Fig. 1. Author using a microscope to confirm the presence of *Sarcoptes scabiei* mites in samples collected from a euthanized black bear with severe mange.

Fig. 2. *Sarcoptes scabiei* mites collected from a severely affected adult red fox that was submitted to Penn State's Animal Diagnostic Laboratory for postmortem examination.

Mange Girl: Science Communication and Engagement within a Hunter and Trapper Community

Hannah S. Tiffin

As we drive up to the hunting club, someone approaches with a huge smile and shouts out "Hey, it's the Mange Girl. She's here, fellas!" Mind you, I didn't start my Ph.D. research with such high hopes as being known as "Mange Girl," but alas, you can't choose your nicknames.

My First Experience

As you can imagine, I haven't always been Mange Girl. The first time I saw an animal with mange was a month into my Ph.D. research on the topic. Now, two years in, I have seen more bears, foxes, and coyotes with mange than I can count, but that first bear is still seared into my memory and remains one of the worst cases I have seen. I was with the Pennsylvania Game Commission (PGC) for their yearly summer bear-trapping rounds when we were approached numerous times about a bear with severe mange near the PGC's bear traps. We set traps for her for days, and we finally caught sight of her. She was stumbling and weaving while she walked slowly away from our approaching truck. She was so emaciated that her entire jawline protruded, and every bone in her ribcage was completely visible under the thick, crusted skin, lacking the usual thick fur coat of an American black bear. She was tranquilized and humanely euthanized according to PGC protocols, as she could barely stand, let alone continue to forage or protect herself effectively. We observed flies hovering around her when she

stumbled away from the truck, and within minutes of her euthanization, calliphorids were everywhere. This was an adult female black bear, and she was less than half my weight, at barely 50 pounds (Fig. 1)—not what you would imagine for an animal as iconic as the American black bear.

To confirm that sarcoptic mange was the cause, I scraped her skin with a scalpel to extract the microscopic mites that cause this disease from their thickened burrows. I placed the skin scrape on a slide under a microscope that I erected on the tailgate, and within seconds, I saw movement. Tons of round, tiny creatures with grasping jaws and flailing legs appeared under the scope (Fig. 2). The roundness of their bodies made them appear almost cute and even harmless, until I looked down at the absolute carnage left in the wake of their lifestyle: living and burrowing into the flesh of their host, this emaciated black bear.

The Mite

Sarcoptes scabiei (L.), the mite that causes mange in animals and scabies in humans, has been around since biblical times, and it's thought to be the first disease of which humans knew the cause (Roncalli 1987). However, although mange is an ancient disease, there is still much to be learned about the mites that cause it. This is primarily due to their small size, difficulties involved in collecting large quantities, and their parasitic life histories, making them notoriously difficult to work with in a lab (Arlian and Morgan 2017). Recent research has posited that these mites started off causing disease in humans, and that humans were responsible for their introduction to domestic animals, with the mites then introduced to wildlife (Pence and Ueckermann 2002). Whatever the evolutionary method of host adaptation and species transmission, the mites are now responsible for causing disease in more than 100 different mammals worldwide . . . but get ready for the really weird part. Although S. *scabiei* can infest humans and cause the disease known as scabies, which requires medication to kill the mites and allow recovery, humans are typically able to recover within a matter of weeks, *without medication*, if infested with *S. scabiei* mites from an animal with mange. Yes, you heard that right: same mite, different disease and different ability to recover. The difference is at the subspecies—also known as variant (var.)—level. I won't get into the many controversies that exist around the systematics of this in "mite land," as there is little genetic difference, if any, between many of these different variants. If you are interested, see Bornstein et al. (2001) and Niedringhaus et al. (2019) for brief summaries of these different viewpoints. The main difference between *S. scabiei* variants is that of their preferred host, after which the variants are named: for example, var. *hominis* causes scabies in humans, and var. *canis* causes mange in canids (Bornstein et al. 2001, Niedringhaus et al. 2019). This raises a question: if there is little genetic difference between these variants, how do they have different preferred hosts, and how do hosts have different responses to these different variants?

