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SPEAKERS

Amy, Guest, Jamie, Stump The Chump

Jamie 00:10

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. Hello, everyone, and welcome to another segment of Two Bees in a Podcast. In this segment, we're joined by Dr. Michael L. Smith, who's an Assistant Professor in the Department of Biological Sciences at Auburn University in Auburn, Alabama. He's also an affiliate member of the Max Planck Institute of Animal Behavior in Germany. And at Auburn and doing some of the research he's been doing, he's been looking at one of those things all beekeepers think about, but we just don't know a lot about, which is the fact that bees make hexagons. When we look at our combs, we know that those combs aren't always perfect. Sometimes there are areas of disturbance. So Michael has studied this. He studied comb construction and honey bees. He and his colleagues published a recent paper in the Proceedings of the National Academy of Sciences. That paper is entitled, "Imperfect comb construction reveals the architectural abilities of honey bees," and we're going to talk all about that with Michael. Michael, thank you so much for joining us on Two Bees in a Podcast.

Guest 01:52

Thank you for having me. I'm happy to be here, virtually.

Jamie 01:56

Michael, I forgot to talk to you about this before we started on the air but my PhD supervisor in South Africa, Randall Hepburn, was fascinated with comb construction and wax use and bees. And of course, he wrote some books on nest architecture and things like that. So when I saw that this was the topic that you were going to talk about today I got excited because it instantly took me back to my PhD student days. But Michael, before we get there, all of our listeners love to be introduced to our guests and want to know how you got into bee research, beekeeping, bee science, and how you got where you are. So could you tell us a little bit about yourself and your journey?

Guest 02:34
Yeah, so I'm Michael Smith. I'm currently an Assistant Professor at Auburn University. But I first got interested in honey bees and beekeeping when I was in Wales at boarding school, and I just randomly met this beekeeper and he was kind. I just I met him and I don't know, it was kind of random, but I was just like, "I love bees." And he was like, "Oh, well, come check out my apiary sometime." And yeah, so I met him, I started learning beekeeping and just was kind of hooked from day one. So that was high school. And then I kind of just continued that interest through my time in college when I was also working for Heather Mattila at Wellesley College. I was like her bee flunky in the summers. And then I did my PhD at Cornell with Tom Seeley, which was a great experience. And then I continued with the bees as a postdoc at the Max Planck Institute, working with Ian Couzin, who's an awesome guy and just an awesome Institute. And now I'm here sticking with the bees here at Auburn University. Yeah, so I'm here at Auburn. The funny thing is that I started with bees, actually, from a beekeeping side because I was really just interested in the beekeeping. I kind of didn't realize that you could actually make a career of it until I was actually in college. So it was really a fortunate accident but I actually was able to interact with Heather Mattila. And that's because basically, both of my sisters went to Wellesley, and so I was visiting them, and because there was a bee lab, I immediately was like, "Oh my god, I have to see Heather Mattila," and my sister was actually working for Heather so I was able to kind of sneak my way in there. And that's how I actually kind of got into it.

Amy 04:19
That's so fun. I love that story. I feel like I got into the whole beekeeping industry or, I guess, in academia, because similarly actually, I found out that there were bee labs and I had started from the beekeeping perspective. I was in grad school when that had happened. And so, it's funny how we kind of just fall into the beekeeping world. I feel like many of us do, except for if you're Dr. Jamie Ellis who's been beekeeping since he was one year old or something like that.

Jamie 04:45
Not quite but close.

Amy 04:47
Okay, so Michael, honey bees are famous for their hexagonal shapes, right? And sometimes they're in these situations where they're actually unable to build these perfect hexagons. So I have a couple of questions for you. But I was told that that bees actually build like a circle and just the way that their wax kind of settles turns into a hexagon. One, is that true? I don't know. Maybe I just made that up. What kind of scenario would honey bees encounter where they wouldn't be able to build this perfect hexagonal shape?

Guest 05:21
Okay, so the first one, I'm going to have to correct a common misconception.

Amy 05:26
Great, I'm excited.

