Ask A Biologist Vol 064 (Guest: Jennifer Fewell and co-host Jane Rector)

Ant Life Part 1

As scientists study the amazing social network of ants they are discovering we could learn a lot from these tiny animals. Dr. Biology and co-host Jane Rector visit with Jennifer Fewell, a biologist who is exploring the world of social insects including ants. They learn a lot about this female dominated world and just what leafcutter ants are doing with all those leaves.

Transcript

Dr. Biology: This is "Ask a Biologist," a program about the living world, and I'm Dr. Biology. I'm here with one of my co-hosts, Jane Rector. Before we get to our expert scientist, tell me. How did you get to "Ask A Biologist" and where are you from?

Jane Rector: I'm from Gold Canyon, AZ. I am at Peralta Trail Elementary School. I entered a competition for "Ask a Biologist." I like reading books.

Dr. Biology: You like reading books. Let me ask you this, are you really into science?

Jane: Yeah.

Dr. Biology: You are? Is there a particular kind of science?

Jane: I really like chemistry a lot.

Dr. Biology: Like chemistry? Well, the two of us get to talk with a really great and wonderful scientist. As a matter of fact, you can introduce her. Who do we have here today?

Jane: We have Doctor Jennifer Fewell.

Dr. Biology: We actually got to visit her laboratory, didn't we? What was the best part of that laboratory?

Jane: I think seeing how the ants were building their colonies.

Dr. Biology: Right. With no more delay, we're going to be talking with Dr. Jennifer Fewell. She is a professor in the School of Life Sciences at Arizona State University. She does some really cool experiments with social insects, of which some of those social insects are ants. Welcome to the show.

Dr. Jennifer Fewell: Thank you. Thank you for asking me.

Dr. Biology: I know that my co-host, she is so anxious to get started on this. I'm going to let you go ahead. Jane, what's the first question we wanted to talk about?

Jane: I noticed that, when I was little, I got bit by a lot of red ants. I just swelled up immediately. Does that mean I'm allergic to it or is it just the venom?

Jennifer: First of all, where were you when you got bitten by the ants?

Jane: I was in an apartment. It was a gravel colony and I kind of sat on it.

Jennifer: You sat on it? [laughs]

Dr. Biology: How old were you?

Jane: I was probably two.

Dr. Biology: OK, all right. Well, we understand at two.

Jennifer: Well, those sound like harvester ants to me. They're local ants. They're the red ones that build gravel nests. They're sort of medium-sized. They're not the tiny, tiny ones that are also very painful.

The interesting thing about harvester ants is that they have really intense venom. When they sting you, it really, really hurts.

So it's hard to know whether or not you were actually having an allergic reaction, which is the body's immune system overreacting to something, or whether you just swelled up because that's actually what their venom is meant to do.

Jane: Oh, okay.

Dr. Biology: Maybe you're not allergic to that type of ant?

Jennifer: Maybe not, it's hard to know. You have to get stung once before you're allergic, so you can't have an allergic reaction the first time you encounter the venom.

Jane: Oh, really?

Jennifer: Yeah, because your body has to learn that it's a foreign protein. Usually, you get stung and it's not an allergic reaction, but then you may have allergic reaction later. So if you got stung a lot, it's possible that you could be allergic to them now.

But probably what happened to you...you got a lot of stings, right? It's probably, basically, exactly what that venom was designed to do, which was to get you away from their nest as fast as possible.

Dr. Biology: I think the moral of the story is, "Don't sit on any ant nests."

Jennifer: Actually, you know what my first experience with a social insect was? When I was six, at a picnic and I took a bite into a cheese sandwich. I didn't know that a wasp had flown into my sandwich and I bit it in half and it stung me on the tongue.

Jane: Oh, no!

Jennifer: Yeah, I have this sort of vague memory of that happening, and then ending up in the doctor's office and them weighing me, and me thinking, "What has my weight got to the do with the fact that my tongue is swollen up?"

