UF IFAS
UNIVERSITY of FLORIDA

EPISODE 221 TRANSCRIPT

Jamie

Welcome to Two Bees in a Podcast brought to you by the Honey Bee Research Extension Laboratory at the University of Florida's Institute of Food and Agricultural Sciences. It is our goal to advance the understanding of honey bees and beekeeping, grow the beekeeping community and improve the health of honey bees everywhere.

In this podcast, you'll hear research updates, beekeeping management practices discussed and advice on beekeeping from our resident experts, beekeepers, scientists and other program guests. Join us for today's program. And thank you for listening to Two Bees in a Podcast.

Amy

Hello everybody and welcome to this segment of Two Bees in a Podcast. I am actually joined by Dr. Cameron Jack today as my co-host. Welcome, Cameron.

Dr. Cameron Jack

Hey, thanks for inviting me. Happy to be here. Can't replace Jamie Ellis, but I'm happy to fill in.

Amy

You are your own person, Cameron. We're happy to have you as a co-host. If our listeners remember from the very beginning of our episodes back in 2020, Cameron was actually supposed to be one of the two bees. And then I don't know what happened. I think Jamie and I just took over.

Dr. Cameron Jack

I got booted out. It was very clear from the very beginning that, you know, I was not meant for the radio. It's OK.

Amy

No, we love having you. I'm happy to have you today. So, Cameron and I today are joined – we're excited to be joined by Dr. Reed Johnson, a professor in the Department of Entomology at the Ohio State University at the Wooster campus today. I'm excited to talk to him about bioacoustics approach to honey bee biology. Our podcast coordinator is extremely excited because he's all about the acoustics. So, Dr. Johnson, welcome back to our podcast.

Dr. Reed Johnson

Well, thanks for having me back. It's good to be able to talk with you again.

Amy

Yeah, we kind of used this year as our year when we were going back to, you know, past episodes. It's been 2, 3, 4 years for some of our guests. And so, we had you in 2022. We had you on our podcast then. But I'd love for you to reintroduce yourself to our audience and tell us how you got into the beekeeping world.

Dr. Reed Johnson

Sure. Well, I've been here at Ohio State for, oh, almost 15 years now, but I got into beekeeping and bee research in Montana. I actually grew up in Missoula, Montana. When I was an undergraduate, I got a summer job working with Dr. Jerry Bromenshenk there at the University of Montana. And then one thing led to another, and I was in a PhD program at the University of Illinois working on the honey bee genome. And then I got my position here at Ohio State after taking a detour to the University of Nebraska to do a postdoc with Marion Ellis there.

Dr. Cameron Jack

Very awesome. Yeah, that's so cool. I actually didn't know you're from Missoula, so that's cool. You know, I've heard you talk a little bit about this research for some time, just from different meetings and things. But we wanted to bring you on today to discuss, you know, this recent, new tool that you've been using called Buzz Detect. So, can you tell us a little bit about the background on how this project all got started?

Dr. Reed Johnson

Well, yeah. So, this is, in the field of bioacoustics, which is using sound to study biology, and we got interested in using sound on honey bees. Well, there have been a number of people who have enjoyed listening to bees before. I mean, any beekeeper can tell you, you pretty much immediately know which colony is queenless just by opening the cover and listening for a moment.

So, sound is a really important way of understanding bees, but we wanted to take that kind of out into the field and try to detect when bees are visiting different flowers by listening to them. And this was really driven by our interest in soybeans because soybeans are a really, I mean, they're a really valuable crop for bees in the Midwest because there's certainly no shortage of soybeans planted around the whole midsection of the United States.

I think we're up to like 80 million acres, kind of the size of the state of Minnesota is covered in soybeans. And we want to know if these soybeans are actually valuable for bees visiting them. But we quickly ran into a problem, and we're not the first to notice this.

But that problem is it's really hard to see bees visiting soybeans. And that's because the flowers of soybeans are, number one, very small, but they're also underneath the canopy, underneath the leaves in a soybean field. So, it's really hard to tell that a soybean field is really in bloom. And you certainly will never see bees flying across the field because they're all underneath the canopy down where the flowers are, where you'd expect the bees to be. So, a research scientist in the lab, Chia Lin, she was trying to look for bees in some soybean plots, but she found it was much easier just to listen for them.