No one really knows. Now, here is where it's fun to be an entomologist on this project. (Okay, the whole project is fun. I get to work on live bears, after all!). As an entomologist, I focus on the strangeness of this disease from the mite's point of view. What changes must take place to enable the mite to adapt to these different hosts?

Back to the Hunting Club

Coyotes and red foxes have long been afflicted by sarcoptic mange in North America. However, black bears with signs of mange were only first reported in Michigan in the 1980s, but it still remained a rare disease in black bears until the 1990s, when reports became more frequent in Pennsylvania and then from surrounding states in the Northeast (Niedringhaus et al. 2019). Spillover has become a more common term in the public eye since the COVID-19 epidemic began, but it's a term with an ancient history, and *S. scabiei* may be among the oldest known cases of spillover among species.[1]

Although my research on mange began with a focus on Pennsylvania's black bears, it soon "spilled over" into research on

Fig. 3. Author confirming the presence of *S. scabiei* from a coyote at the annual Mosquito Creek Coyote Hunt in Pennsylvania, the largest predator hunt held in the northeastern United States.

animals historically affected by this disease—coyotes and red foxes—for comparison to the newly affected black bear species. This brings us to why I was at the hunting club that day and how I became known as Mange Girl (Fig. 3). To study coyotes and red foxes afflicted with sarcoptic mange, I first had to find these animals, which is when I became firmly entrenched in the belief that science communication and engagement is a two-way street. I attended fur shows and auctions and predator hunts, and I plastered my study across social media platforms. I received a *huge* response from Pennsylvania's trapping and hunting communities. By listening and participating at these fur auctions and hunts, I learned of another interesting, and as of yet unexplained, facet of *S. scabiei's* host preference. Not one person that I spoke to had seen or heard of a grey fox with signs of mange . . . only red foxes. I slogged through the literature to confirm this, and lo and behold, they were right: very few cases of sarcoptic mange have been reported in grey foxes. Not only was I able to gather samples from this active community of trapping and hunting enthusiasts, but they also led me to another research question and propelled my study far and wide. I received calls from as far away as Wyoming in response to my call for samples from coyotes and foxes affected with mange.

This hunting community has often asked me how they can help with the study and whether I can provide additional education regarding mange in terms of keeping themselves and their animals safe. This has led to an extremely productive outlet for disseminating information not only about this aspect of the study, but also for tick bites and Lyme disease—a huge issue for Pennsylvanians. While interacting with this community, I have been asked numerous times about how they can keep themselves, their families, and their pets safe from tick bites. Critically, this has also presented opportunities to dispel information that may not be grounded in facts to an audience willing to listen. I did this in a low-stakes environment that has enabled the public to approach me with questions, concerns, and comments that they may not otherwise have felt inclined to share with the scientific community.

Lessons Learned

Science education is often approached as unidirectional, with scientists there to provide information and the public there to listen to this information. However, particularly as community science (also known as citizen science) initiatives have become more popular, it has become clear that the public can play a critical role in gathering and disseminating data. This not only helps scientists in collecting data and contributing to large-scale research initiatives; it provides a platform for public engagement with scientists and grants the opportunity for more open dialogue with the public . . . something we could all be *mitey* proud of.

In response to frequent requests from the trapping and hunting community for more information and updates on my research, I have created a website that does just that, as well as providing information on the One Health concept that fuels my passion for research and inquiry. As a shameless plug, please feel free to visit my site and submit cheeky comments on how incomplete it is, or if you're feeling generous, sign up to contribute to my new One Health blog section at bearlyfamous.weebly.com.

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Endnote

[1]Spillover is often used to refer to pathogens that were originally found in non-human animals and, due to a change in circumstances, have transferred, or "spilled over," into human hosts. However, it can also describe pathogens that have transferred between non-human animals, or from humans to non-human animals; I use both senses of the term in this article.