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SPEAKERS
Guest, Jamie, Amy, 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 episode of Two Bees in a Podcast. Amy, today, we've just got one of those topics that folks are going to be excited about. When I say you and I were talking a little bit about this behind the scenes before coming on the air. We've interviewed a couple of folks in the past about honey bee thermoregulation, hive insulation, and all that goes with that. And we've had multiple guests, and it's been one of those things has been a hot-button topic for our listeners. I think it's growing in interest around the world, all the new research that's coming out about bees and clustering and thermoregulatory needs and inventory needs. And today, we're joined by an expert on this topic. We're able to welcome back a guest who's joined us in the past. That's Derek Mitchell, who's from the Institute of Thermal Fluids at the School of Mechanical Engineering at the University of Leeds, Leeds in the UK. Derek, thank you so much for joining us on this episode.

Guest 01:40
Thank you.

Jamie 01:40
Yuou have just published a really interesting paper. I'm going to read the topic here. And to all of our listeners out there, we're going to link to this paper in the show notes. But the title of the paper is "Honey bee cluster, not insulation, but stressful heat sink." And, Derek, we brought you on today to talk about this because you're already shaking some of the ideas I've also had about thermoregulation with bees. But before we dive into that, I know it's been a couple of years since we've had you on the podcast, could you tell us a little bit about your background, and then ultimately why you began studying honey bee clustering behavior?

Guest 02:18

Okay, I got started in this thing because my wife took me off to a taster session for beekeeping. And I found all the details about honey bees and how they survived winter very interesting. And then we went outside to have a look at the bees and their hives and something really charred because I saw them in these wooden hives. To an engineering mind, this seemed really strange, it was, "Where's the insulation?" because I was seeing animals in the building. And that just provoked my interest, particularly when I saw the cost of these wooden hives as they were in the UK. I thought I could do something cheaper than that. So I ended up doing more inspection of this topic area. And it was really a case of the boys staring at the emperor's new clothes, just got me more and more into the research. I started publishing a paper and then started doing a PhD in it in engineering because I found out that nobody really was looking at this thing from an engineering perspective, looking at how the actual heat transfer works for honey bees. Because with an engineering background, I was always looking at the case of, well, if I'm going to build a building, I need to ask some requirements of the client. I found out that nobody's really, in quotes, asked the client, what it is they really wanted. And so that's what I've been trying to do is get some answers from this client. This paper is one of those answers.

Amy 03:46
Derek, there have been people who come up to Jamie and I, and they say we love your podcast, we listened, "There was this one episode that just stood out to us." And I'm like, "Let me guess." They stand there and they just look at me. And these are people I've never met before. So then I say, "Is it the one on installation?" And they look at me like how did you know that? It was just so funny because people remember the last time we interviewed you and they remember the topic. That episode really stuck with many of our listeners out there. It was just kind of fun because anytime someone says, "There was this one episode that I remember," it's always the insulation one. So we really appreciate you working on this topic. And before we actually get into the insulation, I want to take a step back to talk a little bit about bee clustering and why honey bees cluster. Just in your research, can you tell us about this behavior of the honey bees clustering?

Guest 04:39
So a bit awkward talking about honey bees when I've got somebody on here who's a professor of entomology, but from an engineering perspective, what it looks like to me is that as the temperature inside the nest falls, the honey bees group together and maintain the outer surface of that group at something around about 18 to 20 degrees centigrade. But as the inside temperature falls further, the outer bees don't sustain this heat production needed to keep them up the temperature. And as the temperature of the bees falls, their ability to generate heat and move about falls rapidly. Bees edge inwards to keep the temperatures above 10 degrees centigrade. And thus, we get these layers of bees between 10 and 18 degrees centigrade with impaired heating and moving capability and an inner space with mobile bees. They maintain their temperatures somewhere between 20 and 34 degrees centigrade, depending on other things. The outer layers are called the mantel, and the inner region, the core. We call the whole thing the cluster. Now, the transition between all the bees being at 18 degrees centigrade producing heat to a significant number below that temperature and producing little heat can be very abrupt. And this is effectively a shutdown of heat production by a factor of four. So they're basically turning off all the heating in a large number of the bees. And as the temperature falls inside the nest, falls further, the cluster contracts, and the total heat production stays the same for a bit and then rises. This interaction of things, since the beginning of the First World War, the formation and

contraction of the mantle and the cluster has been described as insulation for the core of the cluster. And that's where I come in.

