Initial pitch:

Hi Laura,

It was nice to chat with you at the AAAS, and I'm excited about the possibility of working with you on the Bolivian chili story. I'll be heading to Santa Cruz, Bolivia on March 14th to take part in this three-week bio blitz. The team will make a loop through eastern Bolivia's Chiquitano dry forests as they map wild pepper populations, collect data on their spiciness, and set up a transplant experiment. In order to sample to as many populations as possible, they'll be taking two 4WD vehicles, and leap-frogging each other, communicating via satellite phone and comparing notes at their campsites each night. Ecologist Josh Tewksbury advised me to bring a tent with a good zipper because the area is infested with kissing bugs -- the vectors of Chagas' disease.

The makeup of the team is part of what will make this a dynamic story. Trip leader Tewksbury from the University of Washington must get about three hours of sleep each night as he's been steadily publishing in *Nature*, *Science*, and *PNAS* since receiving his Ph.D. in 1999. Ecologist Doug Levey from the University of Florida is only slightly more laid back. He's been studying fruit dispersal in the tropics since the mid-80s and has written many of the defining papers in the field. Then, there's botanist Mike Nee from the New York Botanical Garden an expert in the systematics of wild crop relatives in tropical America (chili, potato, tomato, squash, cucumber, etc.), who has described countless Bolivian species over the last 30 years. Tewksbury will also be bringing two postdocs and a graduate student, and we'll meet up with Don Udon, a Guarani parataxonomist and Uco Sapag, the driver who has kept the team alive on the world's most dangerous roads for the last four years.

As we learned last week in *Science*, chilies were first domesticated in the South America 6000 years ago -- even before the advent of pottery. Less than fifty years after Columbus brought chilies back to Europe, they were being harvested on the coasts of Africa, India, China, and the Middle East. But the eastern border of Bolivia is still spiciest place on earth. The first chilies evolved there, and it is home to two-thirds of the world's pepper species. The team wants to untangle the reasons for this diversity and find out how chilies evolved their spiciness. In a paper submitted to *Science*, Tewksbury demonstrates that spicier chilies are more resistant to fungal infections, meaning that their seeds are more likely to be dispersed and germinate. During the upcoming trip, the team will continue to collect these sorts of data over a wider area, but they also want to test whether a certain seed bug is responsible for carrying a pathogenic fungus from fruit to fruit.

Their second objective is more conservation-oriented. Scientists are realizing that the most important reservoirs of genetic diversity are not found in our highly inbred crop plants but in their wild relatives. As you know, a lack of genetic diversity has threatened the Cavendish banana, but the banana is not unique. We cultivate only two of Latin America's thirty pepper species, and the other twenty-eight are threatened by habitat destruction. Unfortunately, many countries place restrictions on the collections researchers can make, and Tewksbury is not allowed to deposit his seeds in a public seed

bank. Instead, the team will report on the status of these chili pepper populations in order to encourage the government to enact protections. Botanist Mike Nee hopes to discover new chili species like the two he described last fall.

After the expedition, I'll stop in at a traditional pepper harvest and visit markets where unusual chilies are sold. In Padilla, USAID assistance has boosted chili production for traditional farmers and their International Chili Pepper Festival is now in its fourth year. Tewksbury says that he never has to look for chili populations on his own. He just asks locals in the nearest town.

I've attached my feature on disgraced ornithologist Anders Møller (the cover story in January's *The Scientist*) along with two newspaper features with a narrative thread. As for photos, Tewksbury has a huge collection from the last few years, and I'll be bringing my own camera.

Story Memo following the trip:

Josh Tewksbury leans against a stack of wooden plant presses in the back of the pickup truck as we wind our way through Amboro National Park in Bolivia on a hunt for a pepper that's not *picante*. Josh cringes with every curve and every pothole. After 1500 miles on some of the worst roads in South America, our suspension finally gave way. In the last hour, the truck's leaf springs – a series of thin metal bands that keep the axle from slamming into the wheel well –were snapping one at a time. At any moment, the hunt for chilies could come to a disastrous end.