Guest 05:26
I mean, this is not a problem. Okay, maybe it's a pet peeve, actually. But it's called the liquid equilibrium hypothesis. And that's the idea that the bees are just building these cylinders, their circles, and then they heat up the wax, and then it just flows into these hexagon shapes. It's an attractive hypothesis because it's this idea of like, okay, great, you can just make the cylinders and then poof, you get hexagons. But to do that, you actually would have to heat up the wax to a level that actually makes it flow. And it's a cool hypothesis. But unfortunately, the bees, they just don't heat up the wax to that level. Also, if you actually just look at the leading edge of where the comb is built, you can already see the shape of a hexagon emerging. So while it is a very simple way that bees could build hexagons, it really just isn't the way they do it. And the reason I say that's a pet peeve is that sometimes I'll be talking to someone or I'll be submitting a grant or something. It's like, oh, we want to figure out how bees do that. And people come over, like, oh, it's just a liquid thing. And you're like, oh, gosh, it was published and then people thought about it, and then people did some experiments. And then it was subsequently shown not to happen, which is great. That's how science works. But it's now like, I constantly have to be like, no, it's not the liquid thing. I'm sorry. It's cool. But it's not the way it goes. So that's the first thing, the liquid liquid equilibrium. So on the other side, so bees, yes, they build a lot of these hexagonal cells. But if you think of a natural nest, or even any beekeepers' nests, there are lots of cases where you just can't build a perfect hexagon. So you'd imagine bees living in a tree, that's an irregular shape, you can't necessarily predict or expect that there's going to be a perfect space for every single hexagon. So they'd have to kind of accommodate some of their shapes. You could also imagine a stick running through the middle of that beak, the tree cavity. They wouldn't be able to build a perfect hexagon there. But probably, most inherently important to the bees for building irregular shapes, or rather, not building irregular shapes, but that they can't always build a perfect hexagon, is that they have two inherent issues in their nest. The first one is that these build two different-sized hexagons, the worker cells and the drone cells. And so if you were to just draw this on a piece of paper, if you have two different-sized hexagons, those don't necessarily fit perfectly. So that's an inherent kind of architectural issue. You have two different hexagon shapes, and you want to fit them into a single lattice. The second inherent problem that the bees face is that because they build their comb in multiple locations simultaneously, they eventually have to put those things together. So if you think of one group of bees building a bit of a comb over here, and a couple of centimeters away another group of bees building some comb, and if those two pieces are aligned, they'll actually be merged together, well, then, you don't necessarily have the perfect spacing on either side of the perfect orientation. So again, you're going to have a case where, sure, bees build a ton of beautiful hexagons but life and biology tend to be a little messier than that. I love listening to what bees do because they always turn out to be amazing to me. So given all that background, Michael, that you were just sharing, you started doing research on this very question, essentially, how do bees handle these irregular shapes they need to merge? Either two merging combs, or merge the interface between worker cells and drone cells. So can you tell us a bit about your research and how you went about trying to examine this? Yeah, so all the work I do, I like to start with a good solid observation, because then you know it's something that the bees are really doing. And a lot of this work kind of came out from the side when I was working on how bees switched from building worker comb to drone comb. I got really good at differentiating worker comb and drone comb just with my eyes because I'd have to measure this amount or that amount. But I also noticed that there were cases where I would be like, "Is that drone comb or not? It seems like they're about to but they haven't quite." So those were these funky observations. Because I'm looking at combs all the time, I also see

all these wild and irregular shapes because they have to merge the combs. And I was always using these natural wooden frames. So just a wooden frame and I just let the bees build on the frame. So, while yes, I'm also a beekeeper, and I'm used to plastic foundation, all the joys of foundation life, I also was interacting with a ton of naturally built comb, and that's where I was seeing just all these wild shapes. So I wanted to look a little more closely into the diversity of shapes that they were building. And that's when I very quickly realized that we needed a better technique. And that's because you can imagine a single irregular cell, and you can take out your calipers, and you can measure, the cell and the different walls and the area and the angles. And I did that for a lot of individual cells. But the problem is that it's fine to do it for one cell, it's fine to do it for 2, 10, maybe even 100. But then if you want to go back and you want to measure additional things about that cell, you have to find where the cell was, you have to measure it again, you're going to drown in a sea of data. So the important thing that we really had to develop was a way to extract the data from these irregular cells and normal cells automatically. And that's where working together with computer scientists and engineers, also at Cornell University, Nils Napp and Kirstin Petersen, we were to develop some methods to extract semi-automated or fully automated, depending on your perspective, metrics from irregular cells. And so that was a really key innovation that allowed us to peer more closely into these irregular cells that bees build. And I say that because we've known about irregular cells for hundreds of years, and we've known that these build these wonky cells, but really studying them carefully has just been hindered because it's just so difficult to measure them. So my favorite example is Vogt, who in 1911, probably did the most robust measurement of honey bee cells. He took over 4000 measurements of cells all by hand in the early 1900s, obviously a ton of work. Even in his papers, he specifically says, "I specifically excluded any kind of irregularities, I only sampled from three combs," and he just did a ton of measurements of a very limited subset. This work, we were actually able to examine a lot more diversity of combs, which then really let us extract more of the cool patterns the bees have in their building. So the way that we're able to kind of automatically extract the information from these images is, well, first, we take a really high-quality image from very far away from the comb so we get a really good angle on the comb. And then we also illuminate it so that the tips of the cells, the edges are much more noticeable. And then basically, what you do is you take that image, and you do a kind of a two-step processing. The first step is a sort of blob detection, where you're just detecting the center of each cell by using a blob detector sort of thing. And so that's just detecting the center of each cell. And then if you imagine you have lots of these cell centers identified, if you then connect the centers to its nearest neighbors, you now have lines connecting the centers of cells to each other. And then if you take that line, you can actually walk along that gradient. And so you're just comparing pixel values. And so the center of the cells are kind of darker and the rims are kind of lighter. And as you walk along that edge, you eventually get to the peak pixel difference, so where it's going to be the most different from the two edges. So then, if you take a perpendicular line, and I know this is a lot of steps. It's a lot easier to see on a piece of paper. But if you then take a perpendicular line, and then find where the lines intersect, that's where you get all the vertices of the hexagonal cells. So while it maybe sounds a little complicated, or it's a lot easier to see it on a piece of paper, that basically gets you two really important pieces of information, the center of each cell, and the vertices of each cell. And the reason I say it's a semi-automated method is that every single image that we process, we then also by hand make sure that it has identified cells correctly. And that's just because mistakes happen. But also, it really lets us be really confident in our results because there's actually a human in the loop that can actually go in and make sure that yes, every single vertex, every single cell center is actually in the right position. So that's how we were able to extract those data. And yeah, I'm really appreciative to the collaborators I work with because I probably would have just stubbed out and been like, okay, here, let me get my calipers out, and this is gonna be a long week. But you really need some of these new tools to be able to investigate really old questions in an interesting way.