Jamie 06:26
So let's focus on that idea there. We just have to assume that a lot of our listeners are beekeepers, and what you've done, then, is you're introducing us to the scientific process. You've made this observation where you're thinking about this expanding and contracting cluster, and then you've got your background knowledge on insulation and engineering. And so you're putting those two together, then, to develop these research questions. So could you elaborate a bit on this. You've made these observations, how did you end up on the research question that you're covering, specifically, in this paper today?

Guest 07:00
Well, this is one of these things of almost a bit of serendipity. I was having to cover, in my PhD thesis, the interaction of thermal conductivity of honey bees in my modeling. And so I was having to dive into that to try and explain why I had researched here and why I hadn't research there. And then I came across an article in the American Bee Journal, which described the mantle as insulation. And this actually was at loggerheads with what I was learning about the engineering processes of when you take something like a porous solid, and you change the gaps in between it. So if you imagine that a porous solid, one example of that is the feathers in a down jacket. And when you compress it and make it more feathers and less air, the conductivity changes. And so the same thing goes for bees. The bees get closer and closer together and there's less air and less air. And in fact, the conductivity goes from being a mixture of, well, from being mostly air and some bees, to being mostly bees. And so conductivity goes up to something approaching steak when you squeeze all the air out of it. Whereas just like with a down jacket, when all the feathers are all that far apart, what the feathers are doing is stopping the air moving, if you compress it, in the end, you end up with something which is equivalent of leather, because that's the same stuff. That really ended up prompting me to think I need to answer this in American Bee Journal. And then when I dove into it a bit further, I realized it wasn't just something the beekeepers believed happened. It was also in the academic sphere, and had been going on for 110 years. That led me into actually getting started in writing this paper. So it started off as popular science and now it's ended up with something with a lot of engineering rigor.

Amy 08:55
So can you tell us about the methodology of the paper and what you were looking at?

Guest 09:01
Well, it's more like methodologies. Because it started off as something that was popular science, I decided to think of insulation in many different ways. All materials have thermal resistance. So if we're going to call something insulation, it's got to be something from other materials. And so it came down to trying to analyze what were people possibly meaning by insulation, and then converting that into engineering and then diving into that by using a combination of modeling and basic engineering science to actually dissect that. Now, one of those ways was to actually try and model the entire system of a hive in a landscape that's got ground, sky, air, then the cavity filled with air, and then the cluster sitting inside that as a ball. And because of the property of honey bee clusters, they have a surface temperature of 10 degrees centigrade. By taking that, I could actually look at the various parameters,

including doing things like measuring the temperature difference across the hive walls, looking at the temperature difference across the air gap inside, and take into account things like not only conduction, but convection, and importantly, radiation, which is a major heat transport inside/outside the hive in winter. And from that, I was able to model all the various relationships. I then put in some real data from Charles Owens' research in the 1970s into real honey bee clusters, looking in between the lines inside that you can actually get an idea of the size of the honey bee clusters as the outside temperature fell. Now from that, I was able to work out, using the information that he gave about the size of the honey bee clusters and the rest of the environments, I was able to find out a value for how much heat honey bees were likely to be producing. And because I could find out how much heat honey bees were producing, and from his information, the amount of area of the cluster, the surface area of the cluster, I was able to gain a value of the energy density coming out of the surface of the cluster, and from that, work out something called R value. And this is something that people are normally associate with the values of insulation for building materials. And the formula I use is effectively a derivation of the same formula that is used to calculate the R value of building materials. And by doing that, I was able to give a plot of cluster size versus the R value of a honey bee cluster, or rather the R value of the mantle. Because we know the inside and outside temperature of a mantle, we know that the outside is 10 degrees centigrade, and the boundary between it and the core is about 20 degrees centigrade, and so I did a plot of what would have been the R value of Owens' honey bee clusters in 1971. And we're able to show that as the temperature fell and the clustering progressed, and it contracted, the R value actually, in fact, decreased. And it decreased dramatically. So actual process of clustering is a decrease in our value, which is quite surprising. The amount it was was about a factor of 11 difference. I also looked at it in other different ways and they all came up with the same answer. But clustering really means a decrease in insulation. And that really, if you think about it from the bees' point of view, it's what really matters, because what really matters for the bees is not dying. In order for them to not die, they've got to keep the temperature above the threshold where it's they're likely to die, which means they got to be above around 10 degrees centigrade. So they could still move perhaps just a little bit, and they move in towards the center. And as they're moving towards the center, the density of the honey bees increases, their conductivity goes up. And this actually allows more heat to pass to the bees on the outside keeping them alive. So it's the inverse of what people were thinking, it's the fact that the insulation goes down, keeps the bees on the outside alive. If you were to think about it the other way, when you put on your down jacket, and you go out in the cold, what's the temperature of the outside of the down jacket? It's very, very cold. If you're going out when it's minus 10 outside, the outside of your down jacket is minus 10. But at minus 10, those honey bees die. So they're trying to go inwards. So if you had only bees rather than down in your jacket, they will be trying to get closer to you to stay alive. As they get closer to you, they will get thinner and thinner, and so allowing the ones on the outside to stay alive as the temperature dropped. When you look at it this way, it seems, well, why didn't we think about that 110 years ago?

