Well then Dennis, if you can give us a little bit of your background and biography and how you came to research bees and colony collapse disorder and we can take it from there.

Dennis vanEngelsdorp: OK well, first things first, thanks for having me on this show. You know, they have a saying in the bee world: once you're stung, it's in your blood and you know you're going to be a beekeeper forever. And that certainly happened to me actually while I was doing my undergraduate degree. I was studying horticulture international agriculture and I took a beekeeping course as an elective and I really fell in love. And so I did a master's in beekeeping, and I think I'd be a beekeeper if it wasn't for the fact that I'm not very mechanical and so it's always if you're gonna be a commercial beekeeper you want to be able to build boxes and build things and I'm much better with statistics than I am with a hammer.

And so in researching bees it really became an avenue. I really also am interested in beekeepers and how beekeepers work, and they're nearly as interesting as bees are in themselves. So I've been very fortunate that I can pursue a job where I do a lot of extension work a lot with beekeepers but I also work with honeybees, which are very fascinating on their own right.

The whole story of colony collapse disorder, it's an interesting one, and I think it's important to realize that since 1945, we had about five million colonies in the country and now we have about two and a half million colonies in the country. So there's been this steady decline in honeybees for well over sixty years. That's troubling, but it really didn't catch the imagination of people until CCD, or colony collapse, hit the news. And what happened there was a very large beekeeper in Pennsylvania, Dave Hackenberg, one of the largest Pennsylvania migratory beekeepers--and I should add that I don't usually name people when talking about bee diseases, but I--Dave's OK with me talking about him. Dave is one of the biggest beekeepers in Pennsylvania, and at the November PA state beekeeping meeting, he was bragging about how good his bees were; he described them as boiling over. And as he does every year, he moved his bees down from Pennsylvania to Florida, and a month later went to visit them, and he describes it as going into a ghost town.

He says he got on his hands and knees looking for bees. He didn't see bees anywhere. And since there weren't dead bees in the entrance, there weren't dead bees in the apiary, they just weren't to be seen. When all was said and done he had lost 2,000 of his 3,000 colonies in a matter of weeks, and it was clear that this was happening to other beekeepers in FL and CA and so that's when a group of us got together and we decided to start sampling bees. And at first we really thought this was varroa mite and varroa mite certainly is the number one problem beekeepers are facing. They're these very large mites, these vampire mites, they're very large, I mean it's like a dinner plate feeding on you, so very large. And when they spit, in order to suck the blood of these, they actually introduce viruses to the bees. And these are killing lots of bees. And I was convinced when he called that it was a varroa mite problem. But we took samples, we asked him to send up the colonies of this next truckload up and we took samples from them. We actually found no varroa

mite in these colonies. Or very little varroa mite that couldn't explain the loss. And it became very clear that this problem was happening in lots of distant places, and at very high levels.

And so that word CCD came when we had a committee, a group of us got together to describe this condition, and we defined colony collapse disorder as caused by a very specific set of symptoms: the colonies died very quickly, as evidenced by the fact that you'd see lots of brood, the young bees, but not enough adult **(5:00)** bees to cover them. Which is very unusual because bees don't abandon their young. And that was clearly what was happening here. The bees that were, the bees that were last in the colony were young, and the queen was there, the queen was one of the last to leave, you didn't find dead bees in the hive or the apiary, and there was a delay in robbing. Usually when a colony dies, it leaves food supplies behind, and other bee colonies will come in and steal that honey. And that wasn't happening in these situations.

And so that's where CCD sort of, that whole story of CCD, happened. I want to say that since then, we find it much more difficult to find cases of colony collapse disorder every winter. But we're finding that the same number of colonies on average are dying every winter. And so that's made this story much more complicated. Because they're not dying with the same symptoms, so we can't call these colonies dying, like CCD colonies or colony collapse disorder colonies. But we're still losing one in every three colonies as we go into the winter every year. And that's a phenomenal number. I can't imagine any other agricultural group losing that many colonies and not having the National Guard called. I mean, can you imaging if one third of all the cows died every winter? That would just be, that would just wreak havoc. And I think that part of the problem is that beekeepers are very good at replacing losses. And so if you have a colony that's died, and you have a colony that's alive, you can split the living colony in half, buy a queen, and you can suddenly have two colonies again in a couple months if you feed them and nurture them along.

