Isaac:

(Narration) Hello! Welcome to Carry The One Radio. My name is Isaac and I am a new producer here. I am super excited to bring you another episode of our Young Scientist Spotlight Series where we meet with scientists across the globe and talk about all the exciting research they are doing. Today, I have the pleasure to share my conversation with Dr. Roshmi Sarma. She is an ecologist at the University of New South Wales, Australia with a serious passion for amphibians. Her work focuses on figuring out how invasive cane toads in Australia are able to evolve so quickly and take over the local ecosystem. She also shared with us some *interesting* strategies that people have come up with to manage these cane toad populations.

Stay tuned to learn about her “ribbetting” research on cane toads and much more!

[CTOR tag]

Isaac:

Welcome. First and foremost, can you tell us a bit about yourself, where you are right now and what are you currently doing?

Roshmi:

So I'm Roshmi and I've recently completed my PhD in biological sciences from the University of New South Wales, Australia. Currently, I'm working as a research assistant with my supervisor, associate professor, Lee Ann Rollins in the University of New South Wales and working on my cane toad project that I had as my PhD project. I'm from India. I grew up in Delhi and I've done my bachelor's. I have an engineering degree in biotechnology and I have another master's degree in environmental science and engineering.

Isaac:

Can you tell us what cane toads are? Why do you study them and why is there all this hate surrounding them?

Roshmi:

So a little background about the cane toads: they are native to central America. And then they were transported across the world for different reasons. And in Australia, they were introduced as biocontrol agents in 1935. Since 1935, they have traveled all across Northern Australia.

So cane toads, so cane toads belong to the family Bufonidae, toads are different from frogs, right? Yeah. So Australia has never had toads. Right. So which means that the native reptiles or snake populations, or crocodiles have never encountered them. Also cane toads have a bufotoxin, which is toxic. So, you know, so even after they're dead, they're still toxic. So even if they die, they will make sure that even you die, if you're eating them up. So as a result, when they were first introduced, so, you know, snakes and iguanas, you know, and crocodiles, they were

eating them up. And then the toxin killed them. So as a result of which a lot of the reptilian population and snake population declined in Australia.

So, yeah. So initially when they were introduced, the situation was quite bad, especially for the native fauna. Agricultural-wise, they don't have that of an impact, but in terms of biodiversity loss, yes, they do have an impact on the native fauna in Australia here. And in general, there are a menace. You have a lot of cane toads running up and down because kids would handle them and they would lick them or whatever. Because they have these toxins around and it'll just kill you. Like, it's not just harmful to the animals, it's even toxic to humans. So you, you don't want them around you.

Isaac:

(Narration) In fact, these cane toads are wrecking so much havoc in the local ecosystem that other species are forced to adapt as well!

Roshmi:

What all also happened was over the years, some snakes evolved and what happened was the gape of some of the snakes became smaller, such that, when they would see a cane toad, they would know that they would not be able to fit that animal into the mouth and they would not eat it. So basicall over time, even the snake, some of the snakes evolved and they learned not to eat them.

Isaac:

So what is it about cane toads that you want to study specifically?

Roshmi:

Since in the last 80 plus years, they have had these different phenotypic changes. So these differences have occurred over a very short period of time.

So now they are invasive species. They are not native to Australia. So how are they able to adapt so well? So we had a lot of ecological work that was done prior to it. So we know these differences are there but what is actually happening at the, you know, molecule level. So we wanted to investigate that.

Isaac:

(Narration) Roshmi was interested in looking at two specific populations of cane toads in Australia. Ones that reside in Eastern Australia or Queensland and ones that reside in Western Australia. These cane toad populations have very different physical characteristics and personalities.

Roshmi:

If you see the cane toads in Queensland, they're smaller, they are shy, and they travel fewer distances compared to the ones that are in WA(Western Australia) so you will find them as much bigger in size. They're bolder, and then they travel longer distances.

Isaac:

(Narration) She then performed a common garden experiment where she brought these two very different cane toad populations from the wild and raised them in the same laboratory environment. This allows her to more closely look at what is happening inside the body of these cane toads that make them so different. Now one more interesting thing is that these cane toads are also cannibalistic.

Roshmi:

They eat their own, right? If you have a bigger tadpole and you have a smaller tadpole, the bigger tadpole will eat the smaller tadpole. So basically they, they eat their conspecific.

And also they release a toxin, they release a chemical toxin within themselves. Right. So even if a little bit of a drop of that conspecific, you know, that chemical is in the water, the other tadpoles run for their lives. So this is very interesting, and this is only in the Australian population of cane toads, you don't see it in other populations.