Jamie 13:54
So this is all very fascinating to me. And I've got so many questions that are swimming in my head. So this is probably going to sound scattered, Derek, but I'll do my best to get to the point. All right, just to summarize what I believe you're saying is the outer layer of bees on a cluster does not serve, or at least your data suggest, they do not serve as insulation. But rather, as the cluster contracts, the bees on the outside of that cluster move into the middle to be warmed up. And the core of that cluster releases heat to the outside bees to make it possible for them to move into the middle. So it's kind of

like the cycling of bees in this dynamic ball of bees. The inner part of that cluster is generating heat, and the outer part of that cluster is benefiting from the generation of that heat from the inner cluster, inner part of that cluster.

Guest 14:46
That's correct. The contraction is occurring because the outside temperature is dropping. And if they didn't move in, their temperature would drop and they would die. But the very act of them trying to move in actually enabled the heat to move out to keep them warm.

Jamie 15:02
Interesting. It seems, then, like it would be a forever race for the bees in the cluster, right? Because if bees outside of you are moving past you to get inside, you're then being forced out, you're being squeezed out. And then you work your way back in, which squeezes out other bees. So it just seems like this kind of cycling bees.

Guest 15:21
Some of that it's been observed by some people that there is a recirculation of bees from the core to the outside. And if you think about what's happening, we know the bees, when they get into the cold, generate a lot of heat, and then they stop and disappear into the mantel. Now, if you think about it, these bees are only able to generate at a high rate of metabolism for a short period of time. They get exhausted, and then they fall back into the mantle. And so that's how you're going to get that turnover. But I think that's a question not for an engineer, but more for an entomologist to find out in more detail.

Amy 15:58
Derek, it's really interesting to hear this information from you, especially with some of the beekeeping practices that many beekeepers throughout the world use. And one of them being the clustering and putting them in refrigerators. I'm just trying to think,, taking this all, bringing it together and actually looking at how is this information useful for beekeepers, and what do you think beekeepers should be taking away from the research that you've been doing?

Guest 16:25
Okay, well, probably the first thing about this is when it comes down to insulation, it's not the cluster, it's the air gap outside of the cluster, and the actual hive or nest enclosure walls that are doing the work here. Right? When the temperatures outside get low, there are two things going on. The air gap and the walls. The 110 years of talking about the cluster, now we need to throw that away and concentrate on what happens. And that means they've got to provide something that's got walls that do something that's significant. And because the air gap is there, and it's got its contribution, you really need to go big with the insulation for it in order to have any effect because you've got to be significant compared to the air gap at low temperatures. Now, you've got to think about well, what on earth is happening if the bees aren't in clusters? A previous paper of mine also suggested that the bees themselves, even when they're distributed around the hive, are acting effectively as insulation. They're slowing down the convection currents considerably. So you've got to really rethink things. Got to start thinking, how do bees want to be inside? How they would want to have been in a tree? Because, as we know, quite a few of their behaviors can be interpreted as seeking a high insulation environment. And that is what they need to think about and rethink this idea that they need to go for keeping them at a low

temperature to reduce sugar usage because that high sugar usage is really a result of keeping them at low levels of insulation. It gets quite complicated in there. And maybe if we do the right research in that area, we can come up with something which actually says we still end up with low levels of sugar usage, but without forcing them to be in a cluster.

