One World, One Health Podcast
Episode 27, Season 1- Transcript
Guest: Raina Plowright
Hungry bats, flowering trees, and dead horses – A tale of disease spillover

Maggie Fox *(0:00)*

Hello and welcome to One World, One Health with the latest ideas to improve the health of our planet and its people. I'm Maggie Fox.

Planet Earth faces problems such as pollution, climate change and new and reemerging infectious diseases, and they are all linked. This podcast is brought to buy the One Health Trust with bite-sized insights into ways to help.

Bats are found almost everywhere on the planet and they do important work: eating insects and pollinating plants. Without bats there would be no bananas, avocados or chocolate. But they do also carry diseases including rabies, coronaviruses and viruses called Hendra viruses. Many disease-carrying bats live far away from people. But as human populations move and expand, they disrupt the places where bats live. That can bring people and bats together in ways they did not meet up in the past.

In this episode, we're chatting with Dr. Raina Plowright, a professor in the Department of Public and Ecosystem Health at Cornell University and an expert in the ways pathogens spill over from animals to people. Raina, thanks so much for joining us.

Raina Plowright *(1:08)*

Thank you. It's wonderful to be here.

Maggie Fox *(1:10)*

Raina, you and your colleagues have made some surprising discoveries about how and why viruses especially can move from bats to other animals and to people. One of them is Hendra virus. Can you tell us a little bit about this particular virus?

Raina Plowright *(1:25)*

Yes, Hendra virus is a very dangerous pathogen for humans and actually for horses. Horses operate as an intermediate host between the bats or the humans. But it causes no disease in the bats. It circulates in all of the four species of large fruit bats in Australia, and it probably has done so for millennia. In fact, we didn't even know it existed until 1994. And we probably wouldn't have discovered it if it wasn't for a very large outbreak that involved a famous horse trainer and a stable full of horses in the suburb of Hendra, Brisbane, Australia.

There's never been an instance of the virus spreading directly from bats to people but all cases have come from horses. Seven people have been infected and four have unfortunately passed away because of the infection. All of the people who have been infected have been caring for sick horses.

Maggie Fox *(2:20)*

I remember when this happened and of course, you'd naturally want to say, "How did this happen? How did this new virus show up?" And all these years later, after decades of research, you've described your findings in a report in the journal *Nature*. You've helped to explain what's going on here as bat habitats are disturbed.

Can we first talk about where these fruit bats live and how they normally intersect with human populations?

Raina Plowright *(2:46)*

Historically, the bats that are the hosts of Hendra virus lived in huge aggregations, tens of thousands, sometimes hundreds of thousands of animals. And they would move nomadically across the landscape. They would feed in these patches of forest that produce flowers and nectar and they would travel hundreds of kilometers for these patches of nectar. But they're constantly moving because nectar only flows for one or two months, and then it dries out, and then another patch would produce nectar. So the bats had to move around to find food. And people didn't intersect very much with these bats because they were feeding in these native forests.

But what we noticed is over the last 25 years, we started to see more and more bats actually residing and feeding amongst humans in urban areas and in agricultural areas. When we started to put the data together, we actually noted that across the subtropics the number of populations of bats increased three-fold, but also those bats resided now outside of native forests and in human-dominated areas.

Maggie Fox *(3:49)*

And so what were people doing that changed the bat behavior?

Raina Plowright *(3:52)*

This has been a ten-year study for us to try to figure this out. I would say that there are a couple of really important things that happened which led to this study. The first was doing my work on Hendra virus. Around 2006, we noticed that we found the highest levels of Hendra virus exposure in bats during a period of time when the bats were starving. It was actually a pretty terrible situation for us, because we had a big team of National Geographic reporters, photographers coming out to look at our research and we said, “You'll see hundreds of

thousands of bats, this is amazing, is a great spectacle” and when they arrived at our field site, we couldn't find any bats, of course.

What we realized after they had left is that the bats had essentially left the area because there was no food. There'd been a large cyclone off the coast of Australia, and we think it probably diluted out all the nectar or stopped all the flowering. We eventually found a small population of bats but they were starving, they're emaciated, they were not reproducing, and that's where we found the highest levels of Hendra virus. So we had this clue that there's something going on with food and Hendra virus.

Then in 2011, on the east coast of Australia, there was this unprecedented outbreak of Hendra virus. There were 17 spillover events in the subtropics just within a short period of time. That was more spillover events in one period than had actually ever occurred in the past. We were trying to figure out why all of a sudden there was so much Hendra virus. I talked to my colleague, Peggy Eby, who is a bat behavioral expert, and she had been on some of the properties where horses had succumbed to Hendra virus. And she said, she noticed that on these properties, the bats were eating really poor quality foods, foods that bats would only eat if they were trying to avoid starvation. We realize there's some connection here.