The problem with that scenario is that it's really expensive. It's very expensive in terms of lost income, increased labor, and increase in cost. And that's where our real concern is, I think. And as the research community there's relatively few commercial beekeepers in the country. Maybe eight hundred to a thousand of them managing ninety to ninety-five percent of the colonies in the country and these are the beekeepers who move colonies across the country to pollinate our fruits and vegetables. And if these kinds go out of business, they're very difficult to replace, and we're worried that with these high levels of sustained thirty percent losses every winter--we've lost a couple, we're probably going to lose some more--if this keeps happening, we just it won't only affect those families, those beekeepers moving their colonies around the country, it's going to affect a blueberry producer in Maine, a cranberry producer in Massachusetts, apple producer in PA, a cucumber producer in New Jersey. And of course the almond producer in CA. All of these

different farmers rely on that same beekeeper to move his or her colonies around to pollinate those different crops.

I've heard figures anywhere from 25 to almost 50% of the fruits and vegetables that we eat are related to the pollination of bees.

DV: Yeah, so it depends a little bit on how you count, but I think it's safe to say that about 1 in 3 bites of food we eat are directly and indirectly pollinated by honeybees. There's some crops that are clearly pollinated direct like apples. We wouldn't have apples if we didn't have honeybees. Or some insect pollinators, and honeybees are the best, most efficient apple pollinators. There are other crops like blueberries, where honeybees are simply the most convenient pollinators. The fruits that for a short period of time that they're flowering and take them out before they start spraying.

And so what you need is you need this moveable pollination force and so that's where honeybees are important. They're also important for seed production, and that's also part of this one third. So for instance, a lot of dairy cattle are fed alfalfa. And where that alfalfa seed comes from are alfalfa seeds, you know, in the Midwest. For alfalfa seed production, which use honeybees to set that seed.

The honeybees provide a large number of services that just wouldn't be possible without them.

DV: Well that's right, and I think it's really important to remember that in North America, honeybees have been introduced over here, who brought over here were the Europeans, and so they're not made. But neither are a lot of the crops who grow. SO for instance apples and almonds are old-world crops that were brought over. But there are thousands of species that are made to be so bumblebees and beautiful little solitary and stainless bees that also pollinate the different crops that we have here like squash, the sunflowers, these are much more efficient at those crops. In fact what they find though, is that in the presence of both honeybees and native bees, the fruits taste better and the quality of the food, the fruit, is better, too. So it's not a comparative thing; **(10:00)** I think having room for both are important.

And there's a very important movement in agricultural circles where they're trying to reintroduce the hedgerow, which acts as habitat and a place, a reservoir, for these native bees that usually live solitary lives. It's not like they're in colonies that can get trucked around. They're filling holes in wood or they're boring into the soil and sand as nesting sites to provide pollination services. And sometimes that pollination service is for a very specific plant at a very specific time, so you have some species that are only out for a couple of weeks in association with a certain type of plant, and sometimes these are very close evolutionary relationships. And some really good studies out of Europe that show in England and the Netherlands that if you see declines in some of these solitary bees that can involve these very specific relationships with certain style plants, not only are you seeing a loss in those bees, but you're also seeing a loss in the plants that rely on them for pollination.

So the loss of one is reflected in the loss of the other.

DV: That's right. Honeybees and pollinator species in general are the keystone species. They're the species that hold the system together. For me, it's one of the most beautiful evolutionary stories; it's the one between pollinators and flowering plants. You know, often we think of evolution as being this competition. The strongest survive. Well between bees and flowering plants, it was cooperation. Here we have these insects that have become true vegetarians. They only eat plant protein. Flowers provide copious amounts of this plant protein in the form of pollen. They also produce nectar. And these are rewards to the bees to come over and visit their flower and to take this pollen to another flower so that the plants can essentially cross-fertilize and mate.

