

Eric Moody:

Imagine a forest once filled with the cacophony of life suddenly going silent. Rachel Carson wrote about it in *Silent Spring*. While DDT usage has dropped dramatically, forests around the globe are going silent again because of a new threat. Global amphibian declines in the neotropics. A chytrid fungus is wiping out entire amphibian communities as it moves across the landscape. Younger generations will never even know what these forests used to sound like, what wonders of biodiversity were lost. In this special episode of the *Making Waves* podcast, we examine what the consequences of these declines are and what is being done to save these threatened amphibians.

Eric Moody:

You are listening to *Making Waves*, fresh ideas and freshwater science. *Making Waves* is a bimonthly podcast where we discuss new ideas and freshwater science and why they matter to you. *Making Waves* is brought to you with support by the Society for Freshwater Science.

Eric Moody:

This is Eric Moody with the *Making Waves* podcast. This month, we'll have three different people talking to us about various aspects of amphibian declines and how their work fits into this broader issue. We'll talk with Jonathan Colby, who is a National Geographic Explorer and the director of the Honduras Amphibian Rescue and Conservation Center. We'll also talk with Nikki Roach, who's a PhD student at Texas A and M University and a Fulbright Fellow currently studying amphibians in Colombia. And finally we'll talk with Matt Wiles, who is a professor of zoology at Southern Illinois University. We'll hear from all three of these people throughout the podcast today. Before we can talk about what impacts these amphibian declines might have, we first have to understand what role tadpoles in these tropical stream ecosystems. Let's start with Matt Wiles, who's done a considerable amount of work on this. What type of functional role do tadpoles have in stream ecosystems?

Matt Whiles:

Well, in the neotropics and in healthy streams, tadpoles are quite diverse. We tend to think of them as just algae grazers, and a lot of them are, but they're feeding on biofilm. Some of them are suspension feeders, some of them are filter feeding and some of them are burrowing in organic deposits. And so there's actually a little more trophic or functional diversity there than a lot of people realize. And with the loss of those things comes a loss of a function and processes. And so the main role in the streams I work in, I mean the most noticeable things that tadpoles are doing is removing or grazing biofilm and petrified and bioturbating material. So they're sort of vacuuming off sediments from the rocks and such and exposing biofilm underneath that they're grazing on. And so that's, I think the main thing that's lost with the decline.

Eric Moody:

What kind of differences do you see in streams where the amphibian community is intact versus streams where the amphibian community has collapsed?

Matt Whiles:

You actually can tell the difference between some of our study sites that still have amphibians and where the declines have occurred. The main noticeable difference is a difference in the biofilm on the rocks at other substrata and in post declining streams we see a buildup of a lot of senescent, diatom material, a lot more organic sediments and things that aren't being removed by tadpoles feeding and

bioturbating materials in the stream. The other really noticeable thing is the loss of frog calls, a difference in the sound environment along a stream. Pre declined streams, especially in the evening, you hear a lot of different species of frogs calling and then that's, of course, gone after a decline.

Eric Moody:

One way that researchers have studied the impacts of these amphibian declines is by investigating sites before the decline occurs and watching as the ecosystem changes following the loss of the frogs and tadpoles. They've been able to do this because the chytrid fungus pathogen responsible for these declines has spread through Central America and the Andes in a somewhat predictable fashion. So to understand how this pathogen spreads, I asked Jonathan Kolby about his work on how the chytrid pathogen can be transported among sites.

Jonathan Kolby:

There's a couple of different ways that it can move across the land. In Honduras, I found that as young frogs were metamorphosing from tadpoles into land frogs that as they emerge from the water, they very frequently carry chytrid with them and leave a trail of chytrid in the wetness that they leave on the leaves. That's a whole lot of leaves. So basically, if you're a baby frog and you're heavily infected with chytrid and you're perched in a terrestrial area, after you walk away from that spot for some amount of time, that area is now positive for chytrid. Especially in these areas that are shady and humid, as long as that doesn't dry out, it could be made infectious for a few days, if not longer. And if you're a terrestrial species that never goes to the water but you're sitting on vegetation near the water, that might be how some of these salamanders and other terrestrial amphibians are getting chytrid without ever entering the water.