Jamie 18:15
I think, Derek, that's exactly the kind of question I wanted to follow-up on or the statement I wanted to follow-up on is in my mind, it's like a beekeeper has to balance keeping the colony loose within its nests. So by loose I mean not clustering tightly, but making it where it's not inclined to leave that nest if the temperatures are really cold. So is there some sort of happy medium, a perfect insulation, for example, that allows the colony to have minimal clustering behavior, but not force them outside of the nest to die in the cold?

Guest 18:54
Okay, this is getting into my beekeeping experience. Since about 2011, I've been keeping bees in highly insulated hives, at the levels beyond you can buy hives. Another thing that really comes to mind is we know that cold inhibits bees. And as beekeepers, we know the bright light stimulates them. We've got to end up with, although we're going to insulate, we're gonna end up having to think about the other things that honey bees expected in a tree. And one of those was to have a small entrance that was in fact a long tube and it wasn't necessarily going to be straight. And that was going to impact the inside of a natural bee nest. It's in fact very dark, very different from the ideas where you have open bottom meshes on a stand over white concrete. So some of the behaviors we see about bees coming out in the cold are likely to be us, and in fact, there's beekeeping law which talks about you put a plank in front of the entrance, a piece of wood in front of the entrance to stop them coming out, which I haven't got any scientific numbers on that. But it seems as though that works. We've got to do things imbalance. If we make things more like a tree, we have to take in some of the other things that are like a tree. As regards of perfect level of insulation, I would end up having to say, back like a tree, but a tree is not just insulation. A tree has a large thermal mass, engineering terms, it has low thermal diffusivity, and it has a large mass as well, which means the temperatures don't move very quickly. And in fact, they take a long time, and a lot of energy to get them anywhere near equilibrium. In beekeeping terms, that means the bees are going to be in there a long time putting in a lot of heat before things are, in quotes, cozy, right? Just the same. I don't know if you've ever stayed in a thick-walled stone cottage. And if you've gone into it when it's been unoccupied, you have to have the fires on for months before the place is warm. But then it stays warm all through winter with only a very, very small amount of heat. And that's exactly the same phenomenon that occurs with a tree nest. Now, that creates a totally different set of environments. Because it's tall and thin, you've got the thermal gradients in it. And that really means, actually, that we don't know very much about how bees actually really behave in their natural environment. Because in fact, the thermal environment is quite complex. And there hasn't been any real research into it. Approximately zero.

Jamie 21:33
This is fascinating. I tell you, everybody who's listening needs to at least go read the abstract of this manuscript. You make a claim at the end of the abstract, and I want to read out loud, and I want kind of like some comments on it because I think it's a very profound claim. You say as the last sentence of the abstract of this manuscript. Thus, the attitude to force clustering, i.e., deliberately provoking a stressful

survival behavior, needs revision, as avoidable forced stress upon animals may be regarded as cool. So the implication that I'm hearing there is, we are forcing clusters on bees because we think it is what is needed. But if your research is substantiated, and all the things that you're saying makes sense, and they make sense to me, then actually forcing bees to cluster could be regarded as cruel. Could you elaborate on this idea?

Guest 22:29
We know the behavior of the bees in the mantle is to move towards high temperatures. Being cold is somewhere where they don't want to be. We know that. There are other studies that have shown that if you keep bees under cold stress, or heat generation stress, that they actually damage their immune system. There's a study that talks about something called [inaudible], when somebody's discovered the protein pathway. It's in hidden habituation is doing the damage to their immune system. There is research that shows being in a cluster is not a good thing for honey bees. And we might imagine, well, why not? They do this and why on earth do they survive? Well, the engineering provides an answer the entomologists need to follow-up on, and that is a tree nest, as I mentioned, has got this immense amount of thermal inertia. So when bees first move in, they are going to have to cluster in those first few days, weeks, perhaps even months, perhaps even the first winter, until they managed to get through a summer, manage to get that tree up to temperature. The engineering shows they need to be able to cluster in order to get through this terrible time of having first moved in. But what we see is, and there's been research by Tom Seeley showing that although bees in trees have a very high fatality rate in their first year, they have a very low fatality rate in the succeeding years, which tends to backup the engineering view of it. And so we've got the situation that these bees have got this behavior to get themselves through this bad time. And yet, we're making them do it every year. And not only that, most of every year. And there's an issue. If I'd been doing some of my experiments with bees, and they've been vertebrates, if they'd been mammals or reptiles, I would have had to fill out vast amounts of paperwork on describing the level of stress that the animals would be undergoing. So as a researcher, I'm quite keyed into the fact that with things that we do with bees, we're actually doing things to them, although they can cope with the amount of time or on an occasion, we're actually making them do it all the time. And if it was a vertebrate, that would be classed as cruelty, but they're not a vertebrate. So the question is open, do we treat them like that or not?