Amy 15:14
All right, so, we're talking about the different shapes and different distribution of shapes. Can you talk about what the distribution of the shapes are? What shapes are we seeing? Would a beekeeper be able to look at their comb and identify some of these irregularities in looking at their frame? And, also, with your research, how did the honey bees kind of handle this challenge? How do they merge the comb together?

Guest 15:40
Yeah, so, I think the first and the most immediate result that we were able to pull out of this was when bees transition from worker comb to drone comb. So this is where you're in a single plane of comb, and they're building, building, all of a sudden, they're going to make a switch, they're going to build drone comb. The way bees deal with that is they actually make a gradual transition in cell size. So they slowly, over one or two cells, will kind of increase these wall lengths to increase the size of their cells. And it's a really nice pleasing transition from one size to another. And because they are making this gradual transition, they actually don't need to use very many irregular cells, they're kind of able to kind of make the switch entirely on their own. And this was actually something that Francois Huber, actually reported in the 1800s. Him and his wife did a lot of research on some of the original observations. And he mentioned some of these intermediate-size cells. But this was actually the first time that we could actually quantify and actually show what it was that the bees were changing. So they're gradually increasing these wall links. So that's when you transition from workers to drone cells. The far more difficult problem, though, is the merging. And the merging is where you have two independent pieces of comb that have to be stuck together. You can imagine that you could have worker on one side, drone on one side, or you can have drone and drone, or worker and worker and any combination can happen. And that's where we notice a lot more of these irregular shapes. So first and foremost, bees are really good at making hexagons, and they will build hexagons till the cows come home. But in these merging scenarios, that's what we saw, the diversity of irregular shapes. And bees built four-sided cells, five-sided cells, seven, eight, even nine-sided cells, a lot of these really irregular shapes. But within that, they have preferences within those irregular shapes. So we see a lot of five and seven-sided cells. So over 90% of their irregular shapes are five and seven. And the reason I'm not calling them pentagons, and those kinds of things is because a lot of times they're not perfect shapes, so I just call them five-sided or seven-sided. But what's even crazier is that if you look at images of comb and you see where these irregular shapes are, they actually come in patterns themselves. So we call these motifs, so like irregular motifs. So anytime you see a five-sided cell, you're very likely to see a seven-sided cell right next to it. So there are these little paired couplets. There are also even triplet clusters and triplets in lines. So you think of a five and a seven, and they also end up alternating, so it's 5, 7, 5, 7, 5, 7. So it's this sequence and fives and sevens. But they also have these clusters where you'll have a seven-sided cell and a seven-sided cell. And then there's like a little four-sided cell coupled in there. So these are all the different motifs that we see the bees building, and they're all these different irregular shapes. So the reason this was interesting to us is that you could naively think, "Okay, well, you build hexagons, and

then you have these difficult scenarios, and you just ram the hexagons into each other. And who cares?" What this is showing us is that the bees have these really beautiful hexagons they build. And they also have these really cool irregular shapes and combinations of shapes that they're also building. So that was kind of a cool thing for us to see.

