Ask A Biologist Vol 106 (Guest: Beth Pringle)

Tiny Versus Mighty

Have you heard the story about the ant, the elephant, and the acacia tree? No, it is not a children's book story. Instead, it is a story about a battle for a tree between a tiny ant and one big elephant. It is also an interesting tale about how plants and animals can have a relationship that benefits both. Dr. Biology takes to Zoom to talk with biologist Beth Pringle. The two talk about this epic battle of tiny versus mighty along with some interesting twists and other characters.

Transcript

Dr. Biology:

This is Ask A Biologist, a program about the living world. And I'm Dr. Biology.

We continue to do our podcast using Zoom, but we plan on getting back into the studio and on the road this fall. In the meantime, I hope those able to get vaccines have been able to get them or are scheduled to get their shots soon. Having everyone protected from COVID-19, we will be able to make a big change for the better in our lives, and perhaps get back to a more normal way of life.

Now, when we think about making changes, it is not uncommon to think big, big ideas, big projects, big equipment. This thinking can carry over to animals too. If you see an obvious change to your environment, you look to the big animals as the root cause. Humans could be the cause or even things as big as elephants.

But what if tiny is mightier than large? We see this with viruses. They are microscopic, but they can be deadly to animals. Our guest today is not looking at things as small as a virus. She's been investigating the power that some tiny insects have over one of the largest animals on earth. Beth Pringle is an assistant professor in the Department of Biology at the University of Nevada Reno. You might also know her from our virtual tours. Beth took us along on one of her research trips to Kenya. Over 75,000 people have taken that virtual trip in the past eight months. And if you're not one of them, you'll want to make sure you put that on your schedule to do after this show. We'll make sure we put the link to the tour in the description for this episode.

Now back to that tiny insect Beth has been studying. It turns out to be one that everyone is familiar with - ants. Yes, these tiny animals are able to have a big impact on the savanna and its plants and animals. Welcome to Ask A Biologist, Beth.

Beth:

Thank you. It's wonderful to be here.

Dr. Biology:

Now here we go. Let's paint a picture. We're in the savanna of Kenya and there is an acacia tree. And for those that don't know what an acacia tree is. It's one of these trees that has really wicked thorn turns on it. There are spiky they're really, really big. And if you can't picture an acacia tree picture a really big tree. Now let's picture in our mind an African elephant, that is about 10 feet or three meters tall weighing in at 10,000 pounds or 4,500 kilograms standing next to our little red ant that is a fraction of an inch, say five millimeters tall and weighs in at a massive five milligrams,

which is again is a fraction of an ounce. Who wins the battle for the tree?

Beth:

The ants.

Dr. Biology:

Okay. What a surprise. Now the question is, how does this little ant do that?

Beth:

The amazing thing about ants, right, is that they're social animals. So they work in these big colonies. When you see a single ant, she's out there patrolling foraging, doing something for the colony. And she goes back to that colony, which is basically a large collection of her sisters. The queen, right, is their mother and all these worker ants are the daughters of that queen. Working together ants can do amazing things, including fight off elephants.

Dr. Biology:

Oh, okay. So, all right. They can fight off elephants. The question for me is why are they fighting off the elephants for this tree? I mean, it's just a tree, right?

Beth:

Yes. But the tree is also their home. So, in this case, the answer forming their colonies inside the swollen spines of this acacia tree and they spend their entire lifetimes living inside the tree. So by defending the tree, they're actually also defending their own home.

Dr. Biology:

Okay. So, there's something in it for them, right? They don't want this giant animal coming here and basically destroying their home.

Beth:

That's right. Imagine that the elephant comes in and takes off, you know, a big part of the trunk that happens to hold the queen in it. That means that there's going to be no more replacement of worker ants and the colony is basically finished.

Dr. Biology:

So, it's more than just one ant. How do these ant sisters basically take down or deter this giant elephant from destroying a tree?

Beth:

Yeah. They crawl up the nose. [laughter] So, right. So elephants eat with their trunks or they tear off bits of the tree with their trunks and the ants crawl up the inside of the trunk, which seems to have some really sensitive skin in there and the elephants hate it. But elephants also have this really great sense of smell. So what we guess, although it hasn't been tested is that the elephants know when the ants are present on the tree and they hate what happens so much when they do try to eat a tree with ants that they just stay away from those trees with ants in the first place.

