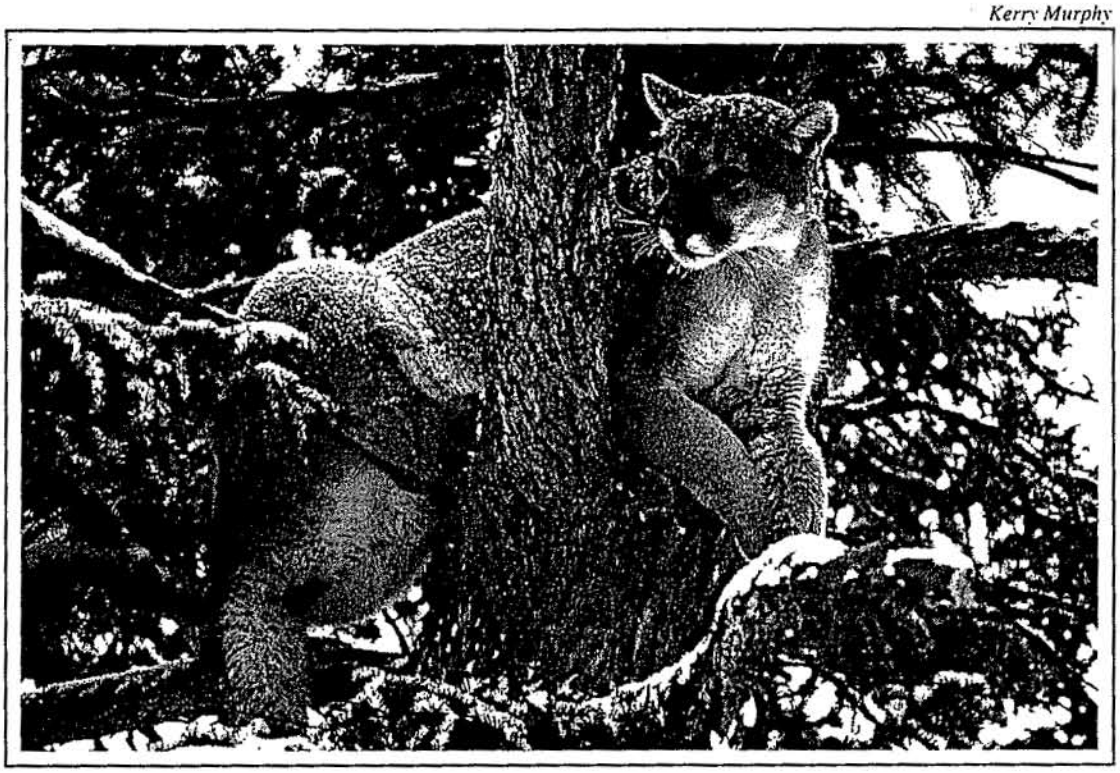
Hoffman, G.L. 1967. *Parasites of North American freshwater fishes*. Univ. of California Press, Berkeley and Los Angeles. 486 pp.

Richard Heckmann, a Professor of Zoology at Brigham Young University, has been involved in research on the parasites of the cutthroat trout in Yellowstone Lake for more than two decades.

The Yellowstone Lion

The homecoming of a native predator: Part One

Kerry Murphy



Mountain lions were native to the Yellowstone region, and were often mentioned by early travelers, who either heard or saw them in the park. The federal predator control programs of the early twentieth century essentially eliminated them from Yellowstone; 121 were reported killed between 1904 and 1925, when the "last" one was taken. For many years after that, only occasional sightings were reported, and the belief that the mountain lion was gone was widespread. But in the past thirty years, sightings increased, and evidence grew that Yellowstone again had its own population of mountain lions.

Kerry Murphy, a wildlife biologist with the Hornocker Wildlife Research Institute in Moscow, Idaho, is now completing a five-year study of this "new" Yellowstone lion population. In this first part of a two-part interview, we asked Kerry about many aspects of the study and its results. In the second part, to appear in the next issue of Yellowstone Science, *we will follow Kerry through a typical day of tracking, in which a lion is treed by the dogs, radio-collared, and released.*

We look forward to hearing more from Kerry on the ecology of the Yellowstone lion as he completes his analysis of the data gathered during this important study.—Ed.

YS How did the lion study come about?

KM The Yellowstone lion study grew out of work that Maurice Hornocker, director of the Hornocker Wildlife Re-

search Institute, did with his colleagues in the Big Creek area in Idaho in the 1960s.

YS That was a landmark study, with lots of cutting-edge methodology.