Jonathan Kolby:

I also was curious about why tree frogs, some of these bromeliad frogs, way up high in the trees, again, never come to the ground, but they live inside bromeliads that collect rainwater and they also had a fair bit of chytrid. That gave us the idea to start looking at weather and if rain and wind could potentially carry chytrid. I actually did find stuff, evidence of chytrid in rainwater that we sampled in the rainforest in Honduras.

Eric Moody:

Indeed, the chytrid fungus is a serious threat to have amphibians in many regions, especially throughout the neotropics. However, it's not the only threat that these species face. I talked with Nikki Roach, a PhD student at Texas A and M University about her research and Colombia and some other threats that amphibians are facing in the region where she's working.

Nikki Roach:

So I'm working in the Sierra Nevada, Santa Martha Colombia, which is a isolated mountain range on the Caribbean coast. And it's actually a mountain range that's older than the Andes. Because of its isolation, it has high levels of endemism, which means species that are only found on this mountain, and it actually contains every single ecosystem found in Colombia is contained in this one mountain range. So we go from coral reefs and the ocean here all the way up to the snowy peaks. It's a really amazing place to study biodiversity. It was actually ranked the world's most irreplaceable protected area in a 2013 study in science and that was based largely on the amphibian endemism in the region. So there's 47

described species of amphibians here and about 17 of them are endemic. But when we go out and do our surveys, we find undescribed species every night, almost.

Nikki Roach:

There's just a lot that's unknown about this area and there's some really cool amphibians and it's actually really interesting. Some of the species here are resistant or it just hasn't spread here, but it's a stronghold for a certain genus like *Atelopus*, which are some of the frogs that have been hit hardest by chytrid. Chytrid may not be the number one concern right now here, but actually climate change is a really big concern because of its isolation, because the species that occur here can't move anywhere else, really. Climate change is probably the number one concern for amphibian species. So I'm excited about my own research because I'm getting to go out and look for the community of amphibians that live here and also monitor thermal gradients across an elevational gradient as well. Hopefully we'll find out more about the vulnerability of these species and be able to do some serious conservation planning in the region with local communities, local universities and the parks service as well.

Eric Moody:

Knowing that amphibians in these regions face so many threats, the question that we have to ask ourselves is what can we do about it? I first talked with Nikki about the efforts that she's leading to work with local communities and farmers and the region she's working and how these types of partnerships can lead to successful conservation of threatened species as well as improve the livelihoods of the people who she's working.

Nikki Roach:

Conservation is usually more about people than it is about the animals. I really am a people person and I love working with communities and so when I was coming to Colombia I knew that I wanted to create a project that involved local communities and coffee's huge and Colombia. It's big in the Sierra Nevada. It's a main economy for farmers here. And it also occurs in a zone of high biodiversity and lots of amphibians are also found in the same areas that coffee beans is being grown and clean watersheds are also really important to coffee. So there's this interaction between where amphibians are occurring and where coffee is being grown.

Nikki Roach:

Actually, just by being here and working with the university that I work with, I got linked up with Federacion de Cafeteros, which is a NGO based out of... well they're all throughout Colombia, but the office here in Santa Marta, I work with them and they have extension agents that work all over the mountain in different coffee-growing towns. I've been working closely with them to develop... we're going to develop a questionnaire that we made for the coffee farmers so we've been doing some informal interviews and focus groups. Try and better understand the history of coffee, what people value, the perceptions of biodiversity and climate change. Some of their families have lived on these farms for years.

Nikki Roach:

In one of sites that I go to often, we were talking with the community and they were like, "Yeah, temperatures have risen in the past 30 years, at least four or five degrees." And this is Celsius, too. But that's a huge jump. They're like, "We used to be so much colder, the streams used to freeze over. They

never freeze over anymore." They say it hasn't affected their coffee now, but just having that such stark change in 20 or so years, what's going to happen in another 20?