[laughter]

Dr. Biology: How powerful is this toxin that the ants have?

Jennifer: It's not the bite. It's the sting. The toxin in a harvester ant is incredibly strong. Ounce for ounce, it's more potent than cobra venom, but you get a lot less obviously from an ant than we do from a cobra.

Jane: You said that ounce per ounce the venom is more potent than a cobra's? When they sting you, does the venom level go down? Can they only sting "x" amount of times before their venom runs out or do they reproduce the venom?

Jennifer: They reproduce venom but, in the instant that they sting you, the first sting is going to deliver most of that. Then, if they sting you multiple times, you'll get a little bit more and a little bit more. Then, they have to produce it. It's a chemical that they have to make inside their bodies.

There is, I guess we can call it, a latency period. Something like that. But by that time you are already running away from the ant, screaming. It's not relevant at that point.

Jane: I noticed in your lab that ants kind of got out of their little boxes. How does that affect the colony?

Jennifer: Oh! We had some escapees from our colonies. We keep our colonies in these plastic containers. We are talking about leaf-cutter ants here. They actually grow fungus to eat in the colony. So we have them in these little chambers, and then they are in boxes where they go and forage.

Then, we have those boxes in a bigger container that we have put a special substance around the side. So, it's like Teflon to stop them from getting out, but these ants are so good at climbing, and sometimes they get out.

Jane: Yeah, I saw a few of them on top of the boxes, crawling upside down.

Jennifer: Yeah, they can actually do that. They can actually grab on to...you think the Plexiglas that they're in is smooth, but it's rough. They can actually grab on to that with their...

Jane: Like tree frogs?

Jennifer: Yes like tree frogs or geckos. They all have special ways to climb up and down things, which are really interesting. The colonies have a lot of workers in them. Them losing a few workers isn't going to change things very much. They have a lot of, what we call, redundancy.

There are lots of workers to do the chores that need to be done, so we don't worry about a couple of them escaping. We do try to keep them as contained as possible though, because people get a little worried when they see ants going up and down the hall.

Dr. Biology: A few escaping is not a big deal. Any mass escapes ever?

Jennifer: Well yes! We have had a couple of times when the entire colony has decided to get up and leave its current beautiful Plexiglas abode and find new digs. We had once an entire colony of workers going down the hall, carrying their brood with them, looking for a new home, which was a little [laughter] bit of a problem to other people working in the building.

But they are native ants. They're native to Arizona, so them relocating isn't actually a big deal. We did gather them up though and tried to convince them that really the lab was the best place for them.

Dr. Biology: If you could actually get inside the head of an ant, I always wonder what they would be thinking, as they are wandering down these giant corridors, trying to find the new home.

Jane: Oh my God! What is this purple tile?

Jennifer: Yeah! More likely, "Follow the trail. Follow the trail."

[laughter]

Dr. Biology: Yeah, exactly. What are they looking for? How come they would give up those wonderful Plexiglas homes?

Jennifer: That's a good question. When you try and bring something in to the lab, and you want its environment to be the same as out in nature, you try to the best of your ability to recapture that.

But there is nothing that you can do really with Plexiglas containers that is going to capture a giant hole in the ground, underneath a Palo Verde tree, in the shade in the desert.

I mean, that's what they've evolved to live in and that's probably what they're looking for. Our colonies do really well. They get pretty large, but we don't actually get them as large as what you'd find if you'd find if you dug up under a Palo Verde tree.

Jane: Yeah. I saw in some of the colonies they have tons of that kind of white gooey-looking stuff. What is that?

Jennifer: The fungus?

Jane: Yeah.

Jennifer: Yeah, that's their food, which is kind of interesting. They're leaf-cutter ants. Actually, Arizona has the northern-most species of leaf-cutter ants. The ones that you're used to thinking about in the tropics with the big leaves they're carrying over their heads. This species is actually related to that, but they live in the desert.

All of these species have in common that their main food source is not actually the leaves that they're carrying back, but a fungus that they grow that is specialized just to survive in those colonies.