KM Right. Maurice asked me to go back there as an assistant to Gary Koehler. The idea was to do another study because the prey distribution and density had changed. Because of the 1960s work, we would have reference information to compare the new findings with. We wanted to see if the lion population had changed in response to the changes in the prey population.

At the time that we went back into Big Creek, in the early 1980s, a lot of the science we used was changing. Researchers and managers were doing more direct manipulation with large carnivores.

YS You mean like capture and handling, and radiocollaring?

KM No. I mean removal experiments, in which lions were taken out of the area, to see how predator social organizations would change or how prey populations would respond to reduced numbers of predators. Lion removal wasn't envisioned for Big Creek right away, but Maurice eventually wanted to experimentally manipulate the population. So we thought we'd study the Big Creek situation for three or four years, and when we understood what was going on, we would take individual lions out, and see how remaining lions responded.

This brought up the obvious question of what to do with the lions we took out. The answer was, "Let's put them in Yellowstone, because the park doesn't have lions." Well, we knew we'd better go take a look.

That's when Maurice proposed to do the survey. The park was getting more sightings, and some park researchers thought there were more mountain lions around than commonly believed, but nobody knew how many or if they were resident.

YS Besides the sightings of individual lions, Doug Houston, one of the NPS biologists in the 1970s, was flying over the Black Canyon of the Yellowstone River in the northern part of the park and photographed a female with two kittens.

Gary Koehler

Kerry Murphy with "Spook" the redbone hound that Kerry claims could actually reason. The lion was a large kitten captured in Big Creek, Frank Church River-of-No-Return Wilderness, March 1987. This capture was part of Hornocker's second study in Big Creek.

KM That was a significant sighting. When reproduction occurs, there is a high probability that the family is resident. Family groups need predictable resources. For this reason, it would be very difficult for the mother to be unattached to a home range and still support a family. We could have guessed right there that resident individuals were present.

From January to April of 1986, Gary Koehler and Jay Tischendorf did the survey. They estimated that there were three to five resident lions on the northern range in the park. It's hard to document population size based only on a survey, but three to five was probably a reasonable estimate.

YS How do you make an initial estimate like that? How do you decide if lions will like a country and live in it?

KM The winter haunts of lions are pretty predictable. Gary and Jay looked on a map for areas where prey, rocks, and conifer cover occur together. They thought the Black Canyon would be great habitat. It had a lot of cover and was prime ungulate winter range. Of course, it did not support as many ungulates as other habitats on the northern range, but lions don't necessarily need high prey densities. Lions are morphologically equipped to find and kill prey efficiently.

Gary and Jay skied those likely areas and inevitably found tracks and other sign. The problem was not finding sign but deciding how many lions left it. That's why telemetry is usually needed for these secretive carnivores. Researchers have proposed using track counts to document population trends, but you really need to establish the relationship between the actual population size and the tracks seen.

YS Let's get back to the launching of

the study. What happened after the initial survey?

KM Well, we immediately recognized that lions were already here, so there was no need to pursue a population restoration using lions from Big Creek. But we had developed a strong interest in how lions affected the elk on the northern range. It was also a unique opportunity to study how the lion population was responding to a very high prey base.

YS Why would that be special?

KM Most of the lion research conducted previously in the western states was in situations where prey were at low or moderate levels. In Yellowstone, ungulate densities are among the highest in the world. We calculated 55 elk per square mile, based on some of Frank Singer's [*NPS ungulate ecologist—Ed.*] numbers. Maurice calls the park an elk supermarket. And that does not include the other lion prey that are present, such as deer, sheep, moose, or large rodents.

Maurice proposed a 5-year study. He put together funding from outside funding sources and the NPS, and away we went.

YS That's where you came in. What were your hopes for the study?

KM I thought I might be able to do my doctoral work here, but I was afraid I might end up writing a dissertation about only one or two individuals. There was some risk involved for Maurice and me. The funding wasn't secure in the long term. We just decided to go for it.

YS How did you start?

KM Jay Tischendorf and I began work right where we thought the best lion habitat was—in the Black Canyon, on lower Blacktail Deer Creek, and lower Hellroaring and Slough Creeks. We caught 10 or 11 individuals during the first winter.

YS That must have been an amazing start, to get so many right off.

KM It was a good winter to capture lions. They were reasonably concentrated. When we started, we caught lions that occurred predictably in the river corridors. But as the study evolved, we worked in areas where the lions occurred at lower densities, such as Pebble Creek. Many parts of the northern range are hard to get to, and so more time and energy is required to capture lions there than in the river corridors.

