

***Baylisascaris procyonis* Roundworm Infection in Child with Autism Spectrum Disorder, Washington, USA, 2022**

[Announcer] *This program is presented by the Centers for Disease Control and Prevention.*

[Sarah Gregory] Hello, I'm Sarah Gregory, and today I'm talking with Dr. Beth Lipton, a public health veterinarian for the Washington State Department of Health. We'll be discussing a case of *Baylisascaris procyonis* roundworm infection in a child in Washington.

Welcome, Dr. Lipton.

[Beth Lipton] Good morning. Thank you for having me. It's a pleasure to be here.

[Sarah Gregory] What is this parasite? In all my years of doing this podcast, this is only the second time it has been discussed, and that was years ago.

[Beth Lipton] *Baylisascaris procyonis*, commonly called 'raccoon roundworm', is a species of worm that parasitizes the small intestine of multiple species. And most people are familiar with roundworms in other animals, such as our pet dogs and cats, which is why we deworm them as puppies and kittens and regularly throughout life. So these *Baylisascaris* roundworms are commonly found in raccoons.

[Sarah Gregory] Other than raccoons, are there other hosts?

[Beth Lipton] Yeah. So the primary or definitive host of the raccoon roundworm is the common raccoon. It's also known as *Procyon lotor*, and the definitive host means that the worm completes its lifecycle within the raccoon. So the raccoons have adult worms in their intestines that are able to mate and produce eggs, and these eggs are then found in the feces of the raccoon. Dogs also can be a definitive host, but it's not extremely common. And another interesting study determined that kinkajous can also be a definitive host for this roundworm.

[Sarah Gregory] And where in the United States are they found?

[Beth Lipton] Infected raccoons are found throughout the United States. It's believed that there's higher prevalence of infection in the raccoons in the Midwest, the Northeast, and the West Coast.

[Sarah Gregory] I just learned recently that rabies does not really infect raccoons on the West Coast much, so I guess I'm a little surprised that these roundworms do. And one has nothing to do with each other, right?

[Beth Lipton] That's correct. There are different terrestrial or mammals on four legs walking around that do carry rabies in different parts of the United States, and yes, the raccoon out in the West is not a concern for rabies. But in some parts of the country, there are more than one reason to stay away from raccoons because rabies is obviously a very serious and pretty much always a fatal disease. So generally, the message is don't touch wildlife and stay away from wildlife for multiple reasons.

[Sarah Gregory] So why are raccoons the primary host?

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[Beth Lipton] Well, parasites depend on another living organism for their nutrition, and raccoon roundworms have evolved to be able to reproduce in raccoons while the raccoon rarely gets sick—they're usually their normal, healthy selves and live a normal life. So this is advantageous for the worms to keep their population going.

[Sarah Gregory] And what percentage of racoons are infected? Do we know this?

[Beth Lipton] There are some studies that give us some ideas of what that is. So in the United States, as I mentioned, it's very common for raccoons to be infected, and the prevalence or the proportion of infection in raccoons at any given point is reaching 70 to 80 percent in the Western United States. So there is likely some geographic variation in the prevalence of infection, but really it's just best to assume that all raccoon feces is infected if you're attempting to clean it up.

[Sarah Gregory] And how do these animals get infected with the roundworm in the first place?

[Beth Lipton] So raccoons can get infected by ingesting eggs from the environment, such as during foraging for food, feeding, or grooming. Also, several mammals and birds can serve as what's called an intermediate or paratenic host, and this means that the infection by the larval stages occur in these animals, but the worms can't mate or complete their lifecycle in these hosts. So we have mammals or birds out in the environment that ingest eggs, the eggs hatch, and then the larva go through what's called the gut wall and will migrate into various tissues where they form cysts. And then the raccoons, which are omnivores, may eat these animals (such as rodents and small birds) and become infected.

[Sarah Gregory] Besides being completely gross, how dangerous is it?