There's something really important here with food shortages. And we started to gather data sets, many that Peggy had collected herself, many that others had collected. One of the really important pieces of data we had was data from beekeepers, because interestingly, bees depend on nectar and pollen and bats depend also on nectar, and often the same species. And Peggy had developed very good relationships with the beekeepers across the subtropics and put together this amazing data set that showed all of the periods when the bees had no food and it corresponded exactly with the periods where the bats had no food. There were huge intakes of bats into rehabilitation centers for wildlife when the bats had no food. And we put this together with the information on where bats were settling in human areas and when the bats had moved into human areas, and we noticed this very big pattern.

Whenever there was a moderate to extreme El Nino year, there was always a food shortage for bats and for bees the following year. And the bats essentially did this massive fission when there was a food shortage. So they went from these big populations that were moving around nomadically in native forests, and then fissioned into all these tiny small populations, often just hundreds of animals, into areas where there's agricultural plants and also urban areas.

Importantly, they moved into agricultural areas where there are horses. Then what we noticed is the winter after that food shortage and that fission event, there were clusters of Hendra virus. But those Hendra virus clusters only happened after the bats had moved into the agricultural areas.

Maggie Fox *(7:19)*

When you say spillover event, you mean horses have become infected. But how did the bats infect the horses -- they're not biting the horses?

Raina Plowright *(7:26)*

That's right. No, they're not vampire bats. So these are fruit eaters and they prefer nectar over anything. But when they're feeding in a tree that might have fruit or nectar in a horse paddock, they're sitting in the tree amongst the branches for some period of time, they might defecate or they might urinate, or they might even chew a piece of fruit and then spit it out on the ground after they've sucked out the juice from the fruit.

So we think what happens is the horse comes along grazing underneath the tree, and it either sniffs up the virus that's been excreted on the grass, or maybe even has a little chew of the fruit that the bat has chewed and then becomes infected.

Maggie Fox *(8:04)*

It sounds like people are affecting bat habitat in two ways: through forest destruction and climate change.

Raina Plowright *(8:11)*

The bats I talked about that were moving from patch of forest to patch of forest looking for nectar -- some of that's actually very easy because there are extensive forests that produce nectar for bats in summer, and many of them are well protected. They're in mountainous areas where there are national parks. But in winter, only five species of eucalypts produce nectar for bats in a reliable way. And all of those species live in these lowland areas, coastal areas of Australia. I'm just talking about the subtropics of Australia here. That land has become very valuable for agriculture and for urban expansion, and it has been selectively cleared. And we actually looked at the winter habitat of bats within this recent paper and we found that just in the last 25 years, 30% of the existing winter habitat was cleared.

We actually think the entire cascade of processes that led to these spillovers was ultimately driven by the loss of those winter trees. So it’s an interaction between climate and habitat loss. We've always thought that that interaction is going to be very important globally in how diseases emerge from animals and how animals respond to anthropogenic change. But here we're really able to show mechanistically how all the pieces came together. We were able to predict all the spillovers based on the climate oscillations and the movement of bats into agricultural areas.

But there was actually one more piece of this story that was really important. We were very happy with ourselves because we got to this point where we could predict spillover events and actually in 2017, everything lined up, there was an ONI, there was a food shortage, and we said

okay, you should vaccinate your horses for Hendra virus the next winter and sure enough, that winter, there was a big cluster of Hendra virus spillovers.

In 2020, everything else started to line up as well. So we had a very severe El Nino, we had a very severe food shortage for the bats. The bats were coming into rehabilitation care, not reproducing. And we also had fires that year that wiped out some of that winter habitat. So we thought it was going to be a terrible year, and then there was nothing. And we thought, “Oh gosh, where have we gone wrong? What is going on here?"

But we had big teams in the field. We were doing a longitudinal study of Hendra virus at the time. So we sent our field teams out, and what we found was there was this massive flowering of trees, a winter flowering of gum trees. Actually, though, 200,000 bats had aggregated around this flowering pulse and 75% of one species of these pteropus bats was around this one pulse of flowering. And we thought this is so interesting, because my colleague Peggy Eby had always been tracing these big flowering events and spotted gum on the south coast of Australia that attracts massive aggregations about every four years. And she had noted that every time we spotted gum flowers, we don't see Hendra virus events.

So we thought we have to do this systematically. We then amassed huge amounts of data and we looked at the patterns of when flowering and aggregations happened in winter, over the last 25 years.

There had never been a spillover event when there was a winter flowering pulse. We put this into our Bayesian network models and found that flowering was actually completely protective of spillover. We don't know how it works, we think what happens is that when there is a big pulse of flowering, the animals empty out of agricultural areas, and then they fly back to native forests. So they're feeding away from horses, away from humans. They're also getting more nutrients, so they're happier, they're healthier animals. And the animals that remain have less competition for food. Perhaps the animals that remain are actually healthier as well.

After all of our work, a decade of work, 25 years of data, we had something like 25 datasets, complex models, to try to figure out how this system works and it is complex. The solution ended up being really, really simple. It's basically: replant these five trees, and it should work. As far as how easy it is, well, it's actually really easy to plant trees, it's not very expensive. There's also already a huge program of replantation in Australia for erosion and shade, salinity problems. Actually the same trees that bats like to feed on, many of those trees are the same trees that koalas like for habitat. There's a lot of concern about koala habitat loss. So there are many win-win situations here. And it really is doable, it's a solvable problem. We just have to get on and actually do it.

Maggie Fox *(12:38)*

So you identified a problem, found a way to predict it, and then that led to a potential solution that sounds like it's really quite doable.

Raina Plowright *(12:47)*

We've now been thinking about "Well, could this work for systems outside of Hendra virus? Could this work for SARS-like viruses? Could this work for Ebola virus or Nipah virus?" And so we've been convening groups of experts from various parts of the world to really explore this idea. And I think one of the most interesting and fundamentally disturbing things is that when we look to other parts of the world, we have almost zero data. We have no idea what's happening with the bat populations.

I mean, we know things are changing. I know my colleagues in Cambodia told me that the bat populations they work on, they used to have to [go] through jungles and go on all sorts of very difficult roads. It took them many, many hours to get to their field sites. And now they just drive up on a two-lane highway. So we know these landscapes are changing enormously and rapidly, but no one's tracking it. My fear is that one day we'll have a new virus suddenly appear in the human population, but we won't have any long-term data to understand how it got there.

Maggie Fox *(13:48)*

And that's why tracking and monitoring these systems is so important.

Raina Plowright *(13:52)*

Yes, at least understanding the fundamental ecology of how the reservoir host of these viruses work. I think it's just not something we invest in. I think we invest in trying to understand the virus. For example, if you look at the number of papers on the structure of the spike protein of SARS-CoV-2, there are thousands and thousands of papers. At one point, I actually looked on Weber [Scientific] and Google Scholar, and there were somewhere between 3 and 10,000 papers on the structure of the spike protein.

At the same time, we were actually doing a review on bats and coronaviruses and we'd looked at how many papers there are of coronavirus circulation and wild bat populations. And there was a handful. There wasn't actually a single study that looked at the circulation of the virus in both space and time. And there were really just a couple of studies that looked at the virus over time. I mean, you couldn't get a bigger contrast than that. We're not investing in understanding the natural history of these viruses, the drivers that are forcing the viruses into human populations. So we'll just continuously be caught unaware...like this Hendra study, it took really understanding the real complexity of the system to figure out the simplicity of the answer. So we need to be doing that in other systems too.

Maggie Fox *(15:02)*

So what should the average person be doing who's not involved in research?

Raina Plowright *(15:07)*

We need to be advocating for conservation. I think fundamentally, this is coming down to the loss of habitat of species that host viruses. So when we clear the habitat of the animals, when we build roads, we fragment those habitats, we create all these edges, we create these new interfaces between people and animals. As we bring people into wild areas, that creates an industry for bushmeat harvesting, for wildlife trade, for guano harvesting. It just brings people and animals into contact in ways that they haven't been before. And we know that wildlife are full of viruses that have the potential to infect humans, and perhaps some of them the potential to cause a pandemic. We should really be doing everything we can to leave those populations alone.

And this is not just about infectious diseases. At the same time, we have a biodiversity crisis, an extinction crisis, and we have climate change. So, the solutions for preventing infectious disease outbreaks are really very similar to the solutions for stopping the biodiversity crisis and for dealing with climate change. We need to find the intersection of all of these planetary crises and we need to address them.

Maggie Fox *(16:14)*

Raina, thank you so much for taking the time to chat with us.

Raina Plowright *(16:17)*

It's been really fun. Thank you for having me.

Maggie Fox *(16:21)*

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