Nikki Roach:

I'm concerned not only for the products, but also for the livelihoods of these people. I mean, their life is dependent on their coffee and they're not going anywhere. So we have to work with communities as well, to do effective conservation in the region. And yeah, I think it's really important and I really enjoy it and I'm hoping that we'll be able to work towards sustainable initiatives, not only to help with amphibians but just to conserve watersheds in the region, which is beneficial for fish and vertebrates, the mammals, the flora as well here. Keeping the watershed clean is probably one of the most important things for the people and for all the flora and fauna in that area.

Eric Moody:

I next talked with Jonathan Colby, the director of the Honduras Amphibian Rescue and Conservation Center or HARCC to find out what exactly they're doing at Cusuco National Park in Honduras to directly on the ground build up the populations of some of these threatened amphibian species.

Jonathan Kolby:

Our goal is to support the persistence of critically endangered frogs in their natural habitat despite the presence of chytrid. Because the main challenge that we face is that we're basically running out of space and time in the wild. As chytrid continues to spread and we haven't been able to stop it and these species just continue to be exposed. So we have found, through about 10 years of field surveys, that looking at all these different life stages of particular species of frogs, it seems that there was a dramatic change in their ability to persist with chytrid between when they are young products coming out of the water versus when they have reached adulthood, if they are fortunate enough to reach adulthood.

Jonathan Kolby:

So HARCC's goal is basically to do a headstart project where we collect large numbers of these baby frogs before they succumb to chytrid in the wild, and we can bring them to our biosecured facility in Honduras, fix them up, cure them with medications or heat, whatever works best for these particular species, and then just raise them till they become stronger adults and then reintroduce them. Basically we believe that by continuing to do this that we can help rebound the population size of adults that are naturally breeding, which will then continue to reproduce and support their species in the wild and try to overcome this bottleneck because of this new threat of chytrid.

Eric Moody:

So are you doing any captive breeding or are you just going to be raising frogs that were already born in the wild?

Jonathan Kolby:

We're, we're going to do both. It's kind of like a long-term, short-term vision where in the short term, we want to get as many frogs living in the wild as possible so that natural selection can continue doing its thing, continue to looking to the offspring for animals that will evolve in resistance and you need lots of animals to do that.

Jonathan Kolby:

That's why headstarting is a faster way towards increasing the population size of adults. But at the same time we still acknowledge that there's a lot of other oppressors happening. There's illegal deforestation in this site, there's climate change affecting the weather patterns, pollution and there's still a lot of things that can just make these species blink out and go extinct in addition to chytrid. So we will, in parallel, have a captive breeding assurance colony in case suddenly there aren't animals to headstart with anymore and in case we become the only source of animals to put back. So there will be a side by side project.

Eric Moody:

So when tadpoles have been reduced in biomass in these systems, has this role been filled by any other animals or is it essentially just gone in these systems now?

Matt Whiles:

So one of the things we were looking at is, would there be functional or ecological redundancy and we don't see it. We don't see invertebrates or anything else building up populations or responding to the loss of the tadpoles. It's just like this kind of void and then you lose the tadpoles, at least in the timeframe we've been looking at, we do not see anything like that.

Eric Moody:

So if these impacts are fairly long lasting, the role of tadpoles is essentially not been replaced by anything else, then what would you say is the reason why this is really important in terms of what's going on in these streams?

Matt Whiles:

Well, one of the things that we've documented in one of the long-term sites we've worked in is reduced nitrogen uptake. So essentially longer spiral length. In that part of the world, that's not a huge issue because there isn't a lot of nitrogen deposition there. But it certainly has implications for streams around the world with the loss of consumers, the loss of the nutrient uptake capacity is, of course, a huge issue in terms of water quality and landscape management. That's one thing that I think... one aspect of this that is concerning. The other is the loss of cysteine generation and the decline in the quality or nutrient content of that cysteine. We all know that cysteine assessment is a fuel for downstream food webs and filter feeders and so forth. That's something that we have not been able to look at yet, but it's certainly conceivable that there are downstream impacts on particularly filtered feeding communities because of the decline in cysteine concentrations and the reduction in cysteine quality associated with the loss of the tadpoles.