Amy 19:19
I think that is so cool. I'm like listening to you talk. And I feel like I have so many questions for you about this. Jamie has the next question but I'm going to go ahead and ask you a question about the five or seven-sided cells and do you know if a queen will actually like lay an egg in there? Do they pack their resources in there? I mean, what does that look like?

Guest 19:42
That is a great question. And it's actually one of the things we're working on right now. What do you do with a five-sided cell? And at least from our preliminary data and what we've been looking at, they do use those cells. They don't necessarily use them for all the same things, but they can still be used for packing pollen, for storing nectar, but that's kind of where we've been going right now is looking at all those irregular shapes and how they're used in the nest. But yeah, that's a great question.

Jamie 20:13
So, Michael, that's really, really, really neat. So did you find any other regularities? I mean, you've talked a little bit about cells with different numbers of sides, five, seven, four, etc. but did you find any other irregularities while you were doing this research?

Guest 20:26
Yeah. So another thing that we found, and this is, again, always guided by just looking at what you're looking at. I think there's no alternative to just using your eyes and looking at things. And one of the things that I noticed was that some of the times when the bees would merge these cells, it was flawless. I mean, you'd have hexagons on one side and hexagons on another, we had taken multiple images, and we knew that they merge these cells together. But it was like a seamless gap, but it was just perfect. And so in those cases, it made us think more about well, what makes merging difficult? And one of the things that makes merging difficult, and this, again, it's also helpful to have a piece of paper nearby. If you imagine two hexagons and imagine the pointy end, the vertex, imagine if they're both on either side, facing up. So that means that the flat part is kind of in line. So if you build, build, build, and keep replicating, you'll have hexagon, hexagon, hexagon, and they'll kind of fit together. But now, if you flip one side, so imagine that the pointy end on one hexagon is pointing up and the pointy end on the other one is facing 90 degrees. Now, you have a much more difficult problem, because basically, the pointy end of one hexagon is going to run up against the flat end of the other hexagon. So we call this the tilt of the cells, kind of the orientation of those cells, and what we found was that when the tilt was aligned for the bees, they were able to merge their cells with many fewer irregular cells. So they didn't need to rely on those irregular cells as much. But as the tilt difference between the two sides increases, and the reason I say tilt difference is that if both tips are facing up, or both tips are facing to the left or right, well, then that's all the same, it doesn't matter for the bees. If there's a difference, that's where it gets harder. So as the difference gets larger, they end up having to build more irregular cells to kind of bridge the gap. But what was kind of unexpected and cool was that if you actually look at the tilt

of the cells, the bees are also rolling the cells into place. And the reason I say that is that if you have imagine that your tilt is not exactly perfect, what the bees can do is they kind of can split the difference between the two sides. So it's almost like this one's angled a little off like this, this one's angled off a little bit, we'll split the difference, and we can stick to a hexagon. And this happens even when the gap was quite large, they kind of always tried to split the difference in there. So the phrasing that we use for this was that they're kind of rolling hexagons into place. And if the roll is too big, that's when you have to throw up your little tarsi and say, "Okay, fine, we're just going to build an irregular cell in here." And so that also showed us some of these cases where the comb was just beautiful. You just almost couldn't see a flaw in there. And so yeah, so that was another cool finding that we found. And again, really just looking at the bees and letting them tell us what they're doing. So not rocket science, but definitely, I think, cool insights into the bees' world.

Amy 23:45
Yes, so I'm just thinking we have a lot of live removalists. And so they'll go into a building, they'll cut comb, and then they'll basically take string or they'll take rubber bands and kind of band them together. What takeaways are there for beekeepers? And should they be orienting the comb in a specific direction if they're doing live bee removal and trying to put that into their colonies?

Guest 24:14
Yeah, so, I guess the takeaways for beekeepers, I mean, I think the first and foremost takeaway, at least to me, is that bees are awesome. And I mean, yeah, if you're keeping bees, you already know that bees are awesome. But I think this is yet another way to show how cool the bees are and just appreciate how evolution has built these super organisms that are so frugal with their wax and still able to build these beautiful combs even in these irregular scenarios. I think it's just always just a cool thing. On the actual beekeeper side of things, I think as beekeepers, we tend to look at some drone comb and you're like, "Gosh, drone comb, not what I wanted." That's reproduction for the bees so they're trying to do their best to reproduce. But I think it's a nice way for us to appreciate some of the cells that they build. But also, if you're a beekeeper and you see a five-sided cell, I'll bet you $1 that there's a seven-sided cell right next to it. And don't actually take that to the bank, because I'll be out of money, I'm sure, pretty soon. But it's cool to be able to look at those kinds of patterns and appreciate what the bees are doing. On the side of people doing cut-outs, and then stabilizing their combs, I've done a couple of cut-outs and I would hate to give a person doing a cut-out yet another thing to think about because, gosh, those can be so messy and so difficult. I think, the practical side of that is you can trust the bees, that they'll actually be able to kind of mishmash and make the best of whatever situation you give them, and that some of our work right now is also looking at how they're using those cells. So stay tuned for what new things we come out with that. I think maybe, and this might be the next question, actually might have bigger implications for some of the architectural things that we do.