What we do is we crush the conspecific tadpoles and the crushed tadpole actually mimics mix the reaction there's like a predator in the environment. So, the tadpoles run away.

So I have this information about the differences across east and west, right. And we know they are cannibalistic, and we know that the presence of a conspecific has this effect. So we designed a common garden experiment where we looked at the different populations. We used this chemical as an environmental change and saw how it affected both populations. And also if this effect was transmitted to the next generation. So it was like a huge multi-generational project.

So basically the whole gist of the thesis was we found that the predation experiment that we did had an environmental effect. So there is this term called epigenetics, epigenetic mechanisms.

Isaac:

(Narration) DNA, which are the building blocks of life, encode genes that determine who you are. Organisms normally evolve by rearranging their sequences of DNA, thereby changing how their genes function. This is a slow process that occurs over the course of many generations. But there is a faster way that organisms can adapt to the environment. Changes in the environment can directly add modifications onto DNA, without changing the underlying sequence. These modifications can be a chemical group that suppresses or promotes the activity of a gene. The study of how the environment produces changes in DNA is epigenetics. What Roshmi found was that these cane toads are able to utilize epigenetics to speed up their course of evolution and become a dominant force in the ecosystem.

Roshmi:

The fact that invasive species are evolving so fast, what is the reason behind it? So the environment induces a change that modifies the DNA, which then affects the gene activity or gene expression.

And sometimes it may be heritable, or it may not be heritable. So this may be one of the reasons why invasive species are being able to adapt to their new environment. So we were testing the predation effect would have actually induced an epigenetic effect. The epigenetic effect that I was studying was DNA methylation.

Isaac:

(Narration) One kind of epigenetic change takes the form of methylation, which is the addition of a special chemical group called a methyl group to the DNA sequence. Methylation generally suppresses the activity of a gene.

Roshmi:

We see how this DNA methylation affects the phenotypic traits that we are looking at. So does this DNA methylation have an effect on the phenotypic traits that are related to invasion ability in cane toads?

I was able to identify certain genes actually are potentially related to traits that may increase invasion ability in cane toads. So these genes, both these genes are associated with tadpole behavior, as well as maintaining homeostasis on the skin. which probably means when these tadpoles were exposed to the predators, they initiated like a protective measure.

So, as I said, cane toads from Queensland or Eastern are shy, less active than compared to the cane toads from the west. With the DNA methylation manipulation that I did, we found that these genes are differentially methylated.

So, which means that definitely there is something happening at the epigenetic level as a result of which you can see these differences in behavior. So basically what's happening inside is can be translated to, you know, we can see what's happening outside. And also how evolutionary, if your parents are exposed to a certain thing that exposure or that experience can have, can have a positive effect on their children. So basically parental experience matters and always listen to your parents.

Isaac:

Yeah. That, that's the moral of the story.

Roshmi:

Yeah. So, I mean, that's like my parents would say, we are parents, we know, listen to us.

Isaac:

Yeah! Now you have a paper to back it up.

[Music break]

Isaac:

Can you tell me a bit about your career trajectory? How did you find your passion for cane toads?

Roshmi

One fine day, I went out with my uncle who works in WWF(World Wildlife Fund) and I saw that, oh, cool. He works in these national parks. You know, he gets to go to these places where regular people don't get to go.

Let's just look at, you know, after doing a master's in engineering, what are the chances of me getting into wildlife? So I was like, okay, there is this Institute organization in India that works, that's a nonprofit organization that works in sustainability and has, you know, works on different species and different hotspots in India. And I was like, well, why not do an internship there? So the masters that I did had a one-year program for doing research and I applied for that internship there and I happened to get it. So the internship that I got was collecting social media data, social media information, basically from Facebook and different websites where people post their pictures of amphibians, frogs, basically of Western Ghats and all across the Eastern Himalayas. You basically make a database out of it. Like what particular species this is, where it is found. And you put the latitude longitude, that way you have basically information of species distribution. Also you have these written journals in records where scientists publish their work describing new species. So I get my information from there. So basically I had a database of like 5,000 plus individuals from social media and different websites where you have people record the sightings of individuals. I used that database to generate a map looking at the geographical distribution of amphibians across the Western Ghats.

Isaac:

(Narration) This is called citizen science - A form of scientific research which involves participation from the general public. Whenever someone posts a picture of a frog, Roshmi would record the location of where the post was made and identify the species with the help of a specialist. Just by searching the internet and looking for social media pictures of frogs, Roshmi was able to generate a geographical map of how frogs are distributed across India.