Eric Moody:

With so many amphibian experts featured here on this podcast, I had to ask them, what is your favorite species of amphibian and why?

Jonathan Kolby:

Oh, my favorite amphibian, that's so hard to say. I usually say that my personal favorite amphibian is the Cusuko spike-thumb frog. It's one of the three species that HARCC is working to protect. It's only found in a few rivers and this one little rain forest and he's this little brown frog with black spots and around the black spots it's like fluorescent green and they're just super cute and charismatic. I would go with them.

Eric Moody:

Sounds like a good pick.

Jonathan Kolby:

It's a good frog, it's a really good frog. But there's a lot of good frogs out there, but I recommend this one.

Nikki Roach:

I'm a big fan of the Centrolenidae family, the glass frogs. When I was first in Colombia, we found a few and I just was so amazed that you can see their organs through their abdomen. And to me that's just such a testament to wow, this species. It is so impacted by its environment that there's just this thin layer of skin, separating an animal from its organs, any chemicals in the water, anything. It really makes you see, literally, see the vulnerability that amphibians may have. There's an *Ikakogi Tayrona*, which is one of my favorite frogs. They call it the Kermit the Frog frog because that's kind of what it's based off of, but it's... just little eyes, its face, every time I see it and it has these really long legs and when you pick it up, its finger is like clinged to your fingers. I've had a couple that just sit on my thumb, just totally at ease and that's kind of the fun part of working with these animals is being able to handle them.

Nikki Roach:

Obviously, I love the *Atelopus* species, too. I would say I love this *nahumae*, which is one of the forest-dwelling *Atelopus*. It's found in streams too, but it's a little more difficult to find. That's also a favorite of mine. They have these bright orange stomachs and they have these faces that look really serious all the time.

Eric Moody:

Finally, these stories about amphibian declines, species being lost, ecosystems being irreparably altered can be depressing, but sometimes this work has a positive aspect as well. I talked with Jonathan Colby about the time that he discovered what turned out to be a species that had long been considered extinct.

Jonathan Kolby:

When we started working there, when I first started doing these surveys there in 2006, there was already a species that had been declared extinct from this site in particular. It was locally extremely abundant up until the mid-1980s and then it just vanished. Interestingly, I did, in the course of this fieldwork, rediscovered that species, which was incredibly exciting, but still difficult to figure out what that means for the species itself. But I did find one individual in 2008 after it was missing for a couple of decades and then I did find a second one five years later. It took me five years to find another one, but I did find another one. I was pretty sure I was hallucinating. Yeah, I definitely did a double-take and the very first time I saw it, I didn't know it was this species per se, but I knew it was something that was not in the guidebooks that was really important to catch and I totally missed it, like really, really bad, came up with a handful of mud. I totally missed it.

Jonathan Kolby:

I went a whole year wondering what the heck was this weird little frog that I'm pretty sure was important and then a whole year later I had one chance to go back to that same site and I saw it again.

Literally on the same rock. I was able to get confirmation that, yeah, indeed this was that missing species. But at the same time we still need to take a step backwards and look at the big picture of the situation. It's still quite grim because these are just a few species here and there and we're looking at hundreds, if not thousands, of species locally that are severely threatened by this pathogen. But it's still really exciting and encouraging to see these species resurface and it does provide hope that some of these species could see the light again.

Eric Moody:

You've been listening to the Making Waves podcast brought to you with support by the Society for Freshwater Science. For more information on this speaker, the Making Waves podcast, or the Society in general, please visit us on the web at the Society for Freshwater Science webpage. Tune in next time for another fresh idea in freshwater science.