And so, here we have these flowers, which are in many ways the first form of advertisement: these big, gaudy, colorful florescences that smell to attract the bees. They're really trying to reach out to the bees and say, "Come over here, come over here, I've got lots of food for you," and in the process are you not only getting fed and can bring this food home, but you can also fertilize as you're doing it. And so it's one of the most beautiful, I think, evolutionary dances out there. Without these pollinating plants we wouldn't have flowering plants, and without these flowering plants we wouldn't have these bees and pollinators.

There's an imperative there, then, to both provide habitat for the bees as well as homes and everything else that they need so we can continue to propagate many of these plants that are valuable to us and to support the pollinators in turn. It's an interesting cycle between the two.

DV: That's right. And it's a complicated cycle. And I think that's where if we want to go back and talk a little about what's causing the kinds of bees. When we first came across CCD we thought we would have a simple answer. We thought, "Well, maybe its a new disease, maybe it's either a new virus got introduced or a new variation of a virus, you know how the flu every year, we have the flu in slightly different variants of it that can cause problems." Or we thought maybe it was a pesticide, and maybe it was a pesticide that the beekeepers applied to control varroa mites or a pesticide that the farmers applied and the bees are bringing back. Or we thought it could be some other environmental stress. Maybe there was bottlenecking in the genetic pool, maybe the bees were very poorly nourished. And these were the problems.

And so when we took samples from healthy and CCD colonies and compared them, we actually didn't find very many differences between CCD bees and the healthy bees, except in a couple important ways. CCD bees had by far the most number of pathogens. Both populations had about the same number of pathogen exposures, but the CCD colonies sort of had every disease going. So CCD bees were really, really sick. And we thought it was viral collapse that was responsible for the symptom of the rapid decline of adult bees. We think that these, like other social insects, have evolved something called altruistic suicide. Somehow they know they're sick, and so

when they know they're sick, they want to fly away from the hive and die away from the hive in an attempt to protect their nest mates from getting sick too.

I'm saying that as if the bees are really conscious, and of course that's anthropomorphizing it, that's not really what happens, but I think that explains the process we think is going on. And we see this also in termites for instance. Some termites, when they get a fungal infection, will leave the nest, tapping on the ground in a certain way which is called the leper's walk, and they're telling other termites, "Don't touch me, I'm sick. You don't wanna come and get that sickness." **(15:00)** And so we think this explains that rapid loss. But it doesn't explain why the bees are as sick as they are.

The other sort of inconvenient finding from the CCD study was that the healthy bees consistently had more pesticides than the CCD bees and I think we're having trouble explaining that. It could be that the beekeepers who had the healthy colonies were much more aggressive at controlling varroa mite. It could be that the bees in the healthy colonies that had been selected for over time to be more resistant to pesticides and so that's why we found more pesticides in those colonies. Since sort of we don't find CCD and we're still seeing these losses, we're sort of building this case that it isn't a single factor. That what we're seeing out there, it's different for different beekeepers, it's different for different years, and it's a combination of factors. And so what we're seeing is pathogens playing a role, pesticides playing a role, and poor nutrition playing a role. And so this is our leading hypothesis, and whatever the difference in all of them, clearly we know that varroa mite can kill a lot of colonies. And certainly beekeepers, the number one thing a beekeeper can do to keep colonies alive, is to make sure that they're treating varroa mite aggressively, and there's lots of different ways of doing that including some organic options.

We also know that the bees are not getting well nourished. The habitat that they once had isn't available to them anymore. So if we look at the Midwest, we look at North Dakota and South Dakota, there used to be a lot of CRP land, Conservation Reserve land, that was left fallow and it would grow a whole bunch of different crops including flowering plants that bees could forage in. But with corn and soybean going up, we've seen that a lot of that land is getting plowed under and getting planted with corn and soybean, which means that there's less and less for bees to eat. And so we really do think that the bees have lost a lot of their foraging potential. This means that they're being less well nourished and that they're also having to eat and rely on agricultural crops for their protein and nectar and inadvertently the pesticides. But of course pesticides coming into the colonies is a big concern.