What they do is, they bring the plant material back, and they chew it up. Plant materials, like leaves, are very hard to digest. Ants are very good at digesting it, but fungus is really good at digesting that kind of thing. The ants chew up the leaves. They apply it to the fungus. The fungus digests it. It eats it, and then the ants eat the fungus.

They'll take little pieces of the fungus, always tending it, keeping clean, giving it what it needs, and then it's their main food source. They actually farm. They farm for fungus.

Jane: Back to the head, how big are ants' brains?

Jennifer: How big are ants' brains? What a question! I don't know the answer actually. I have been thinking about this, because ants are a lot of different sizes right? You have tiny, tiny ants, and then you have really huge ants. They can be two orders of magnitude, different in size.

You can have some ants that are 100 times bigger than other ants. Actual brain size is going to vary a lot. Then, on top of that, did you know that the entire brain of an ant isn't actually in the head? Most insects have, what we call, more distributed nervous systems, so they have bundles of nerves as you go down each of the legs and then into the abdomen.

All of their processing isn't as focused in the brain as it is in humans, which is why you can actually cut the head off of a cockroach. Not that I am recommending it as a home experiment, but it will still survive and it will still be able to move around. Ants are the same way.

Jane: That's...eww.

Dr. Biology: So the brain is distributed from what we consider the typical location of the brain, all the way down to where?

Jennifer: All the way down to the end of the abdomen. They have bundles that we call ganglier that are concentrated in different locations.

You have three different locations in the thorax, and as it goes into the abdomen, that are areas of more nerves that are responsible for them moving and responding, which is one reason why they can move away from something real quickly, and how they coordinate their three sets of legs.

Jane: I notice that when the ants met each other in those little tubes connecting your makeshift little colony chambers...

Jennifer: Makeshift! [laughter] I prefer a laboratory.

[laughter]

Jane: ...that they kind of felt with their little feelers each other. What are they doing?

Jennifer: Well, ants touch each other to communicate. They get a lot of their information from touch.

When they touch, it's almost like they're smelling because they have chemical sensors on their antennae and on their front legs. So they can actually pick up odors from the ground, from the environment or from each other. They send a lot of information to each other.

One of the things as they are coming into and out of different areas of the colony, one of the pieces of information they need to give is "I belong here," because ants defend their colony from other ants that might want to invade or foreign insects.

They are touching each other partly to see whether they smell like they should. They also have a lot of information on their bodies like, "What task am I doing? Do I need you to do something for me?"

They are also very clean. They groom each other a lot to remove dirt, debris and pathogens, bacteria, fungi and things like that from their bodies.

Jane: Do the ants, when they come out of their pupa stage… Do ants know exactly what work they are doing or do the other ants have to tell them?

Jennifer: That is a really good question because, when people do work, it is often because someone tells you to do this or tells you to do that. So we have this kind of – can we call it hierarchy where there is a boss who basically tells other people what to do? Ants don't really have that same kind of organization.

People thinks that the queen is the boss of the colony but she's not. She is actually a specialist. Her specialty is to make babies, to make new brood for the colony. She is not telling the different ants what to do. Instead, they have what we call a distributive system where each of the ant samples what is going around her and makes a decision on what task needs to be performed.

She does it in a way that is kind of interesting because it is also dependent on what she is like internally. If she is just emerged, then she is more likely to perform tasks that are close to the area where she emerged, including cleaning up the area or she will eventually move to feeding other ants or feeding the brood, grooming, maybe grooming the queen.

Then as she gets a little older she is more likely to move towards the entrance of the colony. She will do things like guarding, trash removal. Then, the oldest ants forage. They go out and collect the resources.

We call that age-based division of labor. Different individuals, at different ages, tend to perform different tasks.

That is not the whole picture; because not everybody does task one at age one and task two at age two. They vary depending on what they like to do. Like people, you prefer to do some things over others.

Jane: Reading over cleaning my room.