[Beth Lipton] So unfortunately, people can also become intermediate hosts when they accidentally or inadvertently ingest these roundworm eggs. And reported infections in people are very rare. There are only 37 known cases in North America—there have been 33 in the United States and four in Canada. But the consequences of infection can be very severe. For example, of these 37 known cases, seven or 18 percent resulted in death, and all but two of these cases describes substantial neurologic symptoms such as seizures, difficulty walking, sleepiness, or confusion. Several studies also indicate that certain people are probably exposed more than is realized, such as a wildlife rehabilitator or others who interact with raccoons or their environment. And in these studies, people showed evidence of being exposed to the parasites—so they had antibodies on a blood test—but they were never sick or diagnosed with infection. And these infections are called subclinical in that any signs a person experienced weren't severe enough for them to seek medical attention or the infections were asymptomatic, so that a person actually never had any signs. So although there are very few reported cases, there is suggestion that more people are exposed and potentially even infected than we realized.

[Sarah Gregory] Okay. So they are exposed, but how would they actually get it? And I think you just mentioned some groups that are most likely to get it, but how?

[Beth Lipton] So a person must swallow eggs to get infected. These eggs are found in raccoon feces or in areas where raccoon feces were previously, as overtime the feces will deteriorate but the eggs will remain—so this could be in a sandbox, a garden or planting area, or on the ground in a yard. So a person gets this fecal material or sand or dirt with the microscopic eggs on their hands or under their fingernails and then puts their hand or fingers in their mouth, either without washing their hands or not washing them well enough. Because it generally requires the hand-to-

mouth contact to get infected and is also related to poor hand hygiene, young children and people with developmental disabilities are known to be at highest risk of infection.

[Sarah Gregory] Okay. So tell us what happens. What's the process as it goes through a person's body once they've ingested these eggs?

[Beth Lipton] If the eggs are infective, which means that they have been in the environment for at least two or more weeks, the person swallows them and then they hatch into larvae in the intestine. They then go through this gut wall and will then move or migrate throughout tissues in the body. The majority of these larvae will go into muscle tissue, while some of the larvae might be something called larva migrans, where the larvae end up moving through the organs, such as the liver or lungs or go to the eye or go to the central nervous system and brain. And these situations are known as visceral ocular and neural larva migrans, and the larvae cause a lot of damage when they do this.

And raccoon roundworm larvae are especially large and tend to be invasive, and they most commonly migrate to the brain in the cases that have been described. And it seems that the severity of illness is related to a few things, such as the size of the person infected, the number of eggs ingested, the extent of a person's inflammatory response, in addition to how these worm larvae move through the body. So symptoms can appear as early as one week after ingestion of the eggs.

[Sarah Gregory] And are there tests to identify it?

[Beth Lipton] There are no commercially available tests for raccoon roundworm infection specifically. The CDC does have a test that can be arranged through public health in cases of suspicion for infection. However, there are laboratory findings that tend to be indicative of parasite infections in general, such as something called eosinophilia in the blood or cerebral spinal fluid. It's a certain type of cell our body produces to parasitic infection. An MRI often has characteristic findings as well. And also, the raccoon feces can be tested for the eggs, and this could help confirm that a person might have been exposed in a specific area.

[Sarah Gregory] So no specific test...what are some of the other difficulties in diagnosing this infection?

[Beth Lipton] Diagnosing infection can be difficult. It's best if people seek medical care right away if they know or suspect that they or their child might have been exposed to raccoon feces. People might not realize they've been exposed. We have raccoons in many residential areas, really everywhere. And this really can, you know, increase the proximity and potential interaction with raccoons. There's also a one-to-four-week incubation period for infection which means that symptoms may not start until four weeks after exposure, so this could cause some difficulty in characterizing potential exposure location for a person.

[Sarah Gregory] Clearly, it's very bad once it's in the body, but is it treatable and are these symptoms reversible?

[Beth Lipton] Treatment is most successful when given as soon as possible, ideally within three days after exposure. So something called prophylaxis—giving the medication before you actually know if a person is infected—is recommended. So if somebody has had known or suspected oral exposure to raccoon feces, it is recommended to get prophylactic treatment with a dewormer. Treatment with dewormer and steroids during the early stage of infection might also

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reduce serious tissue damage, although no treatments are totally effective. And symptoms aren't really reversible, but infected people may improve over time.