Amy 24:56
Derek, I have so many thoughts on that. Jamie and I, we've done the podcast last for three or four years now. We've also had Dr. Meghan Milbrath ask our audience the same question just about honey bees and their general welfare. And so I think that's going to be a topic that we'll be discussing, definitely, throughout the years moving forward. It'll be interesting to hear people's takes on that. The last question I do want to ask you is what next? So where do you see your research headed? What do you think should happen next? As far as research goes, what's next for you? And how can we support that?

Guest 25:30
Well, it's only just begun because now we're into a situation now trying to find out how does the density of honey bees and how it changes in the heat production changing? And how it changes in different energy environments, or different heat transfer environment than all the previous research? So for instance, one of the most interesting things I would think would be Charles Owens' research that he did

with all those thousands of thermocouples, measuring where the honey bees were in the nest and what the temperatures were. We need to have the same or inside insulatedness, and particularly insides anything that mimics a tree so that we can actually find out exactly what's going on with honey bees. The researchers are going to have to learn a lot more about heat transfer because honey bees are really, to my mind, beings of heat management. In one of the posters I've done, I described honey bees as Apis melliferan daughters, sugar fighters, and air conditioning engineers, because from an engineering point of view, that's what they are. They refined sugar, and they do air conditioning. And that tells you that the relationship with their nest is a lot more than just a shelter. It's actually, in my opinion, dramatically more than beavers have with their dams because honey bees are in fact, manipulating dams in different fluids. We're talking about water vapor, heat transfer, carbon dioxide, and we're talking about a more interesting phase changes of evaporation condensation, in addition to refining sugar, while maintaining humidity and temperature profiles for the brood. There's been some research which has been showing that not only do they thermoregulate a temperature, that the brood they regulate thermo regulate several different temperatures, depending on the age of the brood. As another one of those papers, I have to check the date on to make sure they're not April the first because it's another one of these things that honey bees keep on surprising me with that I have to make sure that somebody is making a joke out of it. And the more you learn about the thermal fluids, the heat transfer of it naturally more fascinating, more complex, and mind- boggling. Honey bees, because they literally are sugar refiners, well, less than the fluid engineers. They just don't happen to be human.

Jamie 26:36
That's a fancy title for them. I like that. I'll have to do a presentation someday with that title, Derek. Well, gosh, everything you've taught us has been very fascinating. I really appreciate you sharing about your research. I know there's more to come on this topic because I know that continues to interest you. And for all of our listeners out there, make sure to check out the show notes so that you can follow up by reading this manuscript. Derek, thank you so much for joining us on this podcast and talking about your work.

Guest 28:17
Thank you.

Amy 28:27
So Jamie, it's kind of fun bringing in speakers that we've had in the past. I think this upcoming year is going to be a lot of updates from different speakers and guests that we've had in the past. And it'll be just really interesting to hear some of the general updates on what they're up to. But talking to Derek about insulation, there are a couple of things that I wanted to chat about. At Apimondia, when I went there, there are different hive setups and different boxes and different materials that are used. And I'm interested to see I think, just moving forward, what the industry is going to adopt whether we're going to stick with the standard Langstroth wooden hives or whether we're going to move forward and have bigger, stronger, warmer boxes. I don't know. What are your thoughts on that?