Dr. Biology:

Oh, so the trees, not only do they have protectors, they have almost like a force field.

Beth:

That's right. The answer releasing pheromones all the time. And my guess is, and again, this hasn't been tested, but my guess is that the elephants can just smell that and they stay away.

Dr. Biology:

So, they learned that by basically having gone to one of the trees when they were younger and they learned their lesson.

Beth:

And that's my guess.

Dr. Biology:

Yes. Okay.

Beth:

Yeah, they did do a Y-tube elephant experiment last year or something, maybe one or two years ago, it was published in animal behavior. So, a Y-tube elephant experiment. It looks like you set up an elephant-sized maze. [laughter] And at the end of either side of the maze, you have a preferred plant and an unpreferred plant and they can navigate to the preferred plant through the maze.

Dr. Biology:

Which is a-mazing. Sorry. [laughter] Can there actually be too many ants for the tree because if it's really great, you know, that's kinda like, you know, humans, sometimes we overpopulate areas. How does a tree deal with that?

Beth:

Yeah, that's a great question. So we don't know for sure. It seems as if it's definitely possible for there to be too many ants for a tree because the ants are costly to the tree. So the tree gives some of its sugars to the ants and that's a payment. So of course you can sometimes pay too much if the ants are an insurance policy against elephant damage. Sometimes the insurance policy costs too much. And that's what happens if colonies get really too large. So one of the questions actually that I focused on in my research is can trees have some control over that investment?

Dr. Biology:

You brought up sugars. So, there's a reward system for the ants. Not only is the tree, their home, they're actually getting some food. Where's the sugar come from. I know it's the tree, but does it just secrete the sugars naturally?

Beth:

Yeah. So in the case of these acacias, it does it in two different ways. So one is that it secretes them naturally, you know that flowers have nectar. In this case, it's additional nectar at the base of the leaf. And so we call that extra floral nectar. So not part of the flower, and that's a direct secretion from tree to ants. The other way that these ants get sugar is a way that's far more common across all kinds of plants all over the world. And that is that there are these sugar

feeding, herbivores, so insects that are eating directly from the tree called scale insects that are basically tapping into the trees, sugar, and then pooping out [laughter] a form of sugar. We call honeydew that the ants then eat. And so there's this direct way of providing sugar to the ants and also the indirect way, which is via these scale insects.

Dr. Biology:

Ah, okay. The tree, does this, does it have any control about how much sugar it puts out?

Beth:

Yeah. So that's an important question and we don't know the answer for sure, but it does seem as if there's a lot of variation in the kinds of sugars and the kinds of other compounds that are in the phloem which is the, the, basically the transport system for sugars around the tree. There can also be variation in the quality of sugar. So there are lots of different kinds of sugar molecules and perhaps the tree has some control over whether the ants are getting, you know, table sugar or some other kind of simple sugar molecule. The other thing that the tree is can potentially put in that phloem, is toxins. So trees make all these kinds of other molecules that aren't directly important for their nutrition, but that could function in defense. And so there's a way potentially for trees to put these toxins into the phloem and for that to then get out to the scale insects into the ants to reduce ant colony size.

Dr. Biology:

Ah, instead of getting a sweet taste, they're getting a bitter taste maybe.

Beth:

Right that's possible. Yeah. Yeah.

Dr. Biology:

All right. So, when we talk about these relationships, we're talking about a term that we use at times called symbiotic relationship and in a symbiotic relationship at least one of the participants has to be benefiting. Typically. What we're talking about here is you have both a plant and the animal and under optimum conditions, they're both benefiting. So here we're talking about mutualism, right?

Beth:

That's correct. Yeah. Mutualism.

Dr. Biology:

There are a lot of examples of mutualism. And I think that even with your tree, when I was reading some of your research, it's kind of complex, right? It's not necessarily a one-to-one relationship. So you were talking about all of a sudden, we have these scale insects without the scale insects, then we're reliant on only one mechanism of getting the sugars to the ants. So let's talk about kind of the layers that you have that are involved with this basic symbiotic relationship between multiple organisms.

Beth:

Yeah. So, any of these mutualisms, right, are occurring within ecological communities, which means that there's many species that could potentially interact with them. And I would say in a lot

of cases, those additional species are either enhancing or reducing the benefits that those two partner species are giving to one another and the mutualism. So, we think of this as kind of putting mutualisms into the context of the community. And so how many different species interact with each mutualist and what are their effects on that exchange, that beneficial exchange between the partner.

