Episode 248: Varroa Biology and Pesticide Research with Dr. Kirsten Traynor

Jamie

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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.

Hello everyone, and welcome to another episode of Two Bees in a Podcast. Today, we are joined by our guest, Dr. Kirsten Traynor, who is the Director of the State Institute of Bee Research at the University of Hohenheim in Germany. Kirsten, thank you so much for joining us on today's podcast.

Dr. Kirsten Traynor

Thank you for inviting me on to the show, it's a real pleasure.

Jamie

Honestly, when I saw that you are going to be our guest, I'm like, oh my gosh, we could really talk to you about so many different things, because I've seen your research for a while and I know that you like honey bees. So, you've gone in lots of different directions. But today, I think we're going to broadly talk about your recent work in Varroa biology, and then your recent work in some pesticide research and then branch off any direction you want to go.

But before we do any of that, could you introduce yourself to our listeners? Could you talk about how you got into the honey bee world in the first place and what you're doing now?

Dr. Kirsten Traynor

Sure. I must admit I am a somewhat accidental beekeeper. I had actually done my undergraduate degree in English literature, and then when I graduated, I lived on a farm in Maryland, and I put in a wildflower meadow. For this meadow, I wanted some pollinators and so I stumbled into a short course.

And in the short course, I won a honey bee hive. Not the bees, just the box. But as soon as you have a box, you have to kind of fill it with bees. And I started with three. Within three years, my

three hives became 20 and I was suddenly a beekeeper. And then I had actually applied to study the differences between European and American beekeeping.

And I received a German Chancellor Fellowship from the Alexander von Humboldt Foundation, where I was then based in Lower Saxony in northern Germany, but traveled throughout Western Europe to Italy, France, Denmark, speaking with beekeepers, bee breeders and bee scientists.

And I had such a good time doing this. And during this time, I started writing for American Bee Journal about my adventures, and Bee Breeding Around the World was a column that I had written for ABJ. And it was such an interesting world that opened up to me that I decided when my fellowship was over and I returned to the United States, I would like to continue working with bees.

And so, I started writing to honey bee scientists asking if there might be an opportunity for me to continue my education. And I managed to convince Rob Page, who had just moved from UC Davis to Arizona State University, to take a chance on an unusual candidate.

And so, I was allowed to start at Arizona State University, and they gave me one year to pass the biology GRE subject test, which I did with flying colors. And then I was allowed to stay, and I did my master's and PhD on brood pheromones and how they influence foraging behavior in honey bees.

Amy

Kirsten, did you say you did your undergraduate degree in English Literature?

Dr. Kirsten Traynor

Correct. At Kenyon College, a very, very small liberal arts college in Ohio.

Amy

That's so funny. I don't think we've had anyone with a background in English literature before that transitioned and fell accidentally fell into bees, so that's pretty cool.

Dr. Kirsten Traynor

So yeah, it's an unusual life story. It's a turn of events I wasn't ever expecting. But it's probably why I've also always sort of kept a foot in writing and outreach for beekeepers. I really enjoy science communication.

Amy

That's amazing. I love that. So, Jamie had mentioned that you've done a lot of research on Varroa and we were even talking before we pushed record today about all the research that you've done with Varroa. Of course, in this podcast, we talk about Varroa in every single episode.

I actually don't think there's an episode where we haven't said Varroa. And so, you know, let's dig into it. Let's talk about the research that you've done on Varroa. Tell us about some of the work, specifically, that you and your colleagues have conducted.

Dr. Kirsten Traynor

So, it all started out with a review paper we did, which is Open Access, for trends and parasitology where we were pushing the idea that Varroa, we tend to underestimate the damage they do. Varroa is an incredibly well-adapted parasite. It understands its host beautifully.

It listens to the chemical signals that honey bee brood gives off, and it uses this to determine what cells to invade, and it's incredibly well-adapted. So, we tend to think from a bee perspective instead of flipping the coin and looking really from the mite perspective.

And the mites are very, very good at adapting to the different circumstances we have in our honey bee hives. So Varroa destructor is originally a parasite from Apis cerana, the Eastern honey bee or Asian honey bee, where they can only reproduce in drone brood.

They cannot reproduce in worker brood. But when they switch to Apis mellifera, the European honey bee, they are able to reproduce in worker brood. And that's part of the reason it's so problematic because when colonies stop rearing drone brood in summer, in late summer when we tend typically have a nectar dearth, the brood nest shrinks a little bit.