[Sarah Gregory] So let's go back to kids and small children getting this. How does it happen? Sandboxes? Are there other places that they can pick up this worm?

[Beth Lipton] Right. So raccoons defecate in communal locations called 'raccoon latrines', and these latrines are often close to areas of human activity or living spaces such as in yards, near playground equipment, on decks or roofs, in attics or sheds, and as you mentioned, they may use sandboxes as well. We really want people to keep them covered when they're not being used. So these feces can be in the same areas where children spend time and play, and then they may touch or pick up dirt or sand and then put their fingers in their mouth.

[Sarah Gregory] So the raccoons like to make these latrines near where people are. Why?

[Beth Lipton] Raccoons are attracted to food and water sources, as well as places that provide coverage or protection. These latrines will usually be around the areas where they spend most of their time. I'm not sure how they choose which latrine to frequent, but we do know that these latrines might be used by multiple raccoons for over a year period of time.

[Sarah Gregory] Is there a safe way to clean up these raccoon latrines? I would imagine that the surrounding area would be infected also.

[Beth Lipton] The best and safest time to clean up a raccoon latrine is to do it right away, as it does take about two to four weeks for these roundworm eggs to become infective. If it has been longer, however, or if you are unsure how long the latrine has been there, you want to take certain extra steps for protection. These infective eggs can remain in the environment for years and they are very resistant to being killed by disinfectants, so they must either be exposed to very high heat or physically removed from the area. People should wear gloves, rubber boots that can be cleaned, and a respirator-type mask if cleaning up in a confined space. The CDC does have a great fact sheet about how to clean up a latrine and the surrounding contaminated area. It also helps to know what raccoon feces looks like so we can avoid them. They are usually dark and tubular, and they often contain undigested seeds or other food items that have been part of the raccoon's diet.

[Sarah Gregory] I know fox poop is pointy at both ends. Is there some distinctive mark like that on the raccoon poop? You said tubular, but...

[Beth Lipton] Yeah, that's a good question. I've seen various raccoon feces in my own yard as well, actually, and I wouldn't call it pointy at both ends. And I would also say that there's really a variety of what it can look like, but it generally is a few inches long (two to four inches long), not particularly pointy. It can be dark, sometimes it has a pungent odor. And again, you can see various seeds or nuts, depending on what fruits or other yummy eating the raccoon has had access to.

[Sarah Gregory] Is there a way to stop these raccoons returning to the same spot, the same latrine, once you've cleaned it up?

[Beth Lipton] Yeah. Cleaning up the latrine safely and promptly does help the raccoon move on to a different location. But there are also steps people can take to discourage raccoons from living in around our homes or yards or parks to begin with. We want to make sure that they don't

have access to food—so, not leaving out pet food; cleaning up berries and fruit from the ground; keeping your trash containers very tightly closed; closing off access to attics, basements, and under your porches; removing fish ponds (they'll eat the fish and drink the water); eliminating other water sources; removing bird feeders (that's also a good way to prevent rats from being around your yard); and clearing brush so they cannot make a den.

[Sarah Gregory] I think you're going to make a lot of people sad saying remove your bird feeders.

Tell us about your study—what happened and how you became aware of this child.

[Beth Lipton] So we learned about a child who tested positive on that testing at CDC for raccoon roundworm after having symptoms that were consistent with infection and being hospitalized. At the time, there was no known exposure to raccoons or raccoon feces. However, the child has autism spectrum disorder and was known to have pica, which is a condition where one puts non-food items into their mouth. So we conducted a public health investigation to determine likely areas of exposure and provide education to the family. We also did an environmental investigation at the family's property and discovered a raccoon latrine at the base of a fir tree. And samples from this latrine tested positive for the *Baylisascaris* eggs. The family also recalled that the child was near that tree and put material from the ground in their mouth prior to the start of symptoms. It just wasn't a detail they remembered when the symptoms started, and they had never heard about raccoon roundworm.

[Sarah Gregory] Do we know anything about the child's recovery?