Jamie 26:06
Yeah, Michael, exactly. What you said is the way I think about it. Every time someone tells me something new about bees that they discover, in this particular case, moving from one patch of comb to another, the construction of worker to drone cells, merging two combs, etc. just listening to you speak the whole time I was sitting here thinking, "Man, bees are just cool. They're just cool." Now, we've talked a lot about bees and their application from the bee side. But of course, the hexagon shows up

everywhere, architecturally, right? And so I'm curious from a human perspective, could architects today learn anything from watching the bees' honeycomb construction patterns?

Guest 26:46
Yeah, definitely. And there's actually a great YouTube video that I highly recommend people to watch. It's called Hexagons are the Bestagons and it's a cool video, it's very informative, it hits all the cool bits about hexagons. But but my beef with that video is that it doesn't mention all the other cool shapes that the bees incorporate. But the hexagon itself is an incredibly important shape, and all kinds of issues of design and architecture and durability. I mean, it's an awesome shape. When we look at what the bees are doing, we're basically looking at how evolution has tinkered and altered these architectural scenarios for the bees to maximize storage area while minimizing building material while also making a resilient and stiff structure. So the kind of thing that I think about most frequently about this is you think of an airplane wing. And they use hexagons in there to stabilize the wing, but they also need a wing to be flexible. But you can think of an airplane wing, it's going to need different-sized hexagons at different parts of the wing, because in some places you need to be sturdier and more rigid. In other places, you need to be more flexible. So the way humans currently do this is you print one size of a hexagon, you print a second size of hexagon, and then you pretty much just bolt the two together. You can imagine you have to like put a big bolt in a seal to attach those two together. That's weight. That's fuel efficiency, that's all these differences, it's also a weak point for the wing. Well, the bees actually kind of show us how to do that already. If you make a gradual transition, you can actually do it all within a single lattice. So I think that's a really cool immediate application of these kinds of architecture. But also in cases where you have hexagons that maybe aren't aligned, and then how you can use these different shapes to fit within to presumably keep a resilient and strong structure. One of the cool things that we also noticed, it was just totally out of left field, for us, at least, was graphene, which is also hexagonal. It's the carbon lattice. It's these hexagons. In graphene, you have these grain boundaries where you also have sheets of graphene that are merging together. And there, too, you see paired five and seven-sided cells. So it's a really cool instance of where you have these molecular forces that are leading to five, seven-side pairs in this hexagonal lattice. And then you fast forward to honey bees building wax, and they're doing the exact same thing. So I think it's a really cool case. We're potentially looking at some really universal building strategies that really build these resilient and strong structure. So I think it's a cool place to be in and I really enjoy doing it. Partly because at the end of the day, you get to look at actually what the bees are building. That's always fun to have these nice visuals.

Amy 29:58
So when you're looking at bees building comb, if you see them building half of their shape, do you, Michael, know if it's going to be a worker drone or drone cell?

Guest 30:10
Yes, yes, I will. I remember one case, in particular, I had these large observation hives where I was keeping track of their comb building. And I was looking at the leading edge of where they were building their comb. And by leading edge, I mean the point where they're adding additional comb. And I remember tracing out that comb and putting a circle with a little question mark and said, potential drone comb? Because it looks like it might be transitioning here. And so that was before there was actual

drone comb, I could see that there was a little bit something and I was like, "Okay, this looks a little different than what they were doing."

Amy 30:44
Pretty cool. That's my last question for you.

Guest 30:46
I will say, though, that is a very, in terms of marketable skills, I really don't feel like that's much of a CV builder.

Amy 30:53
I think you should add it to your CV for sure.

Jamie 30:57
Well, you got a job. So it couldn't be that bad.

Guest 31:03
I agree that it is great for a job. But if I were suddenly unemployed, I really highly doubt that anyone would come and say we really need someone who can immediately identify where a hexagonal shape is about to change. But I'll put it on there for the future.

Jamie 31:16
I don't know, it sounds like airplane wing designers, engineers could use you.