And so, she would score different soybean varieties just based on the number of bees that she heard in those different varieties. And then we had the idea, well, maybe we could automate this listening for bees and we could just put some audio recorders out in soybean fields and listen for the bees that way. That was great because, you know, we bought some cheap lecture microphones. They last for about 3 days on a set of AAA batteries, and you just put them on a stake out in a soybean field underneath the canopy where the bees are active and just have those listen for the bees.

And that's great because you could get 3 days of recording. You can bring that back to the lab. But then we ran into a new problem, which is, what do you do with a three day long audio recording. You're trying to go through that thing and identify all the bee buzzes in three days of audio.

And so, I worked with a graduate student here who since graduated, Karlan Forrester, and we developed a very rudimentary approach to identifying bee buzzes in those very long recordings. It was extremely labor intensive and required a lot of manual verification to identify what was actually a buzz versus what is just a car driving by or an airplane flying overhead.

And eventually, he got some really good data on when bees are active in soybeans using this kind of semi-manual approach. But the labor involved was just ridiculous. So, I have a newer graduate student, Luke Heron, who has taken up this problem and has really kind of solved that problem of finding bee buzzes in very long audio recordings. And he's developed this tool called Buzz Detect, which uses a machine learning model to separate out those bee buzzes from all of the other noises that you're likely to hear in an agricultural landscape.

Amy

Reed, I'm sitting here listening to answer that question. I'm kind of just laughing and chuckling to myself because, first of all, I don't think my hearing is good enough to be able to sit in the field, and, well, I could probably hear a buzz, but I don't know if I'd be able to identify, you know, the difference between either a honey bee or a bumble bee or, or whatever else, you know, other pollinator.

And then the second thing is just thinking about someone having to listen to days and days of audio recording. That does not sound fun to me.

Dr. Reed Johnson

No, this is a good job for a computer to do, listening to it that long. I should say that Buzz Detect, you'd be surprised that people are actually really good at hearing buzzes and even differentiating between, you know, a bumble bee and a honey bee because they actually do sound quite different when you listen to them. One of the limitations of Buzz Detect that Luke's developed is that we are not yet able to really distinguish between different buzzes.

It just is, essentially, a buzz detector, and it can't tell you yet whether that's a honey bee or that's a bumble bee or maybe that's some smaller bee, though that's certainly the direction that Luke wants to take this, is trying to get some more, you know, information on the type of bee that is buzzing and is being recorded.

Amy

Absolutely. All right, so tell us, what is Buzz Detect? What's the purpose of Buzz Detect?

Dr. Reed Johnson

So, Buzz Detect runs on a computer. At the moment, it is built on YAMNet, which is a machine learning tool developed by Google. The TensorFlow team developed this back in 2022, so it's a bit old as far as AI or machine learning models, but it works well.

This YAMNet model was originally meant to identify sounds in urban landscapes, so it could differentiate between, you know, a door closing or a lawn mower. And Luke took this kind of model that is just generally useful for identifying environmental noises, and he used transfer learning to retrain this model to identify bee buzzes in an agricultural landscape. So, he didn't develop the model from scratch, but he used this freely available model developed by Google to improve it to answer the questions that we're interested with bee bioacoustics.

Dr. Cameron Jack

Yeah, so I mean, this is really interesting, man. Like something that I'm just like totally out of my element here, Reed. This is like a very different bit of research from anything that I've ever done before. So, you know, can you tell us a little bit more about the research behind this tool? And probably, I'm guessing, it's kind of the same for you too. You mentioned your student Luke, who's been kind of taking on this, but did he have to go out and learn a lot and gain some of these skills to be able to develop it? Or did he come to you already with these type of background and skill set that allowed you to kind of work on building this Buzz Detect tool?

Dr. Reed Johnson

So, Luke is not an AI developer. He didn't have a real strong background in, you know, developing these things. So, he had to kind of teach himself as he went along how to take this basically off the shelf tool and repurpose it for detecting buzzes. I mean, I do feel a bit out of my element. This is not something that I could have done myself. But Luke had a really strong background in computational biology and it was not too hard for him over the course of several years now to take this YAMNet model and make it work for buzz detection.