Jamie 29:09
Yeah, I mean, I've got swirling thoughts in my head about it because I'm honestly not sure what direction it's going to take. What I would say,, kind of from the beginning, is that there's clearly more

research that's happening on this topic, and it seems from the research, we need to modify our hive design. So if it's wood, it's got to be thicker walls, presumably, maybe different types of woods. I know, for a long, long time, decades now there's been Styrofoam, hives and hives made of plastic and all types of material. So Derek and others seem to be adding really good data to the argument that the walls of our hives need better insulation values. If you look at what bees do in the wild, they nest in trees, at least a lot of wild colonies do. In temperate regions, they nest in trees. We do a lot of work in South Africa. We're finding lots of colonies nesting in the ground, which is a lot thicker than trees. But, nevertheless, you get the point that bees are choosing cavities and have thick walls. And we're not mimicking that with our style. We're making hive styles that are convenient for us. And it would be a significant paradigm shift to have thicker-walled wooden hives or move exclusively to foam hives or whatever the case may be. And it's, I think, easier said than done. But as the research builds to support this idea, it may be one of those things that we just need to do for the betterment of bees.

Amy 30:34
I mean, that kind of leads me into the second part of what I wanted to chat about. I had mentioned this in the episode that there was this idea about the animal welfare and honey bee welfare. And so I'm just interested to know what your thoughts on that are as well. I say, there's this upcoming thing, but we started podcasting in 2020, and even that topic got brought up during that time as well, in some of the episodes that we had.

Jamie 30:57
Yeah, I'd say I could go on for days about this idea, because I've got a lot of thoughts to kind of put out there. But I'll just summarize my statements here. The older I get, the more I conclude this idea that if we keep bees, we have an ethical obligation to ensure that they are healthy, and productive. Frankly, productivity is a byproduct of them being healthy and in the right location. So I feel if we're beekeepers, we should control Varroa. If we're beekeepers, and bees are starving, we should feed them. If we're beekeepers, and bees are suffering from an ailment, we need to solve that problem. And I believe, again, that we have this ethical obligation to take care of the bees that we keep. So Derek's research then leads to this interesting conundrum. Where in our industry, we think clusters are a good thing, right? They're a static situation where maybe they're not burning through a lot of fuel, their food, in that case, they're not overly active, it gets them through winter. But maybe Derek's research suggests that, well, forcing clusters specifically in refrigeration units may not be the way to go. Well, that's kind of paradigm shifting because right now, there's a lot of research going into putting bees in refrigeration units for the purpose of just kind of stabilizing them over winter. So my guess is that there'll be a lot of research on this topic. And 10 years from now, things will look different than they look now. I think beekeepers, bee academics, etc., we all have that common desire. We want our colonies to be strong and healthy. But our understanding of what it's taking to get there will change significantly so that my grandchildren who keep bees will keep bees probably very different than I do. Whereas my generation of beekeepers can't say that about our grandparents. We keep bees pretty much the same way they've been kept for the last 50 years. But I do think all of this new research is going to push us in a new direction quickly, hopefully for the betterment of bees and for their long-term health and the sustainability of our industry.

Amy 32:59
Yeah, absolutely.

Stump The Chump 33:09
It's everybody's favorite game show, Stump the Chump.

Amy 33:22
Alright, everybody. Welcome back to that question and answer segment. Jamie, the first question we have today is what is moonlight mating? And is it used today?

Jamie 33:33
Okay, it's funny, if you'd asked me this question last week, I would have had to do a ton of research to figure out what the answer to this question is. But of course, our listeners don't get the benefit of knowing what today is. But over the weekend, I was a speaker at the Georgia Beekeepers Association meeting, and Megan Mahoney was there who was speaking about her experiences traveling around the world and things she's learned. And one of the stories that she told was about a beekeeper in Australia who uses moonlight mating to control the drones to which his virgin queens are exposed. So I'm going to give you kind of a very broad and very upper-level general overview of the process because it actually gets quite detailed, but it's very interesting. And the issue is, if you ever want your queens to mate with your drones, you're kind of at the mercy of all the feral bee colonies out there as well as any other colonies that beekeepers may be managing in your area. So the ways people have historically tried to deal with that is absolutely inundate the area with your own drones to increase the probability that your queens will mate with them. Okay, so that's step one. So what this beekeeper in Australia thought through and came up with is, well, maybe what I'll do is only take my virgin queens and my drones outdoors once the other virgin queens and the other virgin drones in the area have stopped flying. So I know that sounds complex, but what he did, Joe Horner's his name, what he did is he watches for the last flying drones of the day. And once those drones have finished flying, he wheels his colonies that contain virgin queens or drones out literally on small train tracks. The colonies are connected to one another by ropes or chains. He pulls on that, which pulls all of these colonies out of the shed where they've been stored for the day, brings these colonies with virgin queens and brings these colonies with drones out. The virgin queens and the drones are eager to start mating. So they don't care that it's later in the day. Plus, they've been in the shed all day so they haven't seen sunshine. So when they come out, even though it's, quote, later in the day than they would ordinarily mate. They start their mating flights after all the other colonies that had been in the area have already concluded theirs for the day. So in this way, he's getting them to mate late in the afternoon, almost evening, and maybe sometimes even in the evening. And the term for this trait or this characteristic, this late mating is moonlight meeting. They're mating by the moonlight or in the moonlight. So it's a really interesting, maybe even ingenious system for getting the right queens and the right drones together. Even when you live in an area saturated with drones that you don't want your queens to meet.