Jennifer: Reading over cleaning your room. Right. That would be good. If you were told to clean up, you might have a preference of what thing you want to clean up. Would you rather do the bathroom or the dishes, or the carpet?

Jane: Yeah, I like doing the bathroom. I don't know why.

Jennifer: That is good news.

Jane: You said she when you are talking about the ants and their work. Are all the ants in the colony female or are there males, because in "Bug's Life" all the boy ants were schlepping the food on their back to the big pile and there were no women ants, except a nursery?

Jennifer: Yes, that is wrong. That part of "Bug's Life" bugged me that's for sure.

One of the central facts about social insects is that all of the workers in the colony are female, all the hymenoptera--the ants, the bees and the wasps. If you are look at a worker, you are looking at a girl. You are not looking at a boy. So I am not sure why "Bug's Life" has to all the boys doing "boys' tasks" and all the girls doing "girls' tasks."

Jane: Like nurseries.

Jennifer: Like nurseries versus carrying something. Even the soldier ants with giant jaws, they are girls. They are all girls.

Jane: They are all girls. Do you hear that?

When do the boys actually come into the colony and where do they work? Or do they work?

Jennifer: They come in at certain times of year and they do not work. The colony is interesting because all the workers that you see are sterile. They don't reproduce. They are there to help the colony. There is only one reproducing individual in the colony and that is the queen.

She mated before she became the queen of the colony. There had to be males involved, because she mated with males. So what happens in a typical harvester ant colony or a leaf cutter ant colony is, once a year, the colony instead of producing workers will switch to producing reproductives.

New queens that are going to leave and form their own colonies and males that are going to mate with the queens. These ants are different from the worker ants because they are reared to be larger and they have wings. Have you seen ants with wings?

Jane: Yeah, like right after rain.

Jennifer: Yes, right after rain. That is really good because, in the desert, they produce them so that they will leave right after the rain so that the queen can dig new nests in an area where there are lots of resources and it is easier to dig.

The males, their only job is to sit in the colony until it rains. Then, they go out with the reproductive females and they mate in a big mating swarm that is called a lek. Then, the females

drop to the ground. They actually chew their wings off. They dig a hole and they start a new nest and the males die.

Jane: So not all the male flying bugs are male.

Jennifer: Not all the winged flying bugs are males? That is right. The reproductive females have wings as well as the males. They fly away from the natal nest, the nest they were born in. Workers never have wings. That is a big difference between a queen and a worker.

Jane: Why do the queens chew their wings off?

Jennifer: The queens chew their wings off because what they are going to do now is dig a hole in the ground, make a nest and they are going to stay in that nest for the rest of their life. They are not going to use their wings again.

They are not going to fly. The wings are kind of useless. Plus they get in the way when you are trying to dig a nest. They are going to get broken. They are going to get frayed.

They chew them off right at the buds. They use the stored resources to produce babies instead of fly.

Jane: In the lab, you said that the females took a piece of fungus with them to start a new colony. Could they start a colony without that fungus? Could the fungus grow?

Jennifer: No. They cannot. This fungus is specialized for these ants. We have never found it in the natural world, outside these colonies. So if a queen flies away, digs a nest and doesn't have her fungal starter, then she is not going to have any food to live on and she is not going to have any food to feed the brood.

She will starve and that colony will die. Each of the queens takes a tiny little piece of that fungus from their natal colony with them. She carries it through the mating swarm and she deposits it after she makes a nest.

Jane: If the fungus does not grow anywhere, then how did it...?

Dr. Biology: Where did it start, right?

Jennifer: Excellent question, thinking back. Not all of the types of fungus that you see in leaf cutter ants are this specialized. It is clear that way, way back a relationship had started between some ant and fungus, where the fungus was available in the natural world but did well in ant colonies and the ants started to feed it.

Then, because that relationship worked so well, they became very locked onto each other so that the genetic diversity present in the fungus decreased and decreased until it was only able to survive in the context of the ant colony.

Jane: Ant colonies.