YS Mention of capturing lions brings up another subject. Many people are curious about the use of dogs in this project. Dogs have a long history of conflict with wildlife in many places, and unleashed pets are not allowed in national parks. In fact, for many years, dogs were absolutely forbidden in Yellowstone. Even in recent decades, residents were not allowed to own them in the park's interior. That must have required some careful diplomacy between you and the local people, to suddenly be running a wild animal in the backcountry with dogs. Was that a problem?

KM When I arrived here, I didn't appreciate how much opposition there might be against hounds. I had worked with lions and dogs in other places and it was not a problem. Dogs had been used in Yellowstone in the early 1900s to control lions. And Yellowstone was not the first national park to do lion studies with dogs. Everglades, Big Bend, and Guadalupe Mountains national parks had all used dogs, so precedents existed.

So we said, "Hey, what's all the concern? It's been demonstrated that dogs can be used effectively without disrupting ungulates, if you show common sense." Still, the opposition was there.

YS Some of the problem must have been misunderstanding of what your dogs would do. If you mention using dogs to catch lions, a lot of people would think of a string of twenty or so dogs out there, with lots of noise, and elk and deer being spooked in all directions. People picture the old fox hunt.

KM Exactly.

YS But that isn't how it works. If a hiker came along and saw you at work, they would see two fellows with heavy backpacks, and a couple of dogs on leashes.

KM Right. In the first three years of the study, we took out a lot of rangers and other park personnel. They saw the nature of the operation and its logistical difficulties. That was a big factor in reducing concern over the hounds.

The dogs were not allowed to bark when we hiked. After we released them to follow lion tracks, their barking was partly absorbed by the canyons and the forest.

Spook, the same redbone, early in the Yellowstone study, April 1988.

YS When were you in the field with the dogs? When did you catch lions?

KM Generally our capture season was from late October through March 30. We did it that way to avoid confrontations with bears.

YS So grizzly bear denning times dictated your field season?

KM Yes. We did immobilizations outside the park when bears were not denned, but only in areas that we thought supported few grizzlies.

YS Another time frame that you had to deal with was the lion-hunting season in Montana, north of the park. How did you work with that?

KM The lion-hunting season opens December 1 and closes when quotas are reached. That would often be in early January, but sometimes seasons wouldn't close until about February 15.

YS So you tried to do your work outside before and after the hunting season, and then work in the park during the hunting season?

KM Right.

YS What proportion of your work was outside the park?

KM Thirty to forty percent of our effort was expended outside the park. In the winter, the density of lions was greater there, maybe because the cats preferred deer, which were more abundant there

than in the park. We tried not to work outside the park during the lion hunting season because we didn't want to alert the hunters to where radio-collared lions were.

YS Later we want to verbally travel with you through an entire tracking session. For now, how about some background on the process by which you gathered information on the lions once they were caught and collared? How many radio relocations did you need?

KM We might only get one radio location every two or three weeks, depending on the weather for flying or our objectives on the ground at the time. During spring, summer, and fall, we camped in the vicinity of some lions, and might have continuous radio contact with them from dawn until nine or ten o'clock at night. If necessary, we would get up in the middle of the night and use the telemetry equipment to see if a lion had moved from its previous position.

Our most intensive work occurred when we were attempting to document lion-prey relationships. This included estimating the rates at which lions took deer and elk.

YS How many days would you follow a lion to collect predation data?

KM Our advising statistician, Dr. Pat Munholland, from Montana State University, suggested that a monitoring sequence should last until it contained at least three ungulate kills. That period of time was variable, but it might be as long as 50 days.

YS During that time, how much of the cat's actual movements did you track?

KM During one sequence, Greg Felzien and Todd Fredricksen monitored a family group for 24 days and believed they had seen almost every footprint the cats made. Obviously that's very intensive effort, and we weren't able to achieve that level for many sequences, especially not in the summer when snow cover was absent. If we lost the telemetry signal of the lion, we would call Bill Chapman [*contracting pilot on the study—Ed.*] and he would use his airplane to locate the cat for us. Then we would have just one contact point for that day.

YS Was there a risk that your presence on all those days would disturb the lion and influence your findings?

KM Our objectives were to not let the lion know that we were actually in the area. We obtained a preliminary radio location from a distance, using triangulation, then moved closer. Eventually, we circled the lion and obtained a precise location by triangulating every 50 yards or so. We used available cover as a screen, but occasionally the lion detected our presence and ran off. It didn't appear that it significantly affected their movement patterns.