Then you start having multiple mites in individual cells. And this is actually something that I'm looking at with my PhD student at the moment, Yakun Zheng from China, who's working with us in Stuttgart, Germany. What the impacts are of multiple mite infestation in this single brood cell.

And this actually was triggered out of a beekeeper question when I was giving a talk on Varroa biology. A beekeeper had asked, well, if you have multiple mites in late summer in a cell, is that slowing down the development time of the pupae and then giving those mites an even longer chance to reproduce and raise more daughters?

And so, we teach a science course every summer for master's students, and we always have mini projects. And in this summer course, then, last summer, we had students insert single mites or 4 mites into a single cell to look at the development time and impact on honey bee brood.

And we've now continued this research because it was quite surprising how many of the pupae did not manage to survive when they had multiple mites in the cell.

Jamie

I tell you, one of the quotes that you said early there, answering Amy's question, I think is scary and telling. We tend to underestimate the damage that Varroa does to bees. And it's funny because that's like what we talk about all the time and what beekeepers control all the time.

But I agree, I feel like we've gotten to the point where people just write it off. When they see colony losses, they blame everything, sometimes, except the culprit, right? And I think Varroa is just beyond our wildest dreams, worse than we give it credit.

And I'm curious, you talked about this really cool project that you're doing, looking at multiple mite invasions in the cell. What is some of your other historical research overall? And what are some other things that you're doing now or you're planning in the near future?

Dr. Kirsten Traynor

So, we've looked a lot at hygienic behavior and non-mite reproduction as part of the SETBie project, which was a larger bee breeding program in the part of Germany where I am. And we find that because the male egg is laid first in a Varroa mite cell, it tends to be near the top of the cell.

And so, when you have this uncapping process, more often than not the male is missing from the cell. We also looked at the different signals from the mites or other glass bead objects that were of similar size to see what triggers removal and uncapping in honey bees, which was quite interesting.

That was the research of Lina Sprau and we are now also working on different management strategies. So, I have a PhD student, Leon Reinhold, who compared four different management strategies in the spring and summer.

So, over the whole beekeeping active season where we have one, which is just biotechnical, so where we do intensive drone comb cutting in the spring and then a process where we cage the queen on a brood frame and move her every nine days and then remove that brood frame once it's capped.

And we compared that to a very common strategy where you do normal drone brood cutting where you have one drone brood frame per colony and then you do a double formic acid treatment in late summer. And then we compared that to no drone brood cutting and just a synthetic treatment in late summer.

And it was really interesting to see that through drone brood cutting, we significantly tamped down the Varroa mite population in early August. So, the colonies where we had no drone brood cutting had somewhere between 2500 and 8000 mites in August when we then started those late summer treatments.

Whereas the colonies where we've been cutting one drone frame on average had between one and 2000 mites, and where we had three drone frames in the colony that we were removing on a weekly basis, we had below 2000 mites per colony, with some only having about 500.

Amy

Kirsten, I'm thinking about all the things that you just said as far as the research that you're doing. And I guess I want to start off, so I want to kind of go through some of the projects that you have just mentioned. And first of all, I think it's really awesome that the research came from the question that a beekeeper had, right?

Because in my perfect extension honey bee science communication world, that's how things would work, right? A beekeeper has a question, you kind of look into it, delve into it, and then realize that there's something bigger to it. So, you know, increasing the number of mites and cells, you're looking at hygienic behavior, you're looking at what triggers removal of cappings. Can you kind of discuss some of the results, like some of the big results that you have from these projects?

Dr. Kirsten Traynor

Sure. What we found with this one where we compared the four different management strategies is that you can control the Varroa mite population in your colony without chemicals. But it's time intensive, so it requires doing much more drone comb cutting.

So, we had three combs of just the wooden frame, no foundation on the edges of the brood nest in the two brood chamber colony. And we put one in every week and then you end up on a three-week cycle. So, every week you're removing one, which has been in the colony for three weeks.

And through this process we actually tamp down on the swarm drive. So those colonies almost never got into drawing out queen cells, whereas in the colonies where we were only doing one drone frame per every three weeks, about 50% of the colonies ended up having swarm drive. And in the colonies where we had no drone comb cutting, all of the colonies ended up wanting to swarm.

And although we're not removing all that many Varroa mites over the given season, so we were removing about 80 to 150 mites with these drone combs cuttings total over the season, when you remove them early in drone brood, a mother mite can produce two to three daughter mites.