Roshmi

One good thing about this project, this kind of project is that it does not require too much money. You can just sit in front of a desktop, spend some time on the internet, Google around but then of course you need specialists who can actually identify that the picture of this particular species is this species.

After I finished my internship, I got a research assistant project with my supervisor. That was on land snails. So from amphibians, I moved to land snails. And then I started working, looking at, again, it was a similar project looking at the distribution of land snails across Western Ghats. And simultaneously I also did a small project on looking at the giant African snail, which is an invasive species.

So I was half midway through my previous PhD But then due to some unfortunate instances, I had to leave it.

So I found my supervisor, she was working in Deakin (University). She had this project on cane toads and I was like, okay, just see what it is. So she says that they're invasive pieces and she had this small whole project that we are going do this fieldwork across Northern Australia.

And then I was like, cane toads. Awesome. Amphibians. I wanna work with them. And then Australia is an amazing place to work with. And so basically it ticked all the boxes that I wanted to, and I was like, you know what, let's just give it a shot. I emailed my supervisor and then we had this conversation and the project involved me having to be in Northern territory, which is up in a really isolated place where you probably would just have five to six people to interact with.

So I remember October, 2016, I landed in Australia in Geelong. And within three weeks I was out on a field trip with my boss for the first time. Within three weeks, we got some paperwork done, whatever permissions we needed. For two years, I was in middle point, it's up in the Northern territory. :

So middle point has, we have a field station. It's basically just a small building, and then you have all these big tubs and where you can run your experiments. I call it the place in the middle of nowhere. And it has nothing to do with the name, but yes, it is far away from this closest city or town. And I, I would have just like three or four people who I interact with.

Isaac:

Is that also the place where you did your molecular work? Is there a lab set up there or were you just doing fieldwork?

Roshmi:

You do not want to call it a molecular lab. It's just that you can just do basic anatomy or like basic cutting and collecting or collection of samples, but you cannot do DNA extractions there. So it's just you know, whatever basic ecological work you want to collect ecological sample, maybe just a bone or maybe just a skin piece. We would basically drive to a certain place, collect all the animals, put them in tubs, get them nice and moist and then bring them to our field station in the middle point.

Isaac:

Awesome. so I want to ask you more about your transition from India to Australia. Can you comment on how life/research differs in India versus Australia? Were there things you find hard to adjust to in Australia?

Roshmi:

So I've been here for the last five years. And I definitely see a lot of differences. Especially first of all, in terms of the finance the money, Australia definitely has a lot of money here for research and compared to India. But also in terms of the kind of work that is being done, because like funding is not that much in India. So we have to work around how to do the best kind of research with the limited resources available. So, like I mentioned that, the first work that I did was use using social media.

So that does not require you a lot of money, you just need a computer and internet and access to websites and Facebook, everybody has Facebook. So you have these different pages where you can collect information, right. And then you can just use that information to gen generate basic level information in order to actually study a particular species. You need to know where it is found, what is it, what's its habitat

So in that way, a lot of work is being done using citizen science. I don't know how nascent it is right now, because a lot of people question like, you know, okay, you're using social media, using citizen science, like, what's the authenticity of it. IIn order to answer that you have specialists, you have trained scientists who can tell you by looking at the picture, what that species is, right. So there is some authentication happening, but obviously, people who have worked on this for long, long years who have like what do I say old school thought would be like, no, you have to go there. You have to find it.

And second is because there are not many resources. So people tend to go out as I did, learn to gain experience and then come back home and see if that can be applied and, do the science that I want to do the research that I want to do, because India has a lot of potential, especially because we have two hotspots, the Western Ghats and Eastern Himalaya, which are, you know, biodiversity hotspots.

And there are like an insane amount of amphibians. Like we have like more than 350 plus amphibians.So like a lot of work can be done. It's just that, because they are frogs, they don't get as much as attention as like a tiger or a rhino or a lion or an elephant would get in India. So we have a lot of tiger reserves. We have a lot of tiger parks you know, tiger reserves national reserves, but most of them are always concentrated on quote, charismatic species. You know you have amphibians which are called environmental indicators. Any change in the environment, you will see an effect on them, even, you know, invertebrates like mollusks and even insects. Right? It is also important to understand that these smaller individuals, these small species, these not so charismatic species also need attention. If you're talking about conservation, everything needs to be conserved under this, biodiversity conservation, not just, the bigger animals.

Isaac:

Yeah. when you say like tigers and lions are more charismatic, are they more charismatic because they're better for tourism. Like they're more money-making in that sense?