That being said, there probably are substantial improvements that could be made in this approach. And that's the limitation why we may never be able to detect different bee species with Buzz Detect as it currently is because of the limitations of this YAMNet architecture that it's built upon.

And it might take a more specialist model that's developed from scratch to be able to really determine bee diversity using audio detection. And there are groups that are working on that. I know at Cornell, they've got a really nice bioacoustics tool called BirdNET, which identifies birdsong. And you can run this on a Raspberry Pi little, you know, small computer setup with a microphone hooked up to it, and it will identify the birds that are in your backyard, and it will identify them to species. I actually have one of these running in my own backyard so that I can look at the different bird species of and kind of see the state-of-the-art bioacoustics set up that's available.

But that BirdNET team is working on developing a bee detection model. So, we're not the only ones out here doing this, but I think Buzz Detect, it's shown that it can really be useful for detecting bees in these audio recordings, and not just in soybeans. Since, you know, we had such success in soybeans, we've taken this on and Luke has deployed it in pumpkins and watermelons and apples, in mustard, in a whole range of different crops and even non-crop plants to see, you know, what's the story of the activity in all of these different flowering plants that are out there.

Amy

Yeah, Reed, I would be interested to know, I know you kind of touched on this a bit, but can you get a little bit more into the research behind, you know, what you all did in order to make sure that everything was accurate or that you were detecting buzzes? I would love to hear more about the research behind it.

Dr. Reed Johnson

Yeah. I mean, that's really important that when we say we're detecting a buzz, that it really is a buzz that the computer's detecting. So, Luke took this very seriously. He's very careful scientist. So, we actually had thousands of hours of audio recordings from this soybean experiment.

We actually got into a situation where we were like, oh, we've got all these recorders, let's just record as much audio as we can get, and we will just have the faith that we can figure out how to analyze these down the road. That's kind of the question that we gave Luke. Here's thousands of hours of audio. Can you make any sense out of this using a machine learning tool that you develop? What he did is we had a whole range of validated bee buzzes from Karlan's project previously. And then Luke went through and he identified more bee buzzes out of this larger audio recording set.

So, these are, we didn't see the bees, but you know a bee when you hear it, particularly in comparison to all of the other environmental noises that are in these agricultural environments. They're all very different, planes flying overhead, cars driving by, a combine, rain, birds making noises. So, it's pretty easy for a human to identify bee buzzes from these recordings. And then he used those human identified bee buzzes to retrain this YAMNet model so that it would better identify buzzes versus all of the other background noises.

We also labeled all these other background noises that you hear in an agricultural environment to help train the model so it could better identify all of these potentially confusing noises. Planes actually sound a lot like bee buzzes if you're a computer. And that was a major accomplishment was getting Buzz Detect to discriminate between a plane flying overhead and a bee at a flower. So, we retrained the model and then he had a validation and test set that he used to validate the effectiveness of this model.

And so, we went through that whole process of training and then validation on human annotated bee buzzes before we turned it loose on these many thousands of hours of audio that it's only Buzz Detect listening to these. And then he does go back and will listen to segments of the audio to validate that Buzz Detect really is getting what it says it's getting with the buzzes. And he has developed a, you know – to look at the precision and the false detection rates that Buzz Detect is delivering.

Dr. Cameron Jack

That's crazy that the airplanes and stuff would kind of sound like that. But I guess that kind of makes sense if you think of the plane like way up in the sky. And if you're just barely listening, like, I mean, the computer just barely picking up those vibrations might kind of be somewhat on the same plane as a bee, which is funny. I just wouldn't have thought about that. So, I mean, you kind of mentioned some of those little challenges. Were there any other things that were surprising, like any other challenges that you ran into that you had to resolve before you kind of felt good about where Buzz Detect was going?

Dr. Reed Johnson

I guess night time was a real problem, and this was another kind of surprising thing. Early on, Buzz Detect was identifying bee buzzes at night. And of course, there's not much bee activity at night. And so, Luke delved in to try to figure out what that noise was.

I mean, he trained it against airplanes and other mechanical noises. So, what was it at night? It turned out crickets could be a real problem, particularly if a cricket is like sitting on the microphone or is very close. That really loud cricket noise was just, I think it was blowing out the microphone and causing the Buzz Detect model to call things bee buzzes. So, it's been some work to try to get it to discriminate between these cricket noises at night and bee buzzes to get good low nighttime values, which is what you'd expect.