Jennifer: Yeah.

Dr. Biology: Now, since is it so important that this fungus be carried to the new colony, is it only one queen that goes? Because boy, it seems like you could have a real problem.

Jennifer: Yeah, and you probably noticed that we have more than one queen in some of our colonies. Yes. It is a dangerous time of life for a queen to start a colony with just this little piece of fungus. In our species of leaf cutter ants, *Acromyrmex*, we find that there are often multiple queens in the colony.

They start their nests together in groups of usually around three or four individuals. Our experiments have shown that this is sort of a safety mechanism for them, hedging their bets. If they lose one piece of fungus, they're OK. If they lose two pieces of fungus, they're OK. The third piece of fungus is still there.

So if you figure that, maybe, half the time, the fungus is lost, then, if you have three or four individuals in there, you have a good shot at starting a colony and getting your fungus big enough so the workers can take care of it.

Jane: On that line, when the queens help each other, do they become friends? Do any ants actually have feelings for each other?

Jennifer: I would not say that ants have feelings for each other the way we have feelings for each other.

The queens tolerate each other, which is actually in itself, a big deal in the insect world. To have two, unrelated--because they're not sisters--unrelated individuals, living together and cooperating with each other is a very interesting thing to see. The workers don't really recognize each other in the same way we do.

It's different than other species. For example, if you looked at a pod of dolphins or whales and you looked at who was next to whom while they were swimming, you'd find that individuals like to hang out with each other. That you actually have what look like friendships. We call them associations.

Jane: Like the mother whale and the baby whale?

Jennifer: Yeah, not even the mother whale and the baby whale, just two unrelated females that like to swim with each other. That kind of thing. We don't see that in ant colonies. We've looked at them very carefully and they don't associate with each other outside of the realm of their doing their jobs.

Dr. Biology: But they can recognize each other?

Jennifer: They can recognize each other. There are two different levels that they can recognize each other at. One we already mentioned was that they can recognize that that other ant belongs in that colony.

Jane: By the feelers.

Jennifer: They smell like they should be there. There's some evidence that they can recognize each other as individuals. We did an experiment a long time ago where we took ants that were foragers. This was a different species of ant, *Paraponera*, the giant tropical ant.

Jane: Oh, yeah.

Jennifer: It's a cool ant. They like to collect nectar.

What we did is we pinned leaves to a tree, in two different places, and we put droplets of sugar water on them. Then, simultaneously, we let two foragers find the sugar water. They lay pheromone trails that the ants follow to get to resources.

We let them lay their pheromone trails, and that's a chemical trail, down the trunk of the tree into the nest. We took one away right before she went into the nest. The other one went in and she excited and recruited the ants in the colony to come out and get the resource and, as she left, we took that one away.

Now you have two pheromone trails, right? To two different leaves with nectar. Which one did they choose?

Dr. Biology: The one that went inside?

Jennifer: The one that went inside, that's right! They could actually recognize the individual trail of the one that came in and told them about it.

Jane: There is differences in the pheromone trail of the ant?

Jennifer: Yeah, so that told us that ants actually lay trails with individual signatures or that they're capable of doing it.

Jane: Have you ever studied the pheromone trail of different ants to see what is different in it?

Jennifer: No, I haven't personally, but we have a lot of faculty here who that do that kind of thing.

Bert Hölldobler, who is very well known for his work on the ants, is a specialist actually on ant pheromonal chemical signals. He wrote a really big book called "The Ants" with E.O. Wilson that I recommend.

Dr. Biology: Actually, he was one of the early guests on our show. If someone likes to follow "Ask a Biologist," and didn't go to our earlier shows, he's the third or fourth show.

Jane: I was just thinking, how do you start one of your laboratory ant colonies?

Jennifer: Well, we have two different species that we grow colonies of, the one is the leaf-cutter ants and the other is the harvester ants, the same ants that stung you. I'm sorry.