Amy 36:51
Yeah, so my first thought is it seems like a lot of work. So my second thought is just wondering the queen quality of production and whether it would be the same for them mating in the moonlight versus during the day?

Jamie 37:05

Immediately before you and I came on the air to do the Q&A, I did read a little bit about this. And of course, I didn't find the original scientific studies, I'm just relying on what somebody had written on the internet, which is never safe. But they were finding, apparently scientists have looked at, again, I haven't looked at the original source, I'm just saying something out loud that they had said that scientists looked at it and said that he was getting, you know, 85% success. Not 85% of queens remaining but that the queens that mated it were mating with -- the drones they mated with were about 85% of the target drones. Again, I don't know if that number is correct or not. I'm just throwing out there that there's some evidence that he was in fact achieving what he wanted: his queens mating with his drones. And for all accounts and purposes, this was working in a production system. And you talked about, as your first point, the amount of stuff that kind of goes into this. The way he does it is that he releases these virgin queens into, essentially, what are mating colonies and keeps them in the shed all day long, right? Keeps them closed up in a shed, the entrance is closed, etc. Same thing for the drones. He wheels them out, literally on railroad tracks, smaller railroad tracks, and it's a pretty remarkable system. It's a very interesting system. Like I said, Megan Mahoney was talking about it. And then I looked up immediately before we came on air, and sure, that's exactly what he does. There's pictures of it online. So you can look up Joe Horner queen production online and you'll see you'll see pictures of how he does this.

Amy 38:31
Very cool. Alright, so it kind of leads into my second question. So the second question is asking do honey bee queens take orientation flights? So we know that workers take the orientation flight when they're going out looking for forage, things like that. But do queens take orientation flights? I'm assuming this question has to do with when they're going out on their mating flight. What are your thoughts on that, Jamie? And has there been research on this? And when do they take orientation flights, if they do?

Jamie 38:58
Yes, so queens do take orientation flights. So what is an orientation flight? We'll start there, right? Well, a bee that emerges from her cell or his cell in the nest has no idea where their nest is in context of the environment. They don't know if they're nesting in a tree in the ground, in a wall in someone's chimney. So when a newly emerged bee ages, as she ages, she gets to be around 15, 16, 17 days of age before she's transitioning from nest-based tasks, to field-based tasks. And so she has to learn where her nest is so she can fly away from it and return to it. So these worker bees will fly off of the entrance of the nest, they'll turn and look at the nest and kind of hover in a pattern looking at the nest and then they'll land. Then they'll fly off of the nest again a little bit further out, turn and hover and then land, and then fly a little bit further out still. What they're doing is they're learning where their nest is in context with the landscape. We call this orientation flights. And especially in spring, when you get these big flushes of new worker bees that are finally hitting the age that they would need to be before they go out and start foraging, you'll see orientation flights taking place in mass, where if you watch it closely, again, it's bees launching off the nest entrance, lots of them sometimes hovering and then coming back over and over and over again. So that's an indication that you're seeing an orientation flight. And so the questioner is asking, well do queen honey bees do the same thing? We know they go on a mating flight. So they leave the nest to mate while flying in the air, some distance from the nest, and they come back to the nest. So do they go on an orientation flight earlier in their life to learn where their nest is? And the answer is, yes, queen honey bees, like worker honey bees, like drone honey bees, do take orientation

flights. Queens are usually fully mated, I'm overgeneralizing here, but when a queen emerges, it takes about two weeks before they're fully mated and in the nest. So her mating flight would be somewhere around 10 to 14 days old. So she would be doing her orientation flights before that official mating flight or mating flights that she ends up taking. So yes, they do orientation flights. They need to do that to figure out where their nest is. And absolutely, folks have looked at this.