Amy

That's hilarious. You know, I don't know why, I'm just in a really funny mood today because I'm just thinking about crickets on the microphones, like just thinking that they're singing into a microphone and here you are like, what the heck, cricket? Get off of our recording stuff. A cricket. Who would have thought?

So, Reed, you kind of mentioned, you know, that you started with soybeans and then you went to other crops. I'm wondering how beekeepers or growers can use this tool in their operations.

Dr. Reed Johnson

So, I don't think anyone could use it yet. It still requires you to record the audio, download that to the computer, run it through Buzz Detect, and then do some data analysis to get the results. But the goal here would be to create what's called an edge client, which is a model that could just run on a really lightweight computer that could be battery powered and placed out in an almond orchard, for example, to validate, you know, what is the level of bee activity through the day or over weeks in an almond orchard to verify that the bees are visiting or when they're visiting.

And so that's, I guess, the goal would be to create some sort of lightweight device that could, not even record the audio, it would classify the audio on board and then just would be able to record the data – how many buzzes, how many seconds of buzzes are in a particular hour over the course of a day.

So, it's not quite there yet, but I think we're getting there. And I think, if people are really interested in this, Buzz Detect is available on GitHub. And if you want to make your own audio recordings of bees on flowers, it's not exactly a walk in the park to get that up and running, but it's not impossible.

Certainly not. Luke has overcome a lot of the challenges already, and you can get this running on really any computer. This is not a high-powered machine learning model that you need to, you know, get another nuclear reactor started to be able to run. This will run on any computer, and

you can classify your own audio using the instructions that Luke has on that GitHub page for Buzz Detect.

Dr. Cameron Jack

That's cool, Reed. It's been fun to listen to this because I just, like I said, it's very different from anything that I've done and learned about. So, I guess we're kind of nearing the end. Where do you think the future direction of this research is going to go? And is there anything else that you think our listeners should know about Buzz Detect?

Dr. Reed Johnson

I think discriminating between honey bees and other bee species is going to be important for its research value. I think there are other commercially available tools that claim to be able to do this kind of thing, identify bees from sound, but this is freely available so anyone can use it.

It's open source, and I'm really curious to see what people do with it. Where can you detect bee activity? I think, in determining when different crops are most attractive to bees is a really important question, not just from a stocking kind of, you know, when should we put bees there, when are the bees active to maximize the pollination services that bees can provide.

But I think it also provides information on when pesticides can be applied. And that's one of the directions I would like to collect more of this data on bee activity so that pesticide applicators have better information on when bees are active in a crop and when they are not active so that then they can tailor their pesticide applications to a particular site. Because that bee activity can vary depending on, you know, the weather, other environmental conditions or probably even the variety that is planted. And so, they can better apply pesticides and avoid having an impact on the bees that are pollinating that crop.

Amy

I think this is all fantastic, Reed. I'm so excited to see, you know, where this can go. Technology has just been booming, and Jamie and I talk about it often on this podcast, just about, you know, the different platforms and different tools that we have. And I just, I can't wait to see this grow.

Dr. Reed Johnson

We're excited to see where it goes from here. I'm sure this is not the last you'll see of using bioacoustics to look at bees. Lots of other people are interested in this topic and hopefully we can continue to improve Buzz Detect as well to make it better.

Amy

Absolutely. So, it's been three years since you've been on. We'll have to have you on again, hopefully not in, you know, sooner than three years. But was there anything else that you would like to add?

Dr. Reed Johnson

This is a podcast. Bees visiting soybeans.

Amy

I'd love to. Cameron, what do you think?

Dr. Cameron Jack

Heck yeah, let's do it.

Amy

All right, let's do it.

Dr. Reed Johnson

Well, there you go. Bees really are out there visiting soybeans.

Amy

I love it. Thank you so much, Reed, for joining us today.

Dr. Reed Johnson

Thanks. Great to talk with you.

Stump the Chump

It's everybody's favorite game show, Stump the Chump.