It was surprising how well we could sneak up on a sleeping lion, which happened if their hearing was blocked by rocks or vegetation. Of course, if they were in open country, they would hear us. Scott Relyea was able to get within 15 or 20 yards several times without being detected. On separate occasions, Greg and Todd saw a male and female mating.

YS How often has that been seen?

KM To my knowledge, these were the first times that has been observed in the wild.

YS Is there something that made such sightings more likely here, or was it just happenstance?

KM It's partly the openness of Yellowstone landscape, which tends to have sparse understories. You wouldn't be likely to see that over on the Olympic Peninsula.

YS You've concluded from your study that the lion population on the northern range has been increasing.

KM It looks like the population in the park *and* the population down the Yellowstone Valley increased during the study. People often believe that lion populations can't increase very rapidly, but lions have a high reproductive potential. In fact, it exceeds that of mule deer. Lion populations can respond quickly if sport harvests are reduced.

YS How significant was the sport harvest north of the park?

KM Very significant. And this is not unique to our particular study; it's been observed repeatedly. Sport harvests among hunted lion populations are usually the single most important source of mortality of adults and subadults. That excludes kittens, who tend to die of natural causes such as disease, predation, and natural accidents.

Another important observation related to management was dispersal from our study area and how it may have affected subpopulations in other watersheds. Our radio-collared subadults dispersed to the Clark's Fork of the Yellowstone River, and to the Stillwater, Boulder, and Gallatin River drainages north and west of the park. I think lions on the northern range constituted one subpopulation that was well-linked to other major drainages in the greater Yellowstone ecosystem. The Yellowstone River watershed appears to trade dispersers with these peripheral areas.

About two-thirds of the kittens that survived to dispersal age (11 to 14 months) left the study area. Conversely, about two-thirds of the yearlings present on the study area were born outside.

YS Is that significant?

KM Yes, because it implies that emigration and immigration of dispersing lions may "rescue" over-harvested subpopulations by continuing to add new individuals. It also points out how adversely interstate highways and human developments might affect local populations if they block exchange.

YS Are you implying that travel corridors are important to dispersing lions?

Jana Mohrman

A lion track photographed on Soda Butte Creek in the Lamar River drainage, Yellowstone National Park.

Greg Zopetti

Three lion kittens hiding at their den site near Grizzly Creek in Tom Miner Basin in August 1989. Dealing with mother lions was sometimes quite exciting. As Kerry explained this episode, "Later that summer, we saw their mother thump a black bear that got too close. She was not too happy about having us around either."

KM I don't think "corridors" are necessarily important to dispersing lions if cover and prey are adequate. For example, one of our dispersers left Quadrant Mountain and travelled almost a straight line to Yellowstone Lake. He then changed direction and went to the vicinity of Shoshone Lake. It appeared that he moved as if on a compass bearing, at least in the early weeks of dispersal. We saw this behavior in other situations too. The point is that they don't always follow what we think of as a travel corridor. They seem to travel without regard to topography. There may be some genetic control over the process.

YS What happens after the initial period of dispersal? How do they go about settling into an area?

KM They leave their natal ranges and remain in "dispersal" mode for a couple or three months. Then suddenly, they switch into a normal movement pattern much like a resident. They generally disperse during summer.

Typically by September or early October, the snow is accumulating and the cats have to figure out where to make a living for the winter. And if they're on the Yellowstone Plateau, it may not be obvious where to go to find deer or elk winter range. That probably puts some of them in a bit of a crunch.

YS Lion population size has always been something of a mystery in Yellowstone. Some of the turn-of-the-century accounts from the park suggested huge numbers of lions. Some of the observers weren't trustworthy, but others were pretty sharp, and they seemed to believe there were much larger numbers of lions around than now. What do you make of all that?

KM I haven't studied the historical literature in detail, but I have a couple thoughts. One is that the folks who noted the high numbers of lions were right. Lion populations may be able to build to levels much higher than we have seen in our lifetimes. Maybe we incorrectly discount those early reports because we're predisposed to think that lions can't reach such high densities.

We should also consider that the human-use patterns in Yellowstone have changed significantly since the park was established. What was suitable habitat when the historical reports were made may not be useful to lions today. For example, take the Lava Creek area, on the road east of Mammoth Hot Springs. Disturbance to lions there was probably low before the road was paved. The cats probably felt comfortable with the noise level and freely used the rocky rims across the canyon from Undine Falls. Today, the traffic and human activity may be so great that lions avoid the area. I was always surprised at how few times we located lions there during late fall, winter, and early spring, considering the prey and rocky cover that are present in the area. The net effect may be that less habitat is now available to lions, which leads to lower lion numbers than in the past.