So, every 15 days, which is the length that you have capped drone brood, you are having a tripling or a quadrupling of the Varroa mite population. So, every mite that you remove in April, in May and in June, you are stopping many, many subsequent reproductive cycles and you are thus tamping really heavily down on the mite population, which is why in August we see these really big differences in total mites that are still in the colony.

And I fully agree with you. I think beekeepers spend a lot of hours in their colonies looking at their bees. They have a very good intuitive sense of colony health. And this is why I always seek to have a dialogue. I feel like research and beekeepers need to be exchanging information and be open to each other's ideas.

Obviously, when you then test them in a scientific context, what we do to our colonies, a beekeeper would never do. I mean, we are taking brood samples every second week to see how infested it is with mites, to see how it's changing over the beekeeping season. And to do a single sample takes 20 minutes.

So, beekeepers are not going to be uncapping 200 cells in the field per colony to look at their mites. Crazy scientists and PhD students, they will.

Amy

Definitely. I do speak to beekeepers' associations quite often and it's always something that I mentioned is, you know, keeping bees for research is completely different from keeping bees as a beekeeper. So, I just wanted to ask, what are some of the greatest research needs with Varroa?

Dr. Kirsten Traynor

So, I think one of the biggest gaps we have, and this is why I'm trying to establish more and more connections with Asia, is looking at Varroa destructor on its original host, Apis cerana, and trying to understand some of the behavioral adaptations that exist in cerana colonies and how they deal with Varroa.

It's also really interesting because when you take Varroa mites that are from Apis mellifera colonies and you put them into worker brood of Apis cerana colonies, the brood ends up dying, sort of committing apoptosis and not developing.

When you take mites though that are in drone brood from Apis cerana, to my understanding, and you put them in the worker brood of Apis cerana, those mites just simply do not reproduce. And so, it's very interesting to me, are there differences in these mite populations?

Are the mites that made the jump to Apis mellifera different in their behavior than the more diverse Varroa destructor population we have within Apis cerana? I think there's a lot of gaps that we can learn from Asia where mites and bees have been co-evolving for much more time.

Jamie

Kirsten, I really feel like we could spend a lot of time with you talking about Varroa because you've got such enlightening discussions. I like the fact that you're spending a lot of time on biology, right? And not just, well, let's just put more, you know, chemical controls in, but you're thinking about the mite, you're thinking about it about it from the mite's perspective.

And I really think we should maybe change this whole podcast episode to stay on Varroa. But alas, we also had this kind of hard pivot to another topic because you guys have also done a lot of work, still doing a lot of work with pesticides, pesticides and honey bees, all of that stuff.

Could you talk about what got you interested in this topic and some of the active projects that you have in this space?

Dr. Kirsten Traynor

Sure, I'd be happy to. So, when I finished my PhD, I switched to the University of Maryland, and I switched from basic research to more applied in the lab of Dennis vanEngelsdorp. And I was given a large data set from the APHIS Honey Bee Health Survey and sort of said, please try to make sense of this as well as some data that had been collected in the aftermath of the large losses from colony collapse disorder where beekeepers were migrating along the Eastern seaboard pollinating different crops.

And samples were taken at multiple times during the season. And we looked at the pesticide residues in those colonies. And what was really, really interesting when we started looking at this is that we found incredibly high concentrations of fungicides and quite a lot of diversity.

So, we were looking at pesticide residues and metabolites from about 215 different pesticides. And what we were finding is that the colonies that did not survive the whole season, that had higher levels of brood disease or queen turnover, were having really, really high levels of fungicides.

And so based on the actual residues we were finding in those colonies, I did a study with Zachary Lamas where we took specific fungicides and specific insecticides that were showing up in these samples quite frequently. We mixed them into pollen, and we fed them over 4 weeks, to colonies specifically to see what impact they have when these colonies are faced with fungicides, which are normally bee safe, but in really high levels, which the bees still have to consume, detoxify, deal with, what kind of impacts will we see? And we did it in the first year in full size colonies.

And what we saw was an odd behavior that confused us a little bit where the colonies would draw swarm cells as if they wanted to swarm, but there was no swarm pressure. The bees still had plenty of room in their brood nest. They weren't confined in space.