But the way we do it is we go out into the field when new queens emerge from their nests, after they mate, we collect them and we bring them back into the lab and we actually start all of our colonies from individual queens.

They grow from just a queen, who's laying eggs, to a few workers, to a few dozen workers, to hundreds of workers and we actually like to track the progress of the colonies.

We ask, "How do they grow? How does the organization of the colony, how does their division of labor and what they do change as they get larger?"

Jane: If the queen loses the fungus when you take her to your laboratories, do you take a piece of the fungus from the colonies that are doing really well or do you just let her die?

Jennifer: Let her die? No, we don't let her die. We try not to. We actually take a piece of fungus from another colony. It sounds easy, but it's a delicate operation because this is a living organism that's growing in other colonies.

We have to pluck it out carefully, and we put into her nest and she tends it. Then, she has to take care of it so it will survive. It's a very delicate operation. We call it "transfungination."

Dr. Biology: [laughs] This fungus, it's sort of like baking sourdough bread, is it?

Jennifer: Yes, yeah.

Dr. Biology: Is that when you have to have a starter?

Jennifer: Yeah! That's a really good analogy. It's like a sourdough starter. You know that across the prairie, people carry this sourdough starter to make bread and they gave it to their kids when they grew up and they gave it to neighbors when they lost theirs. This is the same kind of thing. That's how valuable it is.

Jane: In one of your little soda bottle colonies, I noticed its fungus kind of hanging off the top of the soda bottle. Does it actually stick there or does the queen ant go up there?

Jennifer: Isn't it funny how it actually likes to hang down from the top. We think of it maybe sitting on the ground in the dirt, but it doesn't. They clear a space in their colonies, and they glue it up there, and it grows down, a little bit like honeybees when they make comb, right? They start the comb at the top and it hangs down in space.

Dr. Biology: There's one other thing the advice is, if I didn't say it before, I am saying it now, we are not going to have you going and sitting on any anthills right?

Jane: No, thank you.

Dr. Biology: No anthills. We are not going to test the theory whether you actually are now allergic to an ant sting or not?

To clear this up, not all ants can sting right?

Jennifer: That's right! You can divide ants into ants that sting and ants that don't sting.

Jane: I always thought that ants bite. I never knew that they stung.

Jennifer: Yeah! Everybody says that. I don't know why they think that ants bite. Well, they do bite. They grab you so that they can rotate their abdomen and stick their stinger in.

Jane: Oh, OK.

Dr. Biology: We actually have a real nice article on "Ask a Biologist" with the anatomy of ants. There are two types, and we have the ones with the sting and one without, just a stereotypical kind of an ant.

Jane: How do the ants without stingers protect their...

Jennifer: They can spray formic acid.

Jane: Ow.

Dr. Biology: Yeah, I'd say ow. [laughs]

[laughter]

Jennifer: But it's not as harsh as the sting.

Dr. Biology: Sounds like may be not as deadly as the toxin...

Jennifer: Yeah.

Dr. Biology: ...yeah. That seems like that would do fast work on any ants that were trying to get in.

Jane: Yeah.

Dr. Biology: They can keep stinging, right? It's not like a bee...

Jennifer: Yes, they can keep stinging.

Dr. Biology: With that I'm looking at the time. Let's take a short break here.

You've been listening to "Ask a Biologist." My guest has been Jennifer Fewell, Professor of Biology at Arizona State University, School of Life Sciences. My guest cohost has been Jane Rector.

Together, we've been learning about the amazing world of ants. In our next half of the show, we're talking more about ants and I hope we'll also find out more about the link between ants and the fast pace game of basketball.

Now, what could that be?

The "Ask-a-Biologist" podcast is produced on the campus of Arizona State University and is recorded in the Grassroots Studio, housed in the School of Life Sciences, which is a division of the College of Liberal Arts and Sciences.

Remember, even though our program is not broadcast live you can still send us your questions about biology using our companion website. The address is askabiologist.asu.edu or you can just Google the words "Ask A Biologist." I'm Dr. Biology.

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