And so the big theory then is that it's a combination of these factors, and the study we just released recently sort of helped support this theory that it's multiple factors. And so in this study what we did is we placed colonies in different agricultural settings, and collected the pollen off the bees as they flew back to the colonies. And bees, when they fly away from the colony, build up an electric static charge, so when they land on a flower, pollen jumps on them and they're able to rake that pollen

back and store then press it on their hind legs in what's called the pollen basket. And so there's this pollen pellet on their back legs that they bring back to the colony, they put in a cell and add enzymes to help start digestion and then the nursed bees, who are the youngest bees, will eat that, and then make a milk that has a lot of protein in it that they will feed the young. But what we can do is we can put a trap and follow that colony, and knock those pollen pellets off and then collect those pollen pellets. And that's what we did in these different crops. And then we sent that pollen off to get tested for pesticides. And we found a lot of pesticides, as many as twenty-one different pesticides coming into one colony, on average, nine different pesticides. In some cases we found levels of pesticides well above the LD-50 rate, so that's the lethal dose for fifty percent of the population. So, no doubt there were bees that died in the field while they were collecting this pollen because it was very high in levels.

Then what we did is we sent some of that pollen to newly emerged bees and then exposed them to a fungal infection that's very common to bees called nosema. And a little while later we would then count how many of those bees eventually got this fungal infection. And what we found, which really surprised us, well, we found two things, the first didn't surprise us. And that was we found a lot of miticides. These treatments beekeepers apply to their colonies to control varroa mite, we found in the pollen. And in fact when the bees that ate this pollen with these miticides in it were much more likely to get infected than if they ate pollen without miticides in it. And we'd known that for a long time. Beekeepers know that treating chemicals in their colonies is a lot like chemotherapy: chemotherapy is not good for anyone; it's just much better than cancer.

And so we know that the colonies are gonna die if you don't control varroa mite, but the option is you have to usually treat with something that's gonna have a **(20:00)** detrimental effect on the colony. And so we know that these chemicals hurt bees' immune systems. Then what really surprised us though was the effect of fungicides, particularly a very common fungicide called chlorothalonil. And so, this is not considered toxic to bees at all. Fungicides are usually thought of as very safe for bees. I mean, you can spray fungicide on the bee and it flies happily home! But what we found was that bees that ate pollen that had this were two or more times likely to come down with infection than if they hadn't been exposed.

And so this is evidence that this synergistic effect, that this sub lethal effect, that the fungicide's not killing the bees, but that exposure to the fungicide is making them much more susceptible to disease. It's an important finding. It's important in the fact that when you look at the regulations, regulations are pretty clear in the fact that you're not allowed to spray a flowering plant with an insecticide that will kill that pollinator. And so when plants are in flower, generally farmers don't spray anything but fungicides because fungicides are deemed safe. This suggests that we have to re-think how we label fungicides for application, because we have to start thinking about how to protect the bees, but we also give a tool that beekeepers can use to work with farmers and say, "Hey, I'm renting you these bees, I know you're not

interested in killing these bees, so please, you know, delay the treatment of fungicides until I get the bees out of here." And so it gives an actionable point to the story. And so, a very surprising study. The weakness of that study was that it wasn't designed to look at the nutritional aspect. So, for instance, we found some types of pesticides on apples, and we know that apple pollen is very good for bees. And so it could be that nutrition plays an important role here, too. If we had highly nutritious food, maybe the bees are better able to resist nosema, and counterbalance any negative effects of the pesticides. And we hope to follow up on that work in the future.

So I guess just to summarize, our current thinking is that it's multiple things coming together. Another example, that is like when there's a drought year, if you have a drought year, does that change the nutritional value of the pollen and does it concentrate pesticides in the hives? And so you can imagine that different factors can come together to make it more or less likely that bees will come down with disease.

So this isn't like the bees are getting something that completely compromises them, if you will, like a bee version of HIV or AIDS or something that makes them really sick, it's just a lot of little things are dinging at the health of the colonies, and then as they start to die off, the bees themselves, well, again that's kind of anthropomorphizing, but, the bees are taking an action to protect the rest of the hive, but in that process is causing an even bigger loss to the hive.