Dr. Biology:

Right. And, and I guess my question on a more basic level is if I pull one of those layers out, does it all collapse? For example, if you had an issue with the scale insects, would you have an issue with the overall health of the tree or the health of the ants? And therefore are great big elephant comes in and has its way with the tree.

Beth:

So, to take that example specifically, it's really interesting because for a long time, people hypothesized that the scale on sex because they're herbivores because they're tree enemies, we're actually doing a net harm to the tree and that the tree should evolutionarily prefer to have this sugar going directly to ants. My research has really suggested that there's probably some additional nutritional benefit of having the scale insects and their honeydew that they give to the ants specifically. It could be in terms of some other kind of nutrient that the ants are getting. It could be sort of a more dynamic way to vary how much sugar goes to the ant colony. But the way to test this was done by my collaborators in Kenya, they just removed all the scale insects off the tree to see if, if they just got the nectar directly from the tree, what happened and what they found was the size of the ant colonies and therefore how good the ant colonies were at defending against elephants really was diminished by not having the scale insects present. So they found much higher elephant damage on trees that have the scale insects removed.

Dr. Biology:

All right. Let's just say this symbiotic relationship completely breaks down and there's no longer a defense. What would the savanna look like? What would be the impact of this? Because now the elephants could do whatever they wanted.

Beth:

Yeah. It's an important question now in particular, because the savanna is experiencing this invasion from another kind of ant that lives in the soil. This ant has the nickname, the big headed aunt, because some of the workers have very enlarged heads and they nest in the soil and they're very aggressive. They form very large colonies and they can fight with other ants, including with the acacia ants. So what we see is like a lot of invasive ants like fire ants and Argentine ants here in the United States. These big headed ants tend to colonize soils that are disturbed. So around human habitations and then move out on what we call an invasion front, move out away from that human habitation into the surrounding area. So when these ants do that in the savanna, they actually fight with and take over trees from the acacia and leaving the trees completely undefended. And what we've seen then is these landscapes that look very different from the landscapes where the trees are well defended, basically trees that have been clobbered by elephants with, you know, all of their branches taken off. You see these poor little trees trying to survive by putting up little shoots from the ground, but really a very different landscape with many fewer trees in these invaded habitats.

Dr. Biology:

So, the big headed ants, how invasive have they become in the savanna

Beth:

That I think is an unanswered question at the moment for a long time, they were around, you know, if you look at a map of all the places that these ants had made it all over the world, I mean, they're basically on every continent except for Antarctica. So they've, they've made it to all these different places. They've probably been around for a long time. And it's just been within the past couple of decades that I think they've been noticed in the savanna ecosystems. I don't know why that is if it's just because people are looking more or if they've just arrived at these places where people have set up their settlements and sort of disturbed the soil. But again, it's a relatively recent phenomenon that people have been noticing that they've been overtaking these savannas.

Dr. Biology:

Let me ask you about our tree again, it's got it's ant protector. Does a tree have any other relationships? Is that their only symbiotic relationship they have going?

Beth:

No. So these trees are part of the bean family. So they also fix nitrogen below the soil. And that's an additional mutualism that we think allows the tree to be so dominant in the Savanna habitats, where it is so common, because nitrogen is often a limiting nutrient for plants and trees. And this tree formulates this mutualism with bacteria that fix nitrogen from the air and can provide nitrogen then to the whole system. So that's an additional mutualism in the system

Dr. Biology:

You say, fix the nitrogen, but was it broken?

Beth:

Yeah. [laughter] Jargon. So fixing nitrogen just means taking nitrogen gas from the air and turning it into forms of nitrogen that the plant can actually take up with their roots.

Dr. Biology:

Is there anything else going on underground?

Beth:

Yeah, so I think a lot is going on underground and simply because we stand on the ground, as people looking at the plants, we've focused on what's going on above ground, but under the ground, there's this whole other set of species and interactions, um, that we think is probably really important to how the tree behaves. So possibly, uh, you know, the reason that this tree is so dominant on that one soil type is because of the way the roots interact with the soil and the organisms underneath the ground. And in the case of the invasive ant, we think in particular that it's forming these excavations of the soil where the colony lives and the interactions with the roots that may be driving some of their negative effects on the trees. In addition to their effects on the acacia ants.

Dr. Biology:