Suddenly, a head pops out of the cab of the truck. Carlos Manchego, the trip's GPS guru yells to Josh, "Back there. It's two kilometers behind us." Somewhere back in that fly-infested forest, a botanist from New York once collected a wild pepper plant with a juicy, red berry and a tiny flower – *Capsicum minutiflorum*. In his collection notes, the botanist maintained that the fruit was sweet, but Josh isn't so sure about that. Earlier that week, Josh had found the same species several hundred miles away and tasted it himself. In fact, we all tasted it. We huddled on the edge of an abandoned cornfield and passed the fruits around, biting into them again and again in disbelief. It wasn't the first time this has happened. In the last five years, Josh has been shaking up the world of chili peppers.

Eight years ago, Josh wanted to test the idea that capsaicin -- the spicy compound in peppers -- prevented rodents from destroying the seeds. To do the experiment properly, he needed both a spicy pepper and an identical pepper that wasn't spicy. So, he called up Paul Bosland at the Chile Pepper Institute in New Mexico. Bosland, a reknown chili breeder, remembered one funny plant he had grown from a seed a few years earlier. It had been collected by a botanist named Hardy Eshbaugh back in the 1950s. Eshbaugh was famous for being stingy with his pepper seeds, and one day his pepper lab burnt to the ground sending his massive seed collection up in flames. By sheer luck, Eshbaugh's only remaining seeds were the most revealing ones.

Josh's experiments were a success, and countless newspaper articles where written about

the biologist who discovered why chilies are hot. But even Josh wasn't convinced. He was left wondering whether those mild chili peppers were simply mutants or if there was something more to the story. He called up Eshbaugh and asked him where that funny pepper came from. Eshbaugh pulled out his notes and said that they came from the Gran Chaco -- a vast thorny wilderness that spans the borders of Paraguay, Bolivia, and Argentina – an area some believe is the birthplace of the chili pepper. Tewksbury knew he had to go there.

The Chaco is one of the poorest and most remote regions in South America. The first paved highway in the region is less than five years old. The outlet of the primary river -- the Parapeti -- was not even known until 2001 when a British expedition attempted to descend it for the first time and found themselves stranded in the crocodile-infested Izozog Swamps. One of the last large mammals recognized by western science, the Chaco Peccary was discovered there twenty-five years ago. Indeed, there are quite a few Chaco endemics, including the Chaco guanaco and the Chaco chacalaca, which woke us each morning with its screech of a song. The Chaco is also home to some very distinctive trees like the bottle-shaped Toborochi.

The few people here live in thatch houses and cook with wood fires. At one house we stopped at a yellow lump of iguana fat dangled from the roof. The locals use it as soap. The region is also has the highest incidence of Chagas disease in the world. At hotels, we stripped our mattresses and hunted in cracks for signs of the kissing bug. Josh erected his tent atop his bed, stringing it to the ceiling with nylon climbing rope.

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"This project runs on secondary metabolites: coca, caffeine, and capsaicin," Josh once told me, proudly chewing a wad of coca leaves in his mouth. In truth, the project ran on his boundless energy. He has a kind of naive optimism that rivals Don Quixote. Though we were faced with numerous setbacks though some perseverance of character he was able to make the trip a success. (His father was a similar breed: Peter Tewksbury was the enigmatic director of *My Two Dads*, who suddenly left California for Vermont, where he became Henry the Cheeseman, a local hero who wrote a classic book about cheesemaking.)

Josh's shirts were typically inside-out or backwards. One day, biting into a cactus fruit, he proclaimed that there are no poisonous cacti. Mike Nee, the trip botanist, later told me that there are two – both native to Bolivia. Josh forgot our samples at one field site, adding two hours of drive time to the six we had ahead of us. In his scientific papers, the town of Yacuiti is spelled seven different ways. In one quixotic episode, the team once spent two days looking for one variant -- Yucariti -- a town that didn't exist.

The list goes on. We were also supposed to run a transplant experiment, but Josh's technician was only able to get three out of three hundred plants to germinate. Their scientific purpose now obscure, these three spindly plants sat in the front seat of the car like forgotten mascots.

On top of this, for some reason or another, Josh decided against bringing food with us. Food was hard to come by even in larger towns in the Chaco. Sometimes we would go without dinner or breakfast, finding a meal of canned sardines and rice at two in the afternoon. One time we rolled into a small town around midnight and found the only restaurant behind the bus station. Blackened cow intestine and organ meats sizzled on a makeshift grill. "Some of that's okay," Josh said, "but some of that I can't do."

Incredibly, none of us got sick. Every restaurant we went to had a small bowl of crushed chili pepper on the table, which is a great way to disinfect questionable comestibles. In the highlands, this pepper was often a cultivated variety, either *locoto* or *aji*, but in the Chaco it typically came from the forest.