DV: Well, that's right. I want to emphasize that colony collapse disorder, we're not seeing it anymore. We're seeing a slow dwindle, and that's probably because we're not seeing mortality necessarily that's virus mediated. It's called being remediated by some other illnesses that don't cause that symptom or don't invoke that response. But I think you're right, it's not like there's one. I guess if we're gonna use the AIDS analogy, it's like something's making their immune system like AIDS, except we have lots of different things that can weaken their immune system. So I guess a closer analogy is heart disease. Well, what causes heart disease? You don't eat well, certain toxic exposures, lack of exercise, genetic predisposition. One or a combination of those factors, and it's just the same with the bees, one or a combination of factors that predisposes them to a disease that might be the final straw that takes them out.

Just so I can make sure that I understand the language of this, then, is that you're not seeing CCD as much because that is a clear set of symptoms that you defined for that disorder, but you're still seeing a die-off of the bees as a result of the other mix of environmental, nutritional, and other factors.

DV: Yeah, and I'll just be a little more specific. We're not seeing the symptoms of CCD anymore, so we can't call it CCD. But we're still seeing the same number of colonies every winter. We're not sure what causes those losses, and we're thinking that it's a combination of factors working together. And we think that that's both variable in

time and space. And so some beekeepers are suffering this combination, and another beekeeper may be suffering these combinations. But collectively, I think what it's saying is that the environment is not nearly as friendly to bees anymore, and it's much more difficult to keep them alive.

OK. Thank you. I only know so much about the issue, and trying to wrap my (25:00) **brain around it in a way that is precise enough to discuss it is one of those sticking points for me.**

Now, I'd like to touch on how to make the environment a healthier place for bees, but, before we get there, one of the things that I'm seeing a lot is the impact of neonicotinoid pesticides, potentially on bees, and I was wondering if you can speak to that at all, whether you've done some research on it or if you can speak comfortably on some of the papers that have been written on this.

DV: So, neo-nics are a group of pesticides, or insecticides, because they're designed to kill insects, that were based on nicotine and tobacco plants. And, the advantage of these pesticides, if you like, is that you can use very small amounts of them, and you can either paint them on the seed, or you can drop a little bit in the soil, and the plants will suck up this insecticide, and it will go into their leaf tissue, and into their other plant tissue. And if an insect comes and nibbles on that leaf, they'll get exposed to this insecticide and die. So this is called a systemic pesticide or insecticide. Now, plants have evolved all sorts of toxic components to kill off insects or that discourage insects from eating them. So you think of celery, and celery has lots of toxic chemicals that discourage other insects from eating it. But all these plants that produce these toxins have evolved structures that ensure these toxins don't go into the pollen and nectar because they don't want to discourage pollinators.

The problem with neo-nics, even though I think they were designed with the best of intentions, because they reduce the number of times the farmer has to apply chemicals, they reduce certainly how much chemical has to be applied into the environment, it's very specific to the plant so there's less problems with the runoff...they have a lot of advantages in theory, the problem is that these chemicals are getting in at low levels into the pollen and nectar and the bees are bringing them home. And these are very highly toxic products. And we're seeing that often while the levels in the pollen and nectar aren't sufficiently high to kill the bees outright, there's a lot of papers that show lethal effects. And so I know there's work that I cooperated on that show that these are more likely to come down with nosema infection, which I talked about earlier. We all know that there's work that shows it effects their memory and their ability to find their way home, so there's a lot of sub lethal effects. What is yet to be done, though, is to show colony level effects that we can see detrimental effects on the colony. And I think that work still needs to be done.

Now, in Europe, they have a different sort of criteria for how they evaluate pesticide safety. So there they have the precautionary safety principle. That means, if we can't say that there's no risk, then they might ban the product and wait for more research.

And so starting January of next year, there's going to be a ban on the neo-nics. The real concern is what's going to replace those neo-nics, and there's I think some discussion that needs to be had because I think a lot of these replacement products might be more detrimental to colony health than the actual neo-nics are. The fact is that 20-15 years ago, there were a lot of colonies dying from insecticide spray. The thing is, we knew they were insecticide-killed colonies, because we counted a bunch of dead bees at the colony and that's not happening with sub lethal effects of the neo-nics. And so I think that certainly neo-nics need more attention. However I think that the last study we talked about earlier suggests that we need to look at a host of different products including fungicides, which also is very widely used and very common. And its role too. And so I think that to make sure that we're keeping our conversation broad. Has that answered your question, sir?