The second possible explanation is, of course, that the folks who wrote the historical reports did overestimate the numbers of lion present. When they saw a lot of tracks, they naturally concluded that lions were very abundant. But as I said before, it is difficult to know how many lions correspond to multiple sets of tracks seen over a large area. I once heard a credible wildlife professional confidently estimate the number of lions in an area that I had worked intensively. My estimates were three-fold less. This person assumed each set of tracks he saw represented a different lion.

Another frequent mistake is to observe tracks of female lions with their large offspring, then count each of those lions as a breeding individual. Lion kittens have rates of mortality as high as 66 percent, and many disperse long

NPS Photo Archives

Chief Ranger Sam Woodring (left) and another man with a large lion killed in the park in the mid-1920s four miles north of Tower Fall.

distances from their natal area anyway. With respect to the immediate area, their abundance doesn't matter much. Most wild cat populations limit their numbers through their social organizations, which tend not to tolerate stockpiling.

YS One subject of continual interest around Yellowstone is wolves. What does your study tell us about how lions will do if wolves are restored to the park?

KM Remember that lions evolved in the presence of wolves. In fact, they evolved in the presence of several physically stronger or numerically more abundant carnivores, including grizzly and black bears, wolves, and coyotes. When a lion opens up the body cavity of an ungulate he kills, a lot of scent is released. These other carnivores are naturally attracted to it. Lions obviously had to develop correct behavioral responses when confronted by scavengers. I expect that lions will be displaced from carcasses by wolves. If this happens frequently, lions may have to travel and kill more often. These behaviors carry risk that might reduce the lion's survival.

Keep in mind that the lion is a supercapable predator, fully equipped to consistently provide for itself. In Yellowstone, adult lions seldom need to scavenge because of their predatory skill and the abundant prey. Even if scavenging is necessary, a lion would probably not be competitive at it because other scavengers usually get to the food source sooner using their superior noses. So scavenging is not much of an option. The effect of wolves on lions could be significant, because they would have little alternative but to kill again and potentially face the same problem.

Based on sign and telemetry observations, we observed that black bears displaced lions from their kills at least 4 times. We directly or indirectly observed coyotes do this, or at least try to, 3 times. In fact, we documented 13 coyotes killed by lions. About half of those were in the vicinity of ungulates killed by lions.

In Glacier National Park, researchers have documented at least two occasions where mountain lions were killed by wolves. Think of a pack of five to twelve wolves trotting in on a carcass and finding a female lion and two small kittens. You can imagine what kind of things could happen in that situation.

YS One of the most difficult realities of research in a setting like Yellowstone is the risk to human safety, not so much from the animals but just from the setting. A study like yours, which depends so much upon data gathered in winter, has even more hazards. The death of one of your team members, Greg Felzien, in an avalanche in February 1992, was a great tragedy in Yellowstone research, one you and your colleagues felt keenly. What can we learn from it?

KM If you are going to do lion research and expect to be successful at it, there are risks. It's almost impossible to do the work well and not occasionally find yourself, your partner, or the dogs, in a bad position. We try to instill a safety ethic in everyone and recognize that lion studies come and go, but we keep our injuries when done with the project.

I believe the order of priorities should be yourself, your partner, the lion, then the dogs. Obviously, you are not much good to your partner if you are hurt, so keeping the old number one healthy is a pretty good idea. Unfortunately, you are almost always at the mercy of some force such as gravity, the terrain, or cold weather. There's not much getting away from it. These forces can be pretty unpredictable, and being physically tired doesn't help.

I am still intimidated by the big country in Yellowstone: the steepness of many parts of the northern range, the rocks, the big rivers, and the work late at night. I try never to put myself at excessive risk. That has always been a comfort to me as we turned the dogs loose in potentially dangerous terrain. As I felt my fear go up, I told myself, "I just won't put myself in a bad spot."

YS You have choices.

KM I have the choice, and I hope that my partner is just as careful.

You will never be 100 percent proficient at predicting situations that might get you into trouble, but you can learn to avoid the obvious ones. You can predict what footing is poor, and what temperature conditions and personal energy levels lead to hypothermia. Ultimately, you and your partner determine if it's possible to do the job and get out safely. You just hope that you have enough sense to know when to head for home and forget the work. I remember lots of cold nights in wet clothes when the best part of the day was just the sight of the truck or hearing the voice of 700 dispatch on our park radio. I guess those nights have to be considered as part of the fun too.