We pull over on the side of the road and Josh walks up to a low-slung house. A man with a pockmarked face comes out, his khaki shirt open to his belly button. Josh asks if there's any *arribibi* in the area -- the local name for wild peppers. Asking locals is the easiest way to find his study populations, but it can also be misleading. Josh told me that "the line between cultivated populations and wild ones has been blurred" because local people collect wild peppers from the forest, leave the pepper plants alone when they clear new land, and they also plant wild peppers in their fields. To make things even more confusing, domesticated *aji*, which is long and pointy, grows side-by-side its wild ancestors.

The man in the khaki shirt shakes his head. *Here? No. Up the mountain. Not here.* Josh insists. "Do you have peppers without the spice?" he asks in broken Spanish.

The man just looks at Josh like he's crazy, which he is.

Josh walks to the neighbor's house, where a woman stands with a mop. She, too, insists that he must be mistaken. *No, no ullapica here.*

Undeterred, Josh busts outta there. (In Josh's parlance, "Bust out" can mean everything from entering data in a spreadsheet to climbing into a vehicle. He typically incited us to "bust out" eight to ten times a day. He had a number of other colorful expressions as well.) Josh hops over a strand of barbed wire, and climbs up a steep slope covered with dense greenery. No one else in the group cares to follow. Within minutes, the red globes catch his eye. He takes a bite from plant number one. "Not pungent," he says with relish.

We hike over to another plant. It's not pungent either. Soon, we'd tasted nine plants and not a single one was spicy. Could this species be entirely non-pungent? Josh is growing anxious. He wants to find one more. He disappears into the bush again.

Suddenly, I hear him yell, "Pungent!"

Josh thinks that almost all populations of chili peppers have both pungent and non-pungent plants, a phenomenon known to geneticists as a polymorphism. One of the few

exceptions is the North American chili pepper that we know best, *Capsicum anuum*. That single species, in part, is what has shaped the dogma of the chili pepper community. "No one thought there could be a polymorphic chili," Josh told me. In taxonomic keys, capsaicin is often listed as a defining feature of the genus. But there are close to 30 other species of *Capsicum* in the Americas, and Josh thinks most of them are polymorphic.

Polymorphisms are extremely rare in natural populations. If a beneficial mutation arises in a population, it rapidly spreads until every individual possesses it. Josh thinks the reason that capsaicin hasn't been fixed in the population is that there's a delicate balance. The only time capsaicin is beneficial is when the plants have to worry about a nasty fungus called *Fusarium* that's spread by bugs that feed on the pepper fruits. Capsaicin turns out to be an excellent anti-fungal agent and any time there's a *Fusarium* outbreak, only the spicy plants survive. But the rest of the time capsaicin seems to have a negative effect on the number of fruits a plant can produce and on the size of their seeds.

On our trip, we'd mapped out chili populations in different areas, measuring their density, counting bugs, counting the number of holes the bugs made in fruits, and, finally, tasting the pungency of the fruits themselves. The human mouth is one of the most accurate capsaicin detectors on the planet and I was not only an extra hand, but an extra mouth as well. On one painful day, we had to taste hundreds of potent peppers. You soon overwhelm your nervous system with the pain transmitter, Substance P, and can't tell the difference between a mild pepper and pungent one.

In a place like the Chaco, identifying insects can be a challenge. Josh managed to get some of his specimens ID'd by an entomologists at the Smithsonian last year, but we referred to others in more casual terms: "We've got five red butts on this plant" or "There's a yellow stripe over here." Such lax taxonomy led to the inevitable crisis: "You think red stripe and grey dot are the same thing?" Still, during the course of the trip, ecologist Tomas Carlo assiduously plotted each data point in his laboratory notebook and by the end several trends were visible: a higher density of plants meant more bugs and more bugs meant higher pungency.

One morning in the town of Charagua, I sat next to graduate student Noelle Machinki as she placed each insect on a page of her notebook. "I'm sorry, bugs," she said, "I feel kind of bad." She sliced off their heads with a razor blade and then smashed their heads into the paper. I watch as a mosaic of plant juices colors dye the page red and green, but what's most important is what we cannot see: the fungus. Back in the lab in Seattle, she'll cultivate and identify the fungus from these different populations and test whether it has evolved defenses in response to the spiciness.