Yes, I think that covers the question perfectly. That it's--as much as we may want to focus on these particular insecticides or pesticides because it gives a kind of clarity to where the issue may be arising--that it's kind of a false path to walk down because there are these other problems that have to be investigated. But it has to be kept general.

DV: Right. And I think that you'd find a lot of people who would disagree with me very vehemently there. Like, there are certainly some beekeepers, and there are certainly some scientists who really think the problem is only neo-nics. And certainly there have been problems when planting corn for instance, because corn gets painted with the neo-nics so when they drill that corn in dry soil, when they're planting that corn, the dust cloud comes up, and that dust cloud, if it lands on foreign plants **(30:00)** and some bees visit it, those bees die from neo-nic poisoning. And so there are clear cases of neo-nic poisoning because of seed treatment and how they plant the seeds that needs to get addressed, it's the sub lethal effects that I think some people still question. And I certainly think that it needs to get looked at, but there's a lot of other things that need to get looked up as well. But, I think there would be a lot of people who don't agree with me.

Well, I think one of the important parts of scientific inquiry is to leave many of these questions open so that we can explore them through research and close the ones that aren't valid, but leave the doors open for those that need to be explored further.

DV: Right.

I guess to kind of expand on that thought for a second is that even if we were to ban the neo-nic tomorrow, from your research that's not going to stop the bee die-off, that there are still these other factors that need to be investigated.

DV: Right, and I also don't think even the Europeans think that banning neo-nics are going to stop the die-off right away, in part because they think there's residues in the soil so it may take a long time for the neo-nic to go away. And certainly there are lots of other things killing bees. I certainly would be very surprised if suddenly all

our problems would go away with the banning of neo-nics. I actually think they're causing more problems with pesticides. It would just be direct and immediate.

Because of changing away from the neo-nics to something else.

DV: Right.

It sounds in some ways that this reliance on agricultural chemicals continues to create these different issues that we continue to adjust for within agriculture.

DV: Yeah, I mean certainly there are always other consequences to everything we do. That's very true. And it's hard to see how we can feed the world without using some of these technologies, but at the same time I think it's a very legitimate question is that why is it that nearly all the corn in the country is treated with these neo-nics? Is that really necessary? And so I think some conversation about making sure we're being wise about things is warranted. And so I don't know that banning things always works. I think it's people just using things more intelligently and I think that that's perhaps the more creative solution and the better long-term solution, but of course it's a much more complicated solution and so it's much more difficult to implement.

And at the same time we can look at nutrition, and why is it that we think the green lawn is this beautiful status symbol? You know, that's sort of archaic! That's based in the times that we had kings and queens, really, these big green lawns are big deserts. They support nothing but the grass. And so why is it that we spend all these millions of dollars on herbicides to support what we call weed free? Weeds are flowering plants, and aren't meadows much more interesting than green lawns, and shouldn't that be the status symbol? Maybe we need a cultural revolution in terms of that.

I went to a really interesting talk last week, and it was a guy, I wish I could remember his name, from Delaware. And he was saying if every one of us took 10% of our backyard and turned it into a natural habitat with pollinator plants and native trees and native plants, that would be the equivalent of adding together three of the largest national parks in the country together. Adding that to our ecosystem. So I think that there's a lot of things we can do to help native plants and native birds and native insects by simply being smarter not only in agricultural communities but also in our own backyards, so to speak.

Many of the conversations I've had with past guests, and that my listeners will be familiar with, from trying to do ecological and regenerative design, is conversations about that, about getting rid of the lawn. And making changes to the way that we live our lives in society so that we can create habitat and provide benefits for other creatures beyond just ourselves. And so I'm sure that many of the listeners are doing a lot of the work that you heard in that talk and I'm certainly doing that in my own backyard and working with some

of the master gardeners here about building pollinator gardens here for some of the local private schools.