Roshmi:

Yes. If I'm gonna say that, you know, there's this awesome green red frog versus like, you know, a tiger because tiger gets more importance,they know about it. It also comes down to how you are portraying species. So I remember like when I started working on frogs, my dad actually thought that I was actually doing some illegal smuggling.

He used to tell that to his friends and all, I was like, no, I'm not doing that. It's just very hard to make your parents understand. it's good to make people aware that there are other things besides, you know, tigers and elephants that are beautiful and worth looking at.

[Music cut]

Isaac:

So these cane toads are bad business for everyone. What are some things that people are doing to manage them?

Roshmi:

Now actually there is this project going on by Dr.Georgia Ward-Fear. So she has also worked on cane toads. They're actually teaching iguanas to learn how not to eat them. What they're doing is they're making sausages out of cane toads. This sounds very weird, but yeah, they're making sausages and then they're trying to feed these iguana a little bit. So if they taste it and they don't like that taste, they'll throw it away, but they have that memory. When they actually encounter a real cane toad, the moment they put it in their mouth, they'll remember that taste and they'll throw it. So basically it's in aversion, it's like in aversion therapy.

Isaac:

(Narration) Ummm I don’t know how I feel about cane toad sausages… This is only one of the many things people are doing to get cane toads under control.

Roshmi:

So every year I think we have people gather together and then they go out into the field in the night and they capture as many cane toads as possible and they put them in bags. And then they put them in the freezer, they put them in the fridge and for 24 hours enough so that they die. So basically it's a humane way of killing them. So you don't want to like smash them or anything because if you smash them, the toxins are gonna come out.

Yes. They're called toad busters.

Isaac:

That's a super funny name.

Isaac:

(Narration) They are so hated by the community that even the local wildlife has developed a special strategy to consume cane toads.

Roshmi:

Over the years what has happened is like, you know like water rats. And sometimes even crows and magpies. They've actually learned how to eat the cane toads, so what they do is they just like, you know, take it, and crash it on its back because you know, the toxin glands parotid glands are on their back. So they crash it on its back. And they just open up its the abdominal and start eating from inside. So they've actually learned how to eat the cane toads. So animals are evolving. It's just been what, 80, 85 years and these animals have actually learned. You'll see like cane toads lying around with their open bodies.

Isaac:

This reminds me of the quote from Jurassic park - Life always finds a way.

Roshmi:

You can see how species evolve or how, but individuals evolve. If someone wants to make cane toads its meal, it's gonna find a way. I've seen photographs like magpies being trashing it and just like opening and eating it's in inside.

Isaac:

That is very gruesome but extremely interesting.

Roshmi:

Yeah. That's life.

Isaac:

So when you tell people that you work on cane toads. Are there funny reactions that you have had?

Roshmi:

So people with the first question would be like, so how are you getting rid of them? How are you going to eradicate them? So basically it's, it's funny. Like, you know, people's reaction is always so brutal. Like if you cannot get rid of it, what's the point of studying? I was like you cannot get rid of them, but we are learning ways how to manage them.

Isaac:

Yeah. That's awesome. Are you planning on staying in Australia? Or are there like, like other places that are also dealing with cane toads issues that you can go in, like help them out?

Roshmi:

So cane toads are a menace. Yes. They are a menace in Hawaii. So the population that was bought into Australia was actually from Hawaii. You have more than 40 countries that are infected that have been affected by cane toads. But for now, for a while, I want to stay in Australia and learn a bit more, do a bit more research and publish more papers on cane toads and get some more experience and then maybe build some collaboration. And then I wanna work in India as well. So on, you know, because the work on amphibians in India is still in there, you know, very primitive.

[Music cut]

Isaac:

This episode of Carry the One Radio is brought to you with the generous support of our patreons. A big thank you to our pateron supporters: Anne Colton, Mark Kunitomi, Katheryn Batchelor, Carly Van Orsdel, Meryl Horn, Levi Cai, Stephanie Redmond, Paul Breslin, Karuna Meda, and Columbo Ahmed. We are also supported by the Office of University Development and Alumni Relations at UCSF. If you like our work and want to hear more conversations with these amazing scientists, you can support us at patreon.com/carrytheone. You can also check out our other episodes on our website, carrytheoneradio.com. We are also on Soundcloud and Spotify. Many thanks to Dr. Roshmi Sarma for coming on and sharing her work with cane toads. Hope you enjoyed today’s episode and I’ll see you on the next one! Stay safe and stay curious.