Guest 31:22
They probably would be more concerned, like, "Michael, we're here building a plane and you brought a whole colony of bees to seal this gap. We really didn't need that." I think the last thing that was really interesting in this work that we did, which, I have to highlight, this was a collaborative work. All good science is collaborative. Kirstin and Nils were infinitely important in making this project run and happen. And one of the really cool things, I think, was kind of the cherry on top was that we also were able to do some modeling of how you could potentially merge different shapes. We basically compared the bees to a model we called the naive model, but you probably could more accurately call the stupid model. And the naive model basically is, well, what if you just took hexagons and just rammed them into each other and just filled the space with wax? And we know the bees don't do that. But it was a good exercise in a model of how much overlap would you have to have before you could perform as well as the bees. And it's like, you'd have to overlap cells by like 60%. So we know the bees are smarter than that. But then on the other side, we also did some things, we called it a global model, where we actually allowed all the cells to adjust. And basically, each cell is on springs. So it allows these minute changes. And the cool thing is that that global model, when you have global information, and by global what I mean is that you have information about the whole structure, so you can adjust the whole thing. Those global models still come to the same five, seven-sided cells. And they also mimic a lot of the same changes that the bees do. So things that are hard for the model were also hard for the bees. The only kind of discrepancy there is that the models, because they can adjust everything, is able to perform much better for the bees in terms of keeping cells usable. But the bees, they're working with wax, and

once they build a cell, it's kind of fixed in space. So the bees are still doing a phenomenal job. But it's always nice to see how we may be modeling it either naively or with a little bit of intelligence can either mimic or match what the bees doing. Or we can say okay, the bees are actually doing something that is even hard for us to do. So I think that was a nice last piece of the puzzle to be able to show how the bees fit within what an optimal computer-generated scenario would do.

Jamie 33:47
Michael, that's just fascinating. I could listen to you talk about this forever. And it's really neat to see, again, how amazing our bees are. And I just really appreciate you joining us on this segment of Two Bees in a Podcast.

Guest 33:58
Come check us out in Auburn anytime. I mean, I can guarantee you we've got plenty of combs to look at and extra eyes are always welcome.

Jamie 34:05
Be careful because we might show up at your lab. Everybody, we're going to make sure and link to the manuscript that describes all of this, this collaboration between Michael and his colleagues. That was Dr. Michael L. Smith, who's an Assistant Professor in the Department of Biological Sciences at Auburn University in Auburn, Alabama. He's also an affiliate member of the Max Planck Institute of Animal Behavior in Germany, talking with us about how bees deal with imperfect comb construction. Thanks, again, Michael. And thank you, listeners, for joining us on this segment.

Guest 34:37
Thank you so much for having me. It was a pleasure to chat with you guys.

Stump The Chump 34:42
Enjoying our episodes? Support our programming and the UF Honey Bee Lab by adopting a honey bee, queen, or hive. Your monthly gift can help support research and programming and help more people learn about honey bees. Check out our website at UFHoneyBeeLab.com for more information. It's everybody's favorite game show, Stump the Chump.

Amy 35:22
Okay, we are back at the question and answer segment. Jamie, the first question we have is how important is it that hives face southeast or, at least, towards the morning sun? Is that necessary? And what if you only have a location that faces West?

Jamie 35:38
It's not incredibly important. Let me just give a little bit of background for why this question came up in the first place. There's been ample research to show that when honey bees choose the nesting site, they tend to choose nesting sites with South facing entrances. That's what a lot of work has shown. And one of the interesting things about that, to me, is I always assumed it's because of the way the sun moves across the sky, actually, the Earth's turning, the sun's not moving across the sky. But nevertheless, the way the Earth turns to give the appearance that the sun's moving across the sky, if

you're in the Northern Hemisphere, the sun moves from east to west, but on a southern path. And so I always thought, well, maybe the bees are pointing south because to maximize the sunlight hitting their entrance. However, a former student of mine, Anthony Valdo, and I, years ago for his master's research, he went to South Africa and actually looked at nesting colonies of wild honey bees in South Africa and found that in the southern hemisphere, where he did the work, I can't say this is a universal truth, but where he did the work, the colony entrances tended to face south as well. And in the southern hemisphere, I would have expected them to face north towards the equator. So to make a long story short, it appears that for some reason that I don't know that honey bees prefer nesting sites with South facing entrances. So my mentor, when you hear beekeepers teaching other beekeepers, they almost always say, you want your colony entrances to face South and they won't say that based on the fact that they had read the literature to suggest that's what bees naturally do. They usually say it, again, because the way the Earth turns it gives the appearance that the sun's moving across the southern part of the sky, that facing the entrances South maximizes the sunlight on the entrance throughout the day. So if you face them due east, you would only get early morning sun, sun first thing in the morning, and then by the time noon hit, the sun would actually be behind the hive. If you face them west, you only get the afternoon sunlight. So the idea is if you face them South, that maximizes sunlight to help get the colonies up in the morning and keep them active all day long. But honestly, I think that's just one of those things that beekeepers have said forever. It's probably a best management recommendation. But it is certainly not a requirement. If you don't have the ability to do that with your colonies, in your hives, wherever you're keeping your bees, then just point in the direction that is the most convenient for you. But when you have the option, a southern-facing direction seems to match at least what the bees want to do themselves.