Amy 41:25
That makes sense. Okay, so the last question I have, there's a lot of research being done right now. Frank Rinkovich with the USDA has been giving a talk at lots of different meetings in the past year or so on Varroa resistance. With that topic, there's a method called the Pettis test, and we've had Jeff Pettis on before. I'm not sure, Jamie, is that Jeff Pettis' test? Can we talk a little bit about what the Pettis test is, whether it's linked to Jeff or not, and what this method looks like?

Jamie 41:55
So it is absolutely named after Jeff Pettis. Jeff Pettis was a USDA scientist for many years working in the bee world. We've had him on as our podcast guests and Jeff is now the president of Apimondia and he developed a test that beekeepers can use to determine if their mites, their Varroa are resistant to the compound that the beekeeper wants to use to control them. And the test is real simple. Basically, he creates a cup that has a screw top lid, and the lid is screen mesh, you cut out the middle part of the lid, you replace that solid part with screen mesh, such that when you screw the lid on to the cup, the lid of the cup has screen mesh. Now, Jeff would take, in the case of something like amitraz, which we know is the active ingredient in ApiVar, Jeff would take ApiVar, and cut a little strip of ApiVar and stick it to the bottom of the cup. Then, he would take adult bees from a bee colony and put them into that cup hoping that if he put enough adult bees into that cup, they'd be carrying with them Varroa on their bodies. He would allow the bees to be in that cup for six hours exposed to that strip and while they're being exposed to the strip, the Varroa are being exposed to the strip. After six hours, he would invert the cup. So what was the lid of the cup that's got screen facing up over those six hours, he would turn that cup upside down so that the screen mesh points down so that the Varroa could fall through the screen. So now you've got dead Varroa coming through the screen of the cup and you can count those Varroa. Then, you can put alcohol into the cup to kill the bees and you can wash those bees for Varroa and you can use those two Varroa numbers, those that fell out of the cup and those that remained in the cup, to determine what the resistance rate is of Varroa to that treatment. So let's put some numbers to it to make it a little bit better. All right, let's just say that when we do a Pettis test, seven Varroa fall out of the cup, and now we go back and wash those bees and we recover three additional Varroa. We assume, because those three didn't fall out the cup, they survived exposure to the amitraz. Okay, so seven fell out of cups, seven died, three didn't die. So seven and three is a total of 10. So we had 10 mites in that cup originally seven died, three survived. So we have a 30% resistance rate. Three of the mites survived exposure. There were 10 total mites. 30% of the mites are resistant to amitraz. If seven had remained on the bees and three had fallen out, then we'd have 70% resistance. So Jeff would use this test to determine what percentage of the mites in a particular hive are resistant to a specific treatment. And this test and modifications thereof are used by scientists and beekeepers, really around the world now, to understand some basic information about mite resistance to various compounds.

Amy 45:28
Yeah, do you think it's pretty common for beekeepers to start doing this test in their operations?

Jamie 45:33
I don't think it's very common yet, Amy. I know beekeepers who do it but I think it should be common. And what I mean by that is, I think that it is a very useful tool for beekeepers to determine the level of resistance that their mites might already have. And the reason this is so useful is because a lot of beekeepers kind of fall into that faulty assumption. "Well, I treated for mites, therefore my bees must be okay." Well, you might have treated with something that your mites are resistant to. So knowing their level of susceptibility is a good, good piece of information to knowing whether or not your treatment is going to work.

Amy 46:05
Absolutely. All right. Well, listeners, those are our three questions for the day. Keep those questions coming and we hope to answer them on air soon. Thanks for listening to today's episode. This episode was edited and produced by our podcast coordinator Mitra Hamzavi. Thanks, Mitra.

Jamie 46:32
Visit the UF/IFAS Honey Bee Research and Extension Laboratory's website, UFhoneybee.com, for additional information and resources for today's episode. Email any questions that you want answered on air to honeybee@ifas.ufl.edu. You can also submit questions to us on X, Instagram, or Facebook @UFhoneybeelab. Don't forget to follow us while you're visiting our social media sites. Thank you for listening to Two Bees in a Podcast.