[Beth Lipton] Within a short time after treatment, the child did begin improving. Two months after infection, which was at the beginning of this past school year, the child was taking the bus and going to school. There were still some symptoms, but they were continuing to improve. So very good news for this child.

[Sarah Gregory] Oh yes, that is good news. What are the most important highlights of this study?

[Beth Lipton] I think our study highlights the populations at risk of infection—children and people with developmental disabilities—as well as the benefit of doing an environmental investigation to try to confirm raccoon activity and provide tailored education to a family. This study also stresses the importance of immediate treatment in cases of known or suspected exposure to raccoon feces. This might help prevent disease, which is very important in this infection as the outcomes can be very severe, even resulting in death. Finally, for people who have consistent laboratory and clinical findings, it is very important for doctors to consider this infection, even if exposure to a raccoon wasn't known to happen.

[Sarah Gregory] Do you have any public health suggestions to address these infections? Like you mentioned that the family had never even heard of roundworms, so should there be more communication plans, public awareness campaigns, that sort of thing? What do you think is needed?

[Beth Lipton] Yeah, exactly. I do think the main thing is increasing the awareness of raccoon roundworm and its potential for infection, particularly among caregivers and parents of children and people with developmental disabilities. This infection is preventable, and there are a lot of great resources about how to discourage raccoons from your property, how to identify raccoon *Baylisascaris procyonis* Roundworm Infection in Child with Autism Spectrum Disorder, Washington, USA, 2022

feces, how to safely clean up a raccoon latrine. So although documented infections are rare, I think it's important for public health to help educate people to prevent this disease.

[Sarah Gregory] And I know you already touched on this, but what would you like clinicians to know and do?

[Beth Lipton] I think if clinicians are aware of this infection and its clinical and laboratory findings, they will be more likely to ask about raccoon exposure and also more likely to provide prophylactic or early treatment to help prevent these more serious outcomes. Since it can be difficult to get a diagnosis and as there's no commercially available testing, I think it's really important to consider the possibility of this infection early on.

[Sarah Gregory] Dr. Lipton, tell us what you do at the Washington Department of Health and what you enjoy about it most.

[Beth Lipton] Yeah, sure. My position is the state public health veterinarian for Washington State. I focus on prevention of zoonotic and vectorborne diseases—diseases that pass between animals or vectors (such as mosquitoes or ticks) and people—and also how to improve human health by considering the environments and conditions we share with animals such as climate change impact, antimicrobial resistance, healthy water sources. I really enjoy this work because it uses a One Health perspective—the idea and approach that uses a collaborative effort of multiple disciplines working together to improve the health of our ecosystem, which includes humans, animals, plants, and our environment. It recognizes that everything is interrelated, interconnected. I believe a One Health approach is really needed to solve the world's most urgent and emerging health challenges that we face today.

[Sarah Gregory] Between bad bacteria, viruses, fungi, parasites—which all seem to be increasing rapidly—is there anything in particular that worries you the most?

[Beth Lipton] Well, thankfully there are simple steps that everyone can take to prevent many infections and diseases such as good hand hygiene, covering their cough, practicing proper food safety, getting vaccinations, knowing how to safely interact with animals. There are some infectious diseases that have the potential to cause a pandemic, and we can't ignore this potential. The One Health approach that I just mentioned is really necessary to improve overall disease surveillance, research, planning with all of our partners, creative solutions, even engaging with citizen science. So I don't think I spend a lot of time worrying about emerging diseases. But I think my kids would say that I talk about infectious diseases too much.

[Sarah Gregory] Yes, I think my kids think the same thing. Thank you so much for taking the time to talk with me today, Dr. Lipton.

[Beth Lipton] Thank you very much for having me.

[Sarah Gregory] And thanks for joining me out there. You can read the June 2023 article, *Baylisascaris procyonis* Roundworm Infection in Child with Autism Spectrum Disorder, Washington, USA, 2022, online at [cdc.gov/eid](https://www.cdc.gov/eid).

I'm Sarah Gregory for *Emerging Infectious Diseases*.

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