Amy 35:38
Yeah, I think that's fair. In the plant world, I always recommend having plants at a south-facing window. So plants and bees.

Jamie 38:27
There you go. They seem to like each other.

Amy 38:30
So the second question we have, this person, I think they're looking at, when do we know when bees are more likely to swarm? I think they're wanting to hang swarm traps. And so they're wanting to know is that when days are warmer, when days are longer? What is the answer to that one? Are bees more likely to swarm?

Jamie 38:47
Yeah, a lot of the triggers that lead to swarming co-occur. So it's hard to put a lot of emphasis on one or the other. So let me explain what I mean. Lengthening days, warming days, more sunlight, etc, the production of drones, the availability of floral resources, pollen, and nectar, all of these things are important triggers that lead to swarming, but it's hard to separate them. We get flowers blooming because we get lengthening days. And lengthening days usually are accompanied by spring so it's naturally warming. And when it's naturally warming and you're getting more sunshine, then you get more nectar and pollen-producing flowers. And when you get all of these things, you tend to get

colonies interested in producing drones. So all of these factors kind of co-occur. They're interdependent, and ultimately, lead a colony to start the swarm production process. The common way that I teach about when swarming is going to happen is I will tell beekeepers to back up four or so weeks from the major nectar flow and that's often when swarm season is going to start. Let me give you an example. Let's say you live in the northern hemisphere, and your main nectar flow starts, arbitrarily, I'm saying April 15. So somewhere around mid-March is when swarm season is likely to start for you. And it's just biological. Bees won't to swarm in the weeks leading up to the major nectar flow as well as there in the first part of the major nectar flow, because that's when the resources are available to the new swarm to move into a cavity, construct wax and store enough honey to survive winter that may be four to six to eight months out. So it benefits colonies to swarm in advance of the major nectar flow and during the first few weeks of the major nectar flow because that's when the resources are most available. If your major nectar flow starts April 15, and the colony swarms mid-February, that swarm may not even survive to April 15 because they may run out of resources between mid-February and April 15 and starve to death. If they swarm July 15, rather than May 15, they've swarmed after the major nectar flow, it almost certainly won't be able to store enough resources to survive the coming winter. So swarming is intimately tied to that coming out of winter going into spring period, usually in the four, maybe six weeks, leading up to the major nectar flow. So first of all, figure out when that is for you. And then back up four or so weeks and know that's the time that you're going to start seeing colonies. I believe this individual who wrote this question was interested in putting up swarm traps, these traps you can place around the area and hopefully, be attractive to swarms that are available. So if the major swarm season starts, say, four weeks in advance of the major nectar flow, then I would argue you back up six weeks and start hanging your swarm traps. But you can honestly leave those things up year-round and it's not a problem. But that's, generally speaking, when bees elect to swarm. It's tied to all these kinds of interlocking factors that have to do with lengthening days and warming temperatures, which lead to more nectar and more pollen, the production of drones, and the crowding of hives and all of this stuff.

Amy 42:02
Yeah, and the first talk I ever heard you at it, you were talking about swarming. You said, "Well, swarming happens when the beekeeper least wants it to."

Jamie 42:13
Exactly. And I mean, the reason that's the case is because if the bees are swarming in the weeks leading up to the major nectar flow, or during the early part of the major nectar flow, you're losing bees when you most need to keep them. And yes, the colony is going to requeen itself. And yes, they'll pull out of it. But if you lose 50% of your bees and have to wait six weeks before the new queen emerges, mates, and her first egg goes through all the developmental stages to emerge as worker bees some 21 days after being laid, then you can realize losing half your bees and losing six weeks of brood production during the time of year when your colony needs to be maximally strong, absolutely impacts honey production. So a lot of folks who are trying to be successful honey producers work actively to manage swarming in their colonies.

Amy 43:01

Alright, so the third question, I'm just going to go ahead and read it. And then, we can discuss a little bit more, but this person's asking about Nosema and dysentery. And I guess, they had three hives that died in the winter. They weren't sure what it was fro. It may have just been too cold and the colonies just all three went. But after the person went back into the colony, there was some bee poop on the hive, a little bit on top of the frames, and then some down the frames. And so they're wondering if they can feed these frames back to other bees? Or, put that out, like open feeding for other bees that may look for resources? Should or can this person harvest the honey out of the frames? What are your recommendations, basically, on what to do with the equipment and with the resources after finding the poop on stuff around the hive?