Amy

Welcome back to the question-and-answer segment. Again, this is the second set of questions out of our three series of oxalic acid. Jamie and I are taking turns asking Cameron to be the chump just for a couple of episodes, and then we'll probably get back to Jamie after that. But Jamie, why don't you ask the first question?

Jamie

Yeah, Cameron, I think you're a better chump than I am. Maybe you should do this.

Dr. Cameron Jack

Yeah, I don't know. I don't know how you do this week in, week out. I'm already nervous and sweaty over here.

Amy

I was about to say, is that a compliment or a diss? I'm not sure.

Dr. Cameron Jack

No, it's just hard to be the chump. I know that there's probably people just listening to what I said before and just screaming at their, I don't know where they're screaming. Car?

Jamie

I think you did a great job. You did a great job last time. Here's a good chance of redemption if you feel you didn't.

Dr. Cameron Jack

OK, yeah, this is my chance to redeem myself.

Jamie

So, like Amy said, this is just the second in a three-part series on oxalic acid. We've saved these questions for you because you're the expert. People all over the world ask you questions about OA. So, I'm going to toss the first one your way. And that first one is, is it safe to place a package of bees in a closed, empty brood box and then vaporize the box with OA?

I guess the point is here is you're using vapor on a package of bees, but you're doing that in an enclosed brood box. You know, the question is, is it safe? But I also want to add, is this something that the label would permit?

Dr. Cameron Jack

OK, good question. No, this is not something that the label would permit. So, there is a way to treat packages through, you know, making an OA that you were spraying on, but putting a bunch of packages into kind of a closed, empty brood box and vaporizing them is not a legal application method.

Would it be safe to do that? I think it probably would be relatively safe. I can't imagine it doing a lot of harm. The difference is here is when you get bees in a package, they really are clumped in there nice and tight, right? Whereas, even in a regular, you know, hive situation where they might be sort of clumped, but they're still usually like spread through a number of frames, there's still some different, you know, they're not all right on top of each other like they would be in a package.

So, whether or not it's legal, you know, I've already kind of said, no, it's not really a legal method. Whether or not it would be safe, I can't imagine it would be like incredibly harmful, but I can't imagine it being super effective either when they're so clumped together and they really can't move around that much. I don't think you'd really be getting a lot of OA vapor penetrating inside all those clumped packages, if that makes sense.

Jamie

Yeah. And I might also add that, you know, the fact that we're talking about it and they're getting this question to us means it's probably not been one of those things that's studied. So, it's really something, folks, that when you have a question like this, you're thinking about doing a different strategy, you really need to follow the label. Grab the product you want to use and see how it's legally applied and then follow the label. So, thanks, Cameron for your thoughts on that.

Amy

All right, I've got the second question for you, Cameron, today. And the question is, I can't believe we didn't even start with this question in the first series, but the question is, how does OA kill mites? So yeah, I mean, what does OA do to the mites?

Dr. Cameron Jack

OK, so this is the million-dollar question that has been out there for years. You know, it's like, we know that oxalic acid kills mites. We just don't know exactly how. So, let me tell you, from the research that does exist, let me tell you kind of what we do know. What's interesting is most likely more than just one thing.

But on a molecular level, we're not quite so sure. But you know, what we do know is that when we apply oxalic acid to a honey bee colony, it does a few things. One, is it does kind of elicit a grooming behavior in response, especially OA vapor, right?

Like the bees are getting covered in this OA vapor and then they are doing everything they can to groom themselves. Apis mellifera is not super great at grooming itself compared to something like Apis cerana. Apis cerana is the Asian honey bee that's like very good at grooming themselves, where we kind of have to help out Apis mellifera and give them a really good reason to groom themselves. And then when they do, they often knock off a lot of the mites that are on their body. But it's not just that, right? I can take a mite in the lab, and I can hold it down and I can put a little bit of OA on it, and it will die.

And some researchers have looked at this of trying to kind of pinpoint exactly like what's happening here, and they're not entirely sure. But some people have really cool tools and imaging and have watched, like after treating a mite with oxalic acid, they've watched its heartbeat and they see that it kind of picks up quickly, and then it just will die.

But again, we're not entirely sure. There's something about OA. One of my suspicions is that, structurally, it's very similar to boric acid. I've kind of wondered if it – which is like a really good desiccator. I've wondered if there's been like some, you know, relation there where it might be having some, you know, desiccation effect.

Or causing the mite to kind of lose water quickly. We do see damage to their feet. They have soft squishy feet, that makes it so that they can't really hold on. But, again, molecularly, you know, what is actually happening? We just don't really know yet. It's kind of hard to tease this answer out. So, it's still kind of a mystery here.

Amy

That is so crazy to me. I mean, I have so many other follow-up questions, and I'm sure our listeners will too. But it's like, you know, how do you even decide that OA is the treatment, right? So, I don't know. You guys are the researchers, but we can talk about it in a future episode.

Jamie

So, Cameron, this next question is one that I know a lot of people have asked, and we've even wondered about the legality of it, but they're specifically asking, have we conducted any research that looks at the use of multiple treatments? So, oxalic acid followed by other treatments, you know, other approved mite treatments. And then what sequence might be the most effective. So, for example, OA, then this, then OA. I know how I would answer the question, but I guess the question that I'll pose to you is, are people looking at how to stack treatments or stagger treatments to make them more effective?

Dr. Cameron Jack

So, yeah, great question. The answer is going to be yes. People are looking at this and trying to figure out better ways to kind of maybe sequence treatments to give it the most bang for their buck, right?

But interestingly, I think, based on what I have seen in my conversations with beekeepers and researchers all over the world, it's going to be very different, probably, depending on which part of the world you're in. There's going to be regional differences.

So, we have not necessarily done a lot of this work yet, but Jamie and I have published a study a few years ago where we were looking at the seasonal efficacy of treatments. We saw certain chemical treatments work really well in the winter and then in the spring, but not so well for us in the summer and in the fall.

And so, there are definitely things that you could think of if you're trying to incorporate oxalic acid into your treatment regimen, but then you have like maybe some other things. You know,

one thing that I have seen, and I'm going to speak from the Florida perspective here, which, you know, for us, we usually have kind of really warm climate, it's humid kind of through the summer and the fall.

And we really have a lot of Varroa during the summer and the fall, and it's been hard to control. And then we have pretty mild winters. For us, you know, we have seen that there are other treatments that work pretty well for us in the winter since we have quite mild winters.

You know, something like formic acid can work really well in the early spring and in the winter. Even amitraz, you know, using like Apivar. Even though there are issues with resistance out there, we still have gotten good drop and good kill at that time of the year.

But if we try to use Apivar in the summer or the fall, we just don't get a good kill. So, it would not be effective for us then. But where I think OA can really potentially help out, OA vapor with multiple applications and multiple cycles, we have had good success with that even in the summer, even when there is brood present, which means you're going to have to apply it, you know, more often.

So, if I'm trying to apply other things, and at certain times of the year, I should be thinking of like when I apply this treatment, how long of a coverage am I going to get? So, this is like one thing I'm always just begging beekeepers to take the time to do, even at a commercial level. A lot of commercial beekeepers just say like, well, I don't have time to measure.

You have to make time to monitor your Varroa because that's how you will know what works for you and when does it work, because it's not the same for everybody, and it's not the same based on their region. So, it is something that they should be looking at, and then they can make their own effective treatment regimen.

So, I don't even know if I answered the question very well. I just kind of maybe went on a little bit of a rant there. But yeah, there are people doing research to figure out, you know, best kind of sequences. But I think, ultimately, like I said, it's going to be very dependent on where you're located.

Amy

Sounds good, Cameron. You know, this is what the podcast is all about, just going off track and having rants. That's what Jamie and I do best, I think. All right, well, that was the second of the series. We'll have a third series coming up, our last series. We may throw in an extra question or so, so stay tuned.

Hey everyone, thanks for listening today. We would like to give an extra special thank you to our podcast coordinator, Jeffrey Carmichael. Without his hard work, Two Bees in a Podcast would not be possible.

Jamie

Visit the UF/IFAS Honey Bee Research and Extension Laboratory's website, UFhoneybee.com, for additional information and resources for today's episode. Email any questions that you want answered on air to honeybee@ifas.ufl.edu. You can also submit questions to us on X, Instagram, or Facebook @UFhoneybeelab. Don't forget to follow us while you're visiting our social media sites. Thank you for listening to Two Bees in a Podcast.