I know that work's being done and will continue those of us who are informed to do our best. But what are some of the things that you would recommend for folks to try and create a more hospitable place for our bees? One of the things that you mentioned is an organic option for controlling varroa mite, if someone wants to keep bees, what are some of the things they can do to help control that?

DV: That's a really good question and so the first thing that I always say is, think about becoming a beekeeper. Because beekeeping is actually the most relaxing thing you can ever do, because you have to get into the zen of beekeeping. If you're not relaxed, the bees will let you know and so you have to find that relaxing. And you're also connected with this amazing group organism. **(35:00)** On a beautiful sunny day you can open a colony without any protection, just your smoker, you open that colony and there's 40,000 insects working together collectively. They're making this glorious liquid gold. As a beekeeper you have to become very attuned to your natural environment, you have to know what's blooming and when it's blooming, and it's just the most amazing experience to see how these organisms live.

So, think about becoming a beekeeper and, by becoming a beekeeper, you also become very aware of your environment and become an advocate for it, which I think is a great thing. And as a beekeeper, I think that there are many different ways of keeping bees, I mean, we have a saying, "You get five beekeepers together, you get seven opinions and six are right." And so there's lots of good ways of keeping bees.

And certainly there are ways of controlling varroa mite with less harmful products, some products are registered as organic use, like formic acid for instance, and other products. And so there's those options. The other thing that you can do is, I realize that beekeeping isn't for everybody, but you can buy local honey. And by buying local honey, local honey is the most ethical sweetener in the fact that it takes the least amount of carbon to get that sweetener to your table. And so replacing sugar, refined sugar, in our diets and replacing that with honey is a very positive step forward both for the beekeeping industry, because you're supporting them, but also has some real direct benefits to the environment.

And there I think making habitats for bees, and I think we touched on it, you know the pollinator gardens and making sure that we're not using agricultural chemicals in our backyards or in our urban environments. The fact is that backyard gardeners use many times more pesticides per acre than farmers do. And a lot of this is done on pure ornamentals, which sort of has no, doesn't make any sense at all. And there's a case of thousands, I think of 50,000 or more bumblebees dying feeding on tilia trees in Oregon this summer. And those trees were sprayed, not for any human safety or food safety concern, but were simply sprayed because people did not want aphids to secrete on their cars in the parking lot. And so, again, not using pesticides unless we're really sure why we really need them I think is an important part of the

solution. You can also provide a lot of habitat in not only just the food but there's these natives who are providing, you know, native bee houses out of wood or soil that doesn't have anything growing on it, like sandy soil on a southern face can attract bees, so there's a whole bunch of things that we can do to support bees, both honeybees and the native bees.

One of the aphorisms that I've heard before is, what is it, the solution to pollution is dilution. Even though it's kind of sing-songy and silly in some ways, but that if we're providing a chemical free backyard habitat, that if the bees that are foraging our agricultural areas are also coming into our own yards, that that decreases the amount of the sub lethal pesticides that are then being taken back in the pollen to the hive. And I wonder what type of impact that might have.

DV: You know, I think that's a really good point, and it's one the beekeepers keep quoting to each other. And that's one of the reasons they're feeding the colonies like they've never fed them before, they're feeding a lot of protein diet, and they're feeding a lot of carbohydrate sources in order to dilute agricultural pesticide exposure. I think it's absolutely true. Not only are we providing healthy food to keep sure we have healthy bees, but we might be helping some bees that have had other exposures. Began as sort of anecdotal but I think there's a lot of wisdom there.

Well, sir, you've taken us through so many different topics on this subject, I feel that we've covered everything I wanted to. Before we draw this to a close, is there anything else you'd like to add to the conversation for the listeners?

DV: No, I mean I guess I would just reiterate what I said before, really think about becoming a beekeeper. It's a great community to be a part of. Buying local honey I think is a really positive thing. And making, and it sounds like your listeners are doing this already, is making sure that we are making wildlife habitat, including pollinator habitat, to support bees, both native and the honeybee.

I will certainly share this message and make sure that we get more of that work done in the world. Thank you for taking the time to join me in this interview, I really appreciate it.

DV: And I really appreciate you giving me this opportunity, so thank you as well.