Jamie 44:00
So this is an incredibly tricky question because part of me wants to answer this like a scientist, the other part of me wants to answer like a beekeeper.

Amy 44:07
Well, I asked it like a scientist when I said bee poop.

Jamie 44:11
Yeah, feces, for sure. Yeah. So, as a beekeeper, well, let me restart and then tell you what I would do. So the basic premise of this question is my bees died, the evidence suggests that even if Nosema didn't kill them, the bees had a Nosema infection. And so given that there are feces everywhere, potentially, therefore, Nosema spores, would I be causing a problem in my other colonies if I move these frames of honey to those colonies, or put them outside and allow bees to open feed on them? So there's a lot of ifs and what ifs in this scenario, but I would just say from the very beginning, we don't know with certainty that it was Nosema that killed the colonies and you also don't know with certainty that just because there are feces that they were struggling with Nosema. So I certainly appreciate the motivation behind the question, but it's hard to know, as a scientist, for sure what the major problem was that led to the colony to being dead in the first place. And then secondly, and this is beekeeper Jamie talking, I would probably move those frames to other colonies or allow their bees to open feed on them, because where I live, and in my experience working bees, Nosema has never been a major problem for me. Now, Amy, it's funny, of course, our listeners can't possibly know this. But we're recording this Q&A that I believe is coming out next week but we're recording it after we interviewed someone earlier this morning who I don't think will come on for two months, maybe, in a new podcast episode about Nosema. And she was talking about Nosema infections in Canadian honey bee colonies and how Canadian beekeepers absolutely worry about it and they treat for it and there's evidence that it causes problems in their colony. So under that paradigm, maybe I would hesitate to feed this honey to bees but beekeeper Jamie who's only lived in warmer climates, who sees Nosema in nearly every one of the hives that he manages, I just would move it over to another colony and not think twice about it. But the good news is, if you're worried, I've got this mantra, if you're worried, when in doubt, throw it out. So if you're truly worried that it's going to be a problem for you, don't take the risk, and just find another way to feed those colonies. But I probably would feel comfortable just moving those frames to another hive and watching those hives closely based on the time of year that we're discussing this, it happens to be late February here in Florida, I know that the spring buildup is imminent for colonies here in the United States and elsewhere in the northern hemisphere. So colonies will outpace, potentially,

any Nosema that you move around. Again, all of that is assuming that it was Nosema that led to the demise of that colony. Amy, this brings up a bigger problem that's really worth discussing. And we won't go into great detail, I won't go into great detail here. But I get a lot of questions like, "Well, I think a virus killed my bees or Nosema or some bacterial infection, what would you do?" Well, it's just really hard to know at this point. There are some things like American foulbrood that we know if it's what caused the colony problems, you move those combs around, those bees have a high probability of getting American foulbrood and having problems from it. We don't have the same level of knowledge related to these other pathogens, viruses, Nosema, etc. And so that's why I tend to err on the side, well, even if it was one of these things that caused the problem, if I'm moving it to a strong, healthy colony, it's probably not going to be an issue. But if I'm really concerned about it, I'll throw it out. I think the listener even asked the question, could I use the honey for human consumption? Well, there are no bee pathogens that make humans sick, at least, known to make humans sick at the moment. So if you're worried about feeding to other bees, you can absolutely extract it and use it for human consumption, assuming, of course, it was produced from nectar and not from sugar water and there weren't treatments on the colonies while this honey was coming in and things like that. But that is another good way to get rid of it is to use it for human consumption because Nosema and the bee viruses and other things like that are not a risk to humans. Again, all assuming that the honey was produced correctly, you weren't treating for Varroa or had antibiotics in the hive while it being produced or whatever.

Amy 48:31
Right. So then the other part of the question is what to do with the wax? So do you think would you say that it'd be okay to just use the wax leftover? Make some candles? Make soaps?

Jamie 48:43
Yeah, so what I would do, again, is I would just move the whole frame of honey into another colony and just be done with it. But if you're worried about it, you could extract it, if the honey is palatable and all that stuff, you could extract it and bottle it for human consumption purposes. And then the wax, you could just move into a colony for use when that comes around. But again, if you're worried, you can just melt the wax down and use it for candles or whatever you want to use the melted wax for. I, personally, would not do that. Most commercial beekeepers just move it on to the next hive. But I can certainly understand the concern behind it, the risk, and it's just something we don't know a lot about. I tend to think it's less of a risk than it is a potential problem. So I tend to err on the side of yeah, I'll just reuse it and not think twice about it. But if it were American foulbrood, then my mind would change completely.