They were bringing in pollen, and it was a very odd behavior. So, then the following year we repeated this in 96 smaller mating nucs to see if we saw the same behavior. And when the colonies had really high fungicide exposure, they would try and draw queen cells and replace their queen as if they were swarming.

Whereas the colonies that were not exposed to insecticides or fungicides, they would actually abscond because they would out fill their little space and be too many bees. So, the whole colony would take off. So, it was very interesting taking field results where we had strong correlations and then doing a practical experiment where we forced the bees to consume this pollen with these insecticides and pesticides to see when we stopped feeding the insecticides and pesticides, what impact, what carryover effect would it have on the bees.

So, we then stopped feeding them this contaminated pollen and looked at their brood rearing after the fact. And what we found is that they cannibalized a lot more of their brood. They had significantly fewer amounts of bees that they were rearing, even though this next generation had access to clean pollen and was no longer feeding on the contaminated pollen.

They were the nurse bees that had been raised on contaminated pollen and their behavior towards the next batch of brood was different. So, there were carryover effects. Even though they weren't having negative effects that were killing off the colony, these high doses of fungicides were changing bee behavior.

Amy

That's so intense. I have so many follow up questions. So many things to discuss. OK, so I want to start back with feeding the contaminated pollen and them trying to have a swarm. You know, why do you think that was?

Dr. Kirsten Traynor

My hypothesis, which I always wanted to pursue a bit more, is that this high level of insecticide, I mean it's still sub-lethal doses. So, we have an HQ, a hazard quotient, and you would need a dose of 10,000 consumed in a single day.

And we were feeding this over a 10-day nursing phase where we only had an HQ of 1000, which is what, in our national survey, we find in about 5 to 6% of all pollen samples we analyzed. So, this is a sub-lethal amount of pesticides that we were feeding.

I think what is happening is it’s somehow changing the signals that the queen is giving off. So, her pheromone bouquet is my hypothesis or in the perception of the nurse bees of the queen. She's still laying, so her egg laying rate was similar, but she's no longer being perceived as a fully functioning queen.

And so, then the colony, I think, is trying to raise a replacement queen to take care of this problem. They have a queen who is laying but who doesn't have the full queenly signal that you would normally have in a healthy queen. That's my hypothesis. I always wanted to look into it in more detail, but then I actually ended up switching countries, and I've now been doing pesticide analysis in Germany with a 20-year data set through the German bee monitoring.

And what we find is we find a very high diversity of pesticides. But whereas 5 to 6% of all samples are above 1000 HQ in the United States, in the 2700 samples since 2009 that we've analyzed in Germany, only five of them have been over this HQ of 1000.

And twice, that was because of beekeepers actually painting their hive bodies with an insecticide, a wood preservative that was also an insecticide. So, we just have far lower pesticide levels in Germany due to agricultural policy than we have in the pollen in the United States. It's a dramatic difference.

Amy

Maybe we can pivot over to that because we had kind of mentioned it before we started this episode was just the difference between the beekeeping and some of the results that you have in Germany versus the United States, and then maybe some of the active ingredients or products that are being used.

Dr. Kirsten Traynor

Right. So, in the United States, we have way more active ingredients that are allowed on the market. This is very, very tightly regulated within the EU. In our German bee monitoring, we actually look for far more pesticide residues than we did with the APHIS Honey Bee Health Survey.

So, in the US, we were looking at about 215 different pesticide residues and their metabolites. In Germany, we're looking at about 475, on average, and we do find a large diversity of products. So, we find up to 35 different pesticide products in a single pollen sample that is collected and pulled from 3 to 4 hives.

However, it is in much lower contaminant levels. So, overly, what we find a lot of are fungicides which are considered bee safe and so are not contributing to these high hazard quotient scores which calculate the risk of consumption to a honey bee.

However, even when we find fungicides, we find them in lower concentrations typically then we're finding them in the United States. What has actually happened is that because pesticides are very, very tightly regulated within Germany, a lot of farmers are struggling to find products to deal with a lot of their pests.

So, what they mainly still have access to are fungicides, but many of the insecticides they used to use are no longer allowed.

Jamie

So, Kirsten, we were chatting off the air before we started this podcast, and you were talking about how organic farmers were pivoting to the use of copper to control things. And I'm curious what you have found with its interaction with bee health?

Dr. Kirsten Traynor

Sure. I'd be happy to talk about it. So, there's a big movement within the EU to increase the amount of agricultural land under organic management to about 30% of the agricultural farmland in the next 10 years. And so, we were working with apple orchards down at the Bodensee, the large Lake Constance area in the southern part of Germany, to examine what impacts copper has on honey bees.

And we had set up in an orchard, we collected both the pollen from apple blossoms, and we collected the pollen, the anthers from dandelions, because we end up with a lot of dandelions in apple orchards. They're not removed the way they are in in some orchards in the United States. We collected pollen before and after copper application, and we do find large increases in the amount of copper that is in the pollen.

However, when we feed similar copper doses to bees, we find that if they're given a choice assay, so if they're allowed to choose between uncontaminated copper sugar syrup and contaminated copper sugar syrup, they will preferentially consume more of the uncontaminated copper.

They will still consume some of the copper laced sugar syrup and if we have high enough doses, it does have an impact on longevity. But in the actual colonies we set up in the fields, although we find the copper in the pollen they collect, it is not in the nectar they're collecting.

It is not in the honey they're producing. And the honey bees seem to be able to buffer the use of this fungicide quite well. We had a master's student who just did a master's thesis where we also looked at Osmia, the blue orchard bees that are used in pollination.

So, Osmia bicornis is the one we looked at in Germany. And we dosed their pollen both in the field in their nesting boxes or we took them into the lab and removed their pollen so we could more closely control the dose of copper we were putting into their pollen.

And what surprised us is that with low amounts of copper, we actually had higher rates of pupation and survival than with the water control that we used. And it was only in the very, very high, not field relevant doses that we started having some variability in development times.

But otherwise, we were having no negative impact of this copper in the pollen in normal field relevant doses. So that was quite surprising. So, these Osmia seem to be quite hardy.

Amy

That's pretty neat. It's always interesting too with honey bees and them being able to make the decision of what's considered contaminated versus not. So, it's pretty cool. So, Kirsten, again, you've done a lot of Varroa work. It's really cool to hear the pesticide work that you're working on now in Germany.

And, just overall, what are your big kind of takeaways and what does some of your research mean for beekeepers?

Dr. Kirsten Traynor

That's an excellent question. As I said, I started in beekeeping and then sort of fell into research, so I think the questions I try to ask always end up having applications for beekeepers in the long run. I am really, really curious about basic Varroa biology because this parasite is just so incredibly well adapted to bees and I think we're underestimating our enemies, so to say.

And the better we know our enemy, the better we can manage our hives and think creatively to use the biology of the bees against the biology of the mites. So, I think this is one of the reasons we did this beekeeping management strategy comparison with four different strategies from really time intensive management where you'll have to find your queen and you have to cage her, you're doing intense drone brood removal.

That's sort of for the backyard hobby beekeeper who has a lot of time and a lot of interest. And we compared that across the whole range of Varroa mite management where somebody is a weekend warrior, they're just hanging in their synthetic strips. They're hoping for good Varroa control with that, and we wanted to see how that differs over the whole beekeeping season.

I think also that with climate change and the viruses that mites are transmitting, we have a moving target, right? So, honey bee colonies swarm once a year, they're reproducing, in effect, once a year and raising another generation, even though the queen can lay up to her own body weight in eggs every day.

Varroa mites, in contrast, reproduce only during the capped phase of honey bee brood. So, 12 days in worker brood, 15 days in drone brood. And every time they're having a reproductive cycle, this gives them a huge leg up because they have way more reproductive cycles per year, which allows them to adapt to their host each time.

This is another reason why we end up with Varroa resistance evolving so quickly is they're having so many reproductive cycles and each one is a test on their fitness. So, they're incredibly well-adapted. And I think we have to take a step back and think, what do we want long term?

Do we want to be on a chemical treadmill for our colonies? Do we want to try and work with the natural resilience in our hives? And how do we even assess that? I think sometimes we get so lost

in just getting through the season, getting through the winter, that we don't take the time to reflect.

And I think one of the biggest things we can all do is have more dialogue with other beekeepers and welcome different points of view. I have always learned the most from the people who like to argue with me. And then I think about what they've said, and then I step back and think that's actually a really good question.

How could we design an experiment to really see what the answer to that is? And so, I think looking at our hives and learning from beekeepers and listening to what their actual problems are is super important in research. And so, I welcome more and more dialogue between beekeepers and scientists.

I think that sometimes gets a little lost. So, I think it's wonderful that you guys do this podcast with outreach and you bring on a diversity of speakers. The more ideas we hear, the more we can exchange, the better we all become in keeping our bees healthy.

Jamie

Well said. So, I'm listening to you talk. I know about your history and how you got into the honey bee world. Are you able to keep bees where you live? Do you keep bees personally, or do you just get everything you need from your job with bees?

Dr. Kirsten Traynor

We have about 200 colonies at work, but those are bee colonies for research purposes. And I realized that the hives in Germany, they're a little different than what I was used to in the States. So, last summer I actually started with three nucs again and I just brought them through the winter.

I'm building them up again this spring. So, now I have 3 colonies. They will probably turn into 5 because it's hard to keep them at just three, but that is going to be my maximum. I'm totally just a hobby beekeeper with not enough time for my colonies. They are sometimes neglected more than they should be, but they came through the winter quite well and I'm looking forward to a full beekeeping year with them this year.

Jamie

I love that. I was able to do a sabbatical in Germany years ago. Love the nation, loved my time there. Thought beekeeping would be cool there. And when I heard you were working at this position a few years ago, I'm like, man, this is a cool opportunity for her to do cool bee research as well as raise some bees in Germany.

So that's neat that you're able to do it. I like the fact that you keep your feet in it, as it were. Well, Kirsten, thank you so much for joining us. You guys are doing great work. It's always cool to see you at meetings and hear about your projects. And I really appreciate you sharing some of the information that you guys are generating with us here on the podcast. So, thank you so much.

Dr. Kirsten Traynor

Thank you and have a lovely day.

Stump the Chump

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

Amy

Welcome back to the question-and-answer segment. Jamie, I've got a pretty easy one for you here.

Jamie

I hope so.

Amy

Easy for number one. How do bees make honey?

Jamie

It seems easy, but there's a lot of chemistry that happens in their – chemistry of which I am even unaware even though I've worked with bees for a long time. OK, plants produce nectar, at least a lot of plants. Flowers produce nectar to attract pollinators.

So, some flowers have tissues at the bottom that are called nectaries. And these things produce nectar, right? Names imply. And usually if a plant is producing copious amounts of nectar, they want to be pollinated, right? They're usually pollinator dependent.

Things that don't need pollinators don't produce nectar, like pine trees as an example. All right, so if a flower is producing nectar, it wants a pollinator to visit. A bee goes, sticks its proboscis, its tongue, down to the base of the flower where the nectarines usually are, and they suck up that nectar.

Nectar is really just sugar water. I'm oversimplifying it here, of course, but nectar is sugar water with a lot of secondary plant metabolites in it. It's a big fancy phrase but think about it like this.

If you grow herbs and spices in your garden, you know, peppermint, thyme, those kinds of things. Peppermint and thyme, those smells, those scents, those are secondary plant metabolites. They're just things that the plants made. So, nectar is principally sugar water.

It's about, and I'm going to round this off, nectar is roughly 80% water and 20% sugar with a lot of secondary plant metabolites mixed in. And those secondary plant metabolites give it the color, the smell and the flavor.

So, the bees will suck that stuff up into their crops, which are these nectar storage organs in their bodies. They'll fly that back to the nest. And while they're flying it back, that nectar gets enzymes added to it, and these enzymes do some things to the sugars in that nectar.

When that nectar forager gets to the nest entrance, she goes into the hive and offloads that nectar to a nectar receiver bee. That's a bee whose job it is to just offload the nectar from the foragers. That receiver bee also adds enzymes and then walks to the place where she's going to deposit the nectar into the cells.

At that point, she will actually blow nectar bubbles, almost like bubble gum, where she blows a bubble and sucks it in and blows a bubble and sucks it in and blows a bubble and sucks it in. That starts the evaporation of water off of the nectar.

And again, to over generalize, nectar's roughly 80% water and 20% sugar. Honey is roughly the reverse of that 80% sugar and 20% water. So, a lot of water has to come off of nectar in the conversion to honey, and that nectar receiver is blowing bubbles to start that process.

Then she will put that nectar into the cells. And think about it at this point. That nectar has already had some water evaporated off of it. That nectar has already had enzymes added to it, and with its secondary plant metabolites, it's already got its color, its smell, and its taste.

Then bees stand on the walls of the hive and at the nest entrance and fan their wings, which pulls more water off of that nectar. Those enzymes are converting sugars and doing other things inside of that nectar. And once the bees have enough moisture pulled off of that nectar, they cap it as honey.

And honey is basically processed and dried nectar. It's a super saturated sugar solution, and its color, its flavor, its aroma all come from the secondary plant metabolites that would have been unique to that species of plant, which is why we have different flavors and colors and tastes of honey.

Remarkable, isn't it? What honey really is. It's so cool.

Amy

An Equal Opportunity Institution.

It really is. Yeah, that was way more than I expected you to answer. I thought you were just going to say the bees go out, grab nectar, bring it back in, turn it into honey.

Jamie

I know, Amy, I got excited while I was talking about it and couldn't stop.

Amy

I'm just kidding. That's what makes this a podcast is that we don't just talk about, you know – give you the bare minimum, everyone. All right, so the second question that we have today, this person was cleaning off old frames. They were scraping off empty comb, and there was some pollen that was scooped out of it and this person put it back in the hive.

And the question really is, is there an expiration date on pollen that is packed into a cell? Or, do the bees perceive this as rancid if it's been there for a while? I guess if it's packed into a cell, it's probably stored in there.

But if someone's going in and they're actually cleaning off the frames and they pull that pollen out, you know, what happens to that pollen? Is it OK? Can this person freeze it? Can they serve it back to the bees? What should this person do?

Jamie

You know, Amy, I've actually been asked this question a few times through the American Bee Journal series where I write the question-and-answer article for, and it's essentially this very question. It might be the way that you asked it here in this particular question, or sometimes it comes to me as, I've got this old comb from a dead out hive when I've got this pollen and should I use it?

My answer is always the same. I have looked and looked and looked for evidence that pollen that's six months old, well, let's just say they've converted it to bee bread once it's in the cell. So bee bread that's two months old or bee bread that's six months old, or bee bread that's one year old, or bee bread that's two years old.

Has it lost its nutritive value? At what point do bees not benefit from it? You know, is there any benefit to me putting it back into hive? And Amy, I've not really found good, clear answers. My approach then has been to trust the bees.

And what do I mean by that? OK, I have to make these decisions myself as a beekeeper all the time. When in doubt, if I see pollen in frames that I want to use later, I freeze it so that it'll be ready later. Now, that gives its own set of questions as well.

How long can it be frozen before it's no longer useful for bees? And all of this pivots back to my first statement. I trust the bees. I don't trust myself. I trust the bees. And what does this have to do with this question? Well, I would be very comfortable giving it back to the bees because I know if they can't use it, they'll just clean it out and if they can use it, they will.

I feel like we as beekeepers put too much pressure on ourselves with this particular question. And let me just put it to you this way. If I have reason to doubt the safety of the pollen, in other words, it came from a dead out colony that I worry that pesticides were what killed it, or maybe they had American foulbrood.

If I have reason to question the safety of the pollen, then I'll throw it away and won't put it back in the hive. But if I have reason to question the nutritive value of the pollen or if it's rancid or not, I don't make that decision.

I just trust the bees. I give it to them, and if it's rancid, they'll toss it out. If they can use it, they will. So, if it's a safety issue, I make the decision. If it's not a safety issue, I trust that if I put it in the colony and the bees can't use it, they'll toss it out.

I know that's not an answer to the question because the person wants me to say, well, after six months you can no longer use it, or after three months of freezing, you can no longer use it. Those answers don't seem to exist, Amy. So, it's easier to say if I question its safety, I don't use it. If I don't question its safety, I trust the bees.

Amy

Definitely. I mean, you know, I'm thinking about, we've had Dr. Priya Basu talk to us about pollen and her research on pollen. We were talking about pollen in Florida specifically and how well it would do in a freezer and not, you know, like a laboratory freezer, but just like your basic freezer at home and whether it would produce mold or not.

And so, I thought that this definitely tied into that question. You know, I don't know if we have an answer to that, again, it must be time of year, right? It depends on how moist the pollen is, if we're going to dehydrate it. And then when we start thinking about the pollen in the cells, they're packed in there pretty tight and if you're going to take it back out and give it to the bees, are you going to try to smash that up to make it a pollen powder? Or would the bees forge it and just kind of, you know, try to get as much as they can off a granule, like so many questions that I have.

Jamie

Hey, who out there wants to do a PhD? There's no shortage of bee questions available to study.

Amy

I know. I have all the questions, OK.

Jamie

Yeah, I wish we could have 20 graduate students at a time. That's a ton of work. But my question list, Amy, really is that long. Those are 20 things I could come up with in no time to study.

Amy

I agree. I agree. OK, well to our third question, last but not least.

So, I'll do a little bit of background, and then I'll ask the question and then let you know what the person's opinion is on this and you can let us know if you agree or not. So, with the background, you find queen cups usually in every hive, right? It's to one side of the brood nest, mid-frame or so.

These are usually the supersedure queens because of a failing queen. OK, so when the queen passes these queen cups, empty queen cups I assume, does she lay in them every time or does she wait for the workers to direct her to lay in a queen cup?

Jamie

I tell you, Amy, it's like serendipity. I just finished writing, this is the second time I've referenced this in this episode, I just finished writing the June or July, June 2026 American Bee Journal classroom article and I got asked this same question.

By a different person, in fact. So, I'm actually kind of ready to answer this question. And it boils down to, you know, the basic question is, do queens lay in queen cups? OK, yes, they do. The question then is, how often?

And the other question for the American Bee Journal, their questions were slightly different. So, I'm just going to answer both sets with this kind of overview. We all know as beekeepers that there are queen cups and hives most of the year, right?

If you go into a hive at any given time, you're going to find queen cups. Queen cups are basically the start of queen cells. I recognize two broad categories of queen cells. Queen cells that are being built for swarming purposes.

So, we oftentimes call those swarm cells, and queen cells being built for supersedure purposes. And so, supersedure is replacement of a queen. So, swarming is, you know, the colony's going to swarm. Swarming is a planned event.

Bees build queen cups; queens lay in them. The workers draw out those cells. You know the biology. The old queen will swarm with half the bees and so forth. You go from there. All right. That one's easier to understand. And since they're planned events, those cells tend to occur at the perimeter of the combs.

Supersedure, then, Amy, I split into two categories, so kind of category 2A and 2B. Supersedure is either an emergency, which is response to a dead or a missing queen, or it's planned to replace a failing queen. When it's in response to a dead or missing queen, there is no queen to lay an egg in a queen cup.

So, the workers are going to go to existing female larvae that are 12 to 24 hours old and pull out those worker cells to make supersedure cells.

And in those cases, they're using the youngest available females to make queens, right? Supersedure, that's kind of emergency because there's no queen to lay eggs. So, they have to go to what's available. But there could also be planned supersedure where the queen is failing and she's laying eggs in queen cups indiscriminately.

And the workers will use those eggs laid in queen cups to replace the queen laying those eggs. And so, the question then is kind of a follow up to one of these questions, how often do they lay in them? I've never seen a study on this. Preparing for the American Bee Journal answer, I looked and looked and looked and could not find good data.

But what the consensus, Amy, seems to be is that queens kind of lay indiscriminately into these cups when they encounter them. And then the workers decide whether or not to rear a replacement queen.

So, if a failing queen happens to lay an egg in one of these cells, the workers may carry it to fruition and replace her. If a good queen lays into one of these cells, the workers may even start the production of these cells and then abort them because they know they have a good queen.

And I see aborted supersedure cells made all the time. And that just simply says the queen laid in them because she lays eggs and cells. The workers pulled them out because they rear brood and then decided they had a queen and no longer needed it. So, three categories, swarm, purposeful, queen lays in queen cups because she normally does.

Workers pull that out, they swarm. Supersedure. Emergency supersedure, they go to existing brood because that's all that's there. Or planned supersedure, they might use an egg laid into a queen cup or they might use existing brood because they want to replace the existing queen. So, there you have it. That's the best of what we know at the moment.

Amy

OK, quick follow up. Just a quick one. So, we put foundation with worker cells on a frame. The bees go and take the worker cells and they make a cup?

Jamie

Yeah, what they'll do is there will be aberrations in the comb because workers don't just want worker brood, they also want drones and other things. And so, they will purposely take some of those cells from the foundation up and make them into drone cells. Or you'll get these aberrations in the cone where they will draw out these queen cups. So, you'll see this even in a colony that you give exclusively worker foundation.

Amy

What about drone? Can they go smaller?

Jamie

They can if they need to but if the egg was laid in a drone cell, they can't use it to make a queen, right? But yes, they will take worker size cells and open them to make bigger queen cups and queen cells.

Amy

Very cool. All right, listeners, you know what to do. Send us an e-mail if you've got any questions for us, follow up questions, topic ideas for future podcasts. We love to hear from you all. Thanks so much.

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

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