Andrew Saintsing: Hi, you're tuned in at 90.7 FM KALX Berkeley. I'm Andrew Saintsing, and this is The Graduates, the interview talk show where we speak to UC Berkeley graduate students about their work here on campus and around the world. Today I'm joined by Nina Sokolov from the Department of Integrative Biology. Welcome to the show, Nina.

Nina Sokolov: Hey, there. Nice to be here.

Saintsing: So, great to have you here. Nina, you were just telling me that your field research season just wrapped up. So, are you happy about that or are you sad about that?

Sokolov: Well, as I was saying, I've been doing field work since about February. Since I work on bees in California, they're out for most of the year. At least the honeybees are. I could theoretically be doing field work indefinitely, but I have to kind of put a hard stop on that. Versus the native bees that are out and about, uh, I mean some of my sites, as I was saying, the season seems to be wrapping up for them naturally anyway. So, I really love being outside, and I love doing the field work, but I'm also happy to get a bit of a break from that until about… I think it'll restart again in February.

Saintsing: What do you study about bees?

Sokolov: I'm an entomologist and a disease ecologist, so that means that I study insects and I also study the pathogens that infect them. And disease ecology is the study of understanding how pathogenic organisms exist in an ecosystem, so it's not like, you know, bacteria or viruses just kind of blip into existence and then disappear. They're always kind of circulating somewhere, and for my study organism of choice, I'm really interested in bees, both, as I was alluding to, the honeybee, which is not native here, which is used in crop pollination, but I'm also studying native bees in California. And then the viruses that infect them, and pretty much, I'm interested in that because as a lot of people know, you know, bees are struggling for a variety of these multifaceted reasons, and I'm interested in how disease is impacting their populations and potentially how there is spillover of viruses between these managed honeybees that are used for crop pollination and the native wild bees that they're interacting with.

Saintsing: Okay, viruses affect insects. That's…

Sokolov: Oh, yeah.

Saintsing: Yeah, really weird to think. I mean like insects don't get the flu, do they?

Sokolov: They don't get the flu, no. But they also, as the flu is an RNA virus, they're getting sick with RNA viruses as well. Before when I described spillover events before COVID, it'd be a little bit more challenging. But now that we're living in a spillover event it's really easy to describe it, and so spillovers are defined as pathogens, which circulate naturally in one species, suddenly start to infect a different species via a spillover event. And these spillovers are just absolutely, you know, chaos and can happen at any moment, and

whether or not something turns into a pandemic like this is terrifyingly chaotic. We're having, we're trying to attempt to predict these things, but it's very, very challenging. But these spillovers can be occurring kind of all the time, including between, yeah, managed honeybees and native wild bees. It's just kind of the direction that people usually talk about, but the native bees can also be giving viruses to the honeybees, and even those really simple ecological dynamics of: who's giving what virus to who? Who is it majorly circulating in? What's the actual impact on the populations? All of those basic questions are still barely understood in bees even though bees are really important for crop pollination, for wildflower pollination, for giving us, you know, food on our plates and also the diversity of flowers that we see in nature. But even with all that importance and knowing that diseases are impacting them, we are still really in the infancy of understanding what those diseases are and what they're doing. Specifically for RNA viruses because RNA viruses are really fragile. When I'm out in the field, I have to be collecting these bees onto dry ice, and then putting them into a liquid nitrogen doer, and for a variety of reasons, they're just kind of a pain in the butt to work with. And so, that's why, of all the pathogens, I'd say there's the least amount known about the RNA viruses. But most likely they have a lot of impact and a lot of this cross-species movement.

Saintsing: Okay, so you're studying like RNA viruses in general, I guess. Or, are you… I, so I don't know actually how you study the viruses, so I'm wondering: do you have particular viruses that you're looking for? Or can you just kind of get some bees, and then you can look for any virus? Like, do you need to know what virus you're looking for to start the process?

Sokolov: Yeah, so we're finding more and more viruses kind of the more that we look of course. And so, initially they're called these honeybee viruses because we were starting to find them in honeybees, but whether or not they are, the origin is in honeybees, that's like fully not understood, and so, as i was saying, I go out into the field. I collect these bees using a net, put them onto dry ice, put them into liquid nitrogen, and then I have to bring them back to the lab, where I extract the RNA. And then, I start doing molecular wizardry on them to, as I'm saying, as you were suggesting, I'm looking for specific viruses. Some of them, for me, that are quite interesting are the ones that have been associated with bee die-off in honeybees, like Deformed Wing Virus is kind of this pathogen that we know the most about, I'd say. And it's found in so many different species of insects, it's been found in cockroaches and ants even. So, it's like spilling over millions of years of evolutionary distance, but overall, I'm trying to look for a small subset of these virus species that are known to cause negative impact in honeybees and are starting to be found in other bee species. There are other people who are looking more at, from a, like, discovery sort of perspective, to find new viruses. And yeah, there's so many, and the more that we look the more that we'll find.

Saintsing: And so, you're going out, and you're getting both native honeybees and the managed bee populations, and you're getting individuals from both, and you're trying to see if they both have the same viruses, to see, like, if there's an exchange going? And are you,

is there some way that you're testing to see, like… Can you actually see if, based on the molecular data, the virus is moving between those populations?

Sokolov: Yeah, I'm looking at non-native honeybees, but like honeybees that are out in nature as well, and then the native bees. That's correct. So, I'm going to be able to be using phylogenetic methods. Just as we look at genetic trees to be able to understand the relatedness between animals and everything, I can look at that as well with the viruses. In general, when we look, it's kind of hard to say whether or not it's you know coming from the honeybee or coming from outside of that because, when we look at these trees, we see there's just honeybees, bumblebees, honeybees nested within bumblebees. And so, you would think that it would kind of cluster, like all the ones that infect honeybees in one group on the tree and all the ones infecting bumblebees in another cluster in another part of the tree, but in reality, they're all like intermixed with that. And so, it's really hard to pinpoint the origin a lot of the time. But I'll be using those methods. Additionally, since, as I was saying, I study disease ecology, that is kind of predicated on looking through time. It's not just, you know, looking at this one time point and seeing like, “Okay, who is sick right at this one point in time?” Because then if you find them both infected, you don't really have that much information. You just know that they're both infected, but you don't know who's the source of that. And so, for a lot of my work, I'm going, and I'm sampling from the same sites every two weeks to see, “Do I start to see, say, Deformed Wing Virus increasing in prevalence in the honeybees?” And then with like a week time delay or something or two week time delay, “Do I then start to see that prevalence increase in the native bees?” Or is it the other way around, you know? Because that can give a sense of whether or not there is directionality. If you start sampling through time, and you're able to see these epidemics kind of sweep from one host species to another host species. And in (I'm working specifically in the Sierra for a lot of reasons. One, I really like mountains. i just like the wildflower meadows a lot. But for another, for a lot of these sites, I'm able to sample before any honeybees are there.) So, I get to have a sense of, “What are the native bees that are here, are they infected with anything that's even, you know, baseline interesting?” Then, we experimentally put honeybee hives in certain areas to make wildflower honey and to breed, but then they are also interacting with the native bees that are there. So, I want to see, you know, “Were there viruses there to begin with? And then, do we start to see viruses pop up that weren't there before once the honeybees have arrived?” And so, I'm also even sampling the honeybees before they, they move there to see, “Can I start seeing these viruses pop up in the native bees after they've arrived?” So, getting these is, like, really not simple. Yeah, it's, you know, the direction of all these things is really interesting, and yeah, just super not well figured out quite yet.

Saintsing: Yeah, that sounds super complicated. Yeah, you're definitely more interested in the dynamics from what you're saying, and maybe not so much the way the diseases work, but can I… Like, what is Deformed wing disease? What would, what would happen to the bee?

Sokolov: Yeah, so Deformed wing virus, and a lot of these insect viruses are aptly named, because in the worst kind of case, the highest degree of symptoms that a honeybee can face with it is when they emerge from being a little pupa (so like a little baby bee into an adult bee), when they emerge, they emerge with deformed wings. And so, they're unable to fly, and a bee that can't fly can't really survive. And so, they die soon after that. But what's tricky with a lot of these viruses, and again, what makes them hard to work with is just because they're called Deformed wing virus doesn't mean that they're always going to cause deformed wings. So, many of these pathogens are asymptomatic, and from a spillover perspective, that's even kind of worse. Because they are able to still successfully fly. They're still successfully able to forage, and that's where these spillover events are occurring. It's not from honeybees rubbing shoulders with a native bee directly, but instead, say, a honeybee goes and forages on a flower, they're sick, and they shed virus onto that flower. And then, they leave, and then a native bee comes to that same flower, they forage on it as well, and they pick up a certain number of infectious viral particles. We have no idea of that dose, no idea how long that flower is infectious for, but then, say, if they've gone to enough flowers or, say, their immune systems are compromised because they're stressed in some way, then they are able to get infected with this virus.

Saintsing: And you try to get samples of, if you can find them, the obviously affected bees and samples of bees that are apparently unaffected?

Sokolov: It's very hard to find the ones that are that sick, you know? Like, it'll be very hard unless I'm opening up the hives or something. But then, with the native bees I just would never be able to find them, right? Because I'm collecting them mostly by the ones that are on the flowers since I'm using a net and everything. So, I'm intrinsically biasing myself towards the ones that are less symptomatic, and that's just something I have to be aware of. But from, again, the spillover perspective, the ones that are able to fly even when they're sick and spread it even further are kind of what's interesting to this spillover dynamic anyway. But I'm keeping that in mind. That this is probably likely an underestimation because I'm going to be always biasing away from those that are really sick.

Saintsing: How do people know how the viruses affect the… Like, are the those based on observations in lab settings?

Sokolov: Yeah, so you can… most of our research and where a lot of the research funding for bee research is with honeybees. And so… and that makes sense because they're the powerhouse of crop pollination, and so there's a lot of money from the USDA and everything to figure out why our honeybee loss is so high. And there's a lot of laboratory experiments characterizing these different pathogens. But then with the native bees we're just starting to bring them into lab conditions, experimentally infect them, and see what the effects are. But that side of things is still really, really understudied.

Saintsing: Have you started to get some results from the field work you've been doing?

Sokolov: Yeah, absolutely. Yeah, I'm sitting on like a mountain of things that I need to process. But yeah, I am, in short, finding honeybee viruses infecting native bees on my sites. But now it's to characterize these dynamics through time and get more fancy genetic information and data from that. But I will soon be holed away in the lab for the rest of the semester and not doing any field work, so I should be getting more results out soon.

Saintsing: Are you excited about getting the results? Or do you wish you could be in the field and not doing the statistics?

Sokolov: Yeah, yeah, I think the latter. I feel like I'm definitely happy in the field, and I think that that's where a lot of my skills lie. I just am more of a noob on the statistical analysis things, but it'll come, and I'm, my lab is full of people who are very proficient in coding. So, i can always ask for assistance. It's not like, you know, a solo venture. My lab works on a bunch of different things within the field of disease ecology and disease evolution. So, I was the only bee person my entire time here, but now we just got a new grad student, Sarah, who, she also wants to work on bees. And so, then I can teach her the lab skills that I wish someone would have taught me when I got here because… I knew… I didn't work on bees or diseases. Or I've never worked on either of those subjects before during my PhD, so it was a lot of learning as I went.

Saintsing: How did you end up in the lab that you ended up in then?

Sokolov: A great question. Like, you know, in those personal statements we have to write, you have to have some sort of like logic, right, along the way, but I truly just liked so many different things, and I studied ecology and evolution in undergrad. I worked in a bunch of different labs and had some field experience with insects, and pretty much I really liked the field experience. We did an alpine ecology course actually, like, at the White Mountain Research Station, which is the UC reserve. But I was doing this when I was doing underground in Toronto, and so, I was like, “Yes! Fieldwork! This is great! I love this!” And then I was like, “Yes! Bugs: also great!” I even took, like, a museum study course where I… and I really like to do art as well, and when I started looking at insects under the microscope, I was like, “Oh, my god! Like, look how beautiful you are! Like, my goodness.” Like creepy little aliens, you know? And I just like love how diverse they are, and that's kind of the time where I was like, “Okay. Fieldwork. Bugs. Something. Something from that.” I don't know. I just fussed around. I graduated my undergrad, and then I was working as a research tech for two years, also in a completely unrelated lab. But, I like, loosely dipped a toe into a disease ecology project with these mosquitoes and vector competence sort of questions. Like, why can some species vector deadly diseases and other ones can't? And I always knew that some species could be bad vectors of disease, but I actually didn't know that, like, within a species, based on like the way that the mosquitoes are reared, whether it's in, like, crowded conditions or, like, how well-fed they are, that makes them a better or worse vector. So, it's like, even within species there's a variation in that. I was like, “What?” You know? So, like, disease questions started to come up as interesting within that. I never took, like, a disease ecology course.

I never really thought of that, but I started for whatever reason. Host-parasite things are just like, “Woo!” You know? Like, so cool. And so, I tuned into my intrinsic interest in that. And I was like, “Okay. Fieldwork. Insects. Disease things. What do we do with this combination?” And actually when I was applying here, I was thinking of doing a mosquito project because of that. That was being on my mind recently, but then, yeah, I started talking to my advisor, and we started thinking of these, like, bee-related ideas. And I was like, “Well, actually, this is way better. Because I would love to…” I mean I have to unfortunately kill the bees in order to figure out what they're sick with. Everyone always, like, gets a little heartbroken hearing that. They're like, “Oh, wait. You have to kill them?” And I'm like, “What are you doing to save the bees?” Like, thank you. I guess I have to kill them, but there's also like thousands, you know? Thousands around you right now. It's killing… Me killing off five is fine. But then, yeah, it was kind of just like a natural whittling down. And then, I ended up here like I… Yeah, like I said I didn't even know that I was doing the disease things, so like, I started well into starting here. But it turned out to be great.

Saintsing: And you said art is important to you. Do you, do you use, like, fieldwork as a chance to get inspiration? Are you, like, drawing and going out when you're doing (in between the collecting parts of fieldwork, you know)?

Sokolov: Like, I wish I could, you know? I wish I could be one of those, like, classic naturalists, like out with a sketch pattern paper. But it's just so exhausting that, you know, having any additional energy to do a thing that's not absolutely required is very challenging. I do get inspired all the time for sure, but to do art while I'm out there is quite, quite a challenge. But I definitely think that having art skills are what helped me with a lot of the bee research, because there's over 1600 species of bees in California, you know? There's a lot of diversity, and there's very teeny, tiny, little differences between them, and when I'm drawing or when I even, just the act of practicing drawing any insects, you know, it gives you an attention to detail. These tiny little things, and as I was saying, when I learned, when I went kind of got this appreciation for looking at insects under a microscope, I was taught scientific illustration by a PhD student at the Royal Ontario Museum, who was using illustration for part of his thesis because he was redoing the praying mantid phylogeny (because it's apparently a hot mess). And so, he was a very good teacher in the sense that it was very hard. In the sense that he's like, “Oh, is that patch of hairs there? No? No. Why is it there?” Oh, my god! You know, like, I haven't been critiqued this hard in a long time in my art. But it was actually really good because, yeah, with scientific illustration you’re trying to like, you know, really accurately capture something. Like, I don't even… I… hats off to anyone that does that for their career because it is so challenging. Like, I wouldn't say it's relaxing at all, let's say. It is studying it for a really long time and… because every, because people are wanting to use that as, like, an accurate, like scientific figure, you know? For these, like, species differences, and so, it has to be so precise. So, that's very challenging. But I really, like, appreciate using that for being able to distinguish between these species and stuff. And with the bees, I've even, like, made these little native bee coloring book pages, which I wanted to give out as like (before COVID), like during these outreach events that I do at farmer's

markets. We do little prizes, and I'm like, “We can easily print out these coloring book pages, and it's also an excuse for me to draw these things, you know?” And so, I was like starting to do… I did a little series of those, and I'm going to hopefully continue to do that to show kids like all these different, diverse, and like having a fact sheet on the back of it to show that there's more than just the honeybee, you know? There's all these different kinds of bees, including bees that are parasites, too, you know? So, yeah, a lot of using art in my science for both an attempt at relaxing and continuing that hobby in my life, but also using it pragmatically to teach people.

Saintsing: And what you're… You go to farmer's markets to, or you used to go to farmers markets?

Sokolov: Yeah, I'm hoping to restart that. So, I'm part of the this grad group on campus called CLEAR, which is the Communication, Literacy, and Education in Agricultural Research, and so, it's run by a plant molecular bio professor who does a lot of awesome extension work, and it's a lot of molecular bio people in general. But I'm like the one integrative bio person that's there sometimes, and so, they do a lot of… We do, have done a lot of events together where we do like themed things, and we have, like, a booth at the downtown Berkeley farmers’ market, where we'd have, you know, games or, like, specimens that are there, and talking to people. It quickly devolves into conversations about GMOs often, you know. It's a lot of that, or pesticides and things, but we've also done booths and workshops at, like, the Bay Area Teens and Science Conference or the Bay Area Science Festival, which used to be held up at, like, the baseball stadium in San Francisco. But this past year was done remotely, and so that's why I designed the coloring book pages specifically for that event.

Saintsing: You also mentioned that you have another way that you're using art and outreach, right? That you're trying to get off the ground?

Sokolov: Yeah, yeah, so I'm also working with the Biota Project, which is a collaboration of a bunch of women-identifying academics from kind of all over the US, where we're merging kind of art and science and social justice initiatives. And so, we are trying to get this project off the ground where we are making a kind of a zine workshop for incarcerated individuals in San Diego county, where we are going to be using zines (which are kind of… it's kind of whatever you want it to be, but it's pretty much like a tiny magazine, and it can have short stories, poetry, art, photographs, collage. Kind of just anything in order to communicate ideas, and they're pretty much like a self-published mini magazine. Some people use it for photography. Other people use it to communicate, like, radical new thoughts and everything. Yeah, it's very independent and used for kind of self-expression.) And we really want to have it to integrate kind of ownership of scientific ideas to groups of people that might be kind of feeling disenfranchised by those entire institutions. And so, we are making zines to communicate general ideas, presenting them in classrooms, and we're going to be presenting them in classrooms and jails and prisons in San Diego, and then kind of allowing the incarcerated individuals to also contribute to that, to make their own art

that they can then, we can then integrate into the next zine of the next topic. And so, kind of using that again as a reclamation of knowledge and power back in those classrooms and hopefully having some sort of good impact and to show that, you know, art and science aren't these like two binaries. Like, they can be used together and to be able to be used in a way to, yeah, reach more groups of people than just, you know, rich, middle-class, white people, ideally. So, hopefully, we're working on writing up an NSF grant to get some funding for that. Also trying to get little pools of money along the way to get that off the ground. And it's going to be in collaboration with UC San Diego, that does this, like, science class already in these like local prisons and jails in San Diego County, and Project Paint, which does this, but instead of with science classes, with art classes. So, we're all going to merge forces together and bring these zines into prisons and stuff, so I'm pretty excited about that and have been reaching out to places to get quotes for our first zine, which is about cosmic… It's called "Cosmic Cultures," which is kind of trying to highlight astronomical innovations and research in non-western societies. And so, I was… my little part of that was: through my time that I went to Chichen Itza in Mexicom which is just kind of like a shrine of Mayan astronomical knowledge, truly. And I was really inspired by this kind of pool of water, like this, like pool, where they would fill it with water, and they would… Like children who were going to be destined to be astronomers one day would watch the reflections of the stars and the planets and the water, and that's how they were able to make a lot of their calculations of when eclipses happened, how planets moved, how constellations moved. And I was just like, "What did…?" You know, like, that's insane. So, I drew like an image of like a boy standing in the pool of water and with reflections of stars and stuff, and so, to give like a little blurb about that with that image. And so, collaboratively, us, with Biota Project, we've all like made our own (whatever we were inspired by that theme), we made our own pages to communicate these this kind of research, this kind of knowledge. And now I'm working on figuring out InDesign to put that all into the zine together and start distributing that.

Saintsing: That sounds really interesting. Will it be widely available?

Sokolov: Yeah, so we're hoping to get some money to get them physical copies to be able to hand out to the scholars that we're going to be teaching, so they can keep. And again, soon their own works would be integrated into those zines as we get more of a back-and-forth collaborative effort going. And so, they can again have this, like, ownership of ideas that I think is super important to reaching people that have been excluded in science historically. But then we're also additionally going to have an online copy that anyone can see.

Saintsing: Nice. Something to look forward to. This has been really fun, but unfortunately, I think we are running out of time for the interview. Is there anything you'd like to leave us with before we go?

Sokolov: Yeah, people always kind of ask me when I do outreach talks like, "How do I help the bees?" And so, I always say that like, "Don't get a honeybee hive." Again honeybees are

not native here. They are called the European honeybee and were brought here by colonizers in the 1700s, and the losses that honeybees face, that's an agricultural issue. There are high overwintering losses, a lot of honeybees are dying for a variety of reasons, but that's kind, that's quite an agricultural issue. So, unless you're a crop pollinator, those losses actually like don't, don't impact the health of that species. So, if you want to help bees you can do a lot to help the native bees here, which are actually showing evidence of declines in their species, and there's bees that are starting to be listed on the endangered species list and everything, too. So, if you want to help with that I'd say that any individual can assist in that by providing good quality habitat for native bees, planting native flowers, providing space for, like I was saying, most bees are ground-nesting bees. So, you can just even provide, like, barren dirt for them to make their nests in as well, and so, just turning into any amount of area that you have, if you have access to that, to provide resources for these native bees, especially in these habitats that are really fragmented. And even specifically planting flowers that could be blooming at times when there's not a lot else blooming, like right now things are drying out, you know? It's really, really dry. Not many flowers. You can plant anything that will bloom later in the year or earlier in the year and that will be helpful.

Saintsing: Are there specific things?

Sokolov: There's like… you can look up specific… not all flowers are pollinated by bees. There's a hummingbird-pollinated flowers, and they look quite different. So, you can look up the area that you live in, the flowers, and like the seasons that they bloom in. And so, to try to pick things that that bees like, that bloom in the spring, the summer, and the fall if you can.

Saintsing: And you're saying people like in Berkeley with yards can just have a little patch of dirt and they'll get some bees that will nest there?

Sokolov: Yeah, definitely. The bees will want to ideally make a nest somewhere near floral resources, so having flowers around it also do that pretty well. But yeah, if you build it they will come. If you have flowers that bees like, they will, they will find them. So, I definitely think that people can make an impact on just planting native, native flowers that bees like because they're struggling for the resources, you know? Luckily around here there are a lot of gardens and everything, but I'd say that that's one way that an individual person can help.

Saintsing: And having a native bee nest in your yard, is that like: I could be in my yard and have a native bee nest there and we would both coexist and it would be fine?

Sokolov: Oh, absolutely. Even like, as far as like the aggression goes, like the grumpiest ones are the honeybees, and you're probably not gonna have a feral hive. I've never been like stung by like a native bee. Even like other than the bumblebees, which accidentally like sting me when I'm getting the nest, most bees are solitary, most species. So that means that they don't have a hive and because of that they don't really want to get in a

situation where it's this, like, highly aggressive situation, you know? They don't want to, they don't, they're just trying to look out for themselves, and so they don't want to be in this really high intensity situation potentially. So, they're overall really, really non-aggressive. The only ones that get aggressive are the social ones, and that's when you get like really close to their hives. But I've never been stung by anything just getting close to the hive like that, any native bee.

Saintsing: Okay, great! Today, I've been speaking with Nina Sokolov about her research on bees and the diseases that infect them. Again, thanks so much for being on the show, Nina.

Sokolov: Yeah, thank you for having me.

Saintsing: Tune in in two weeks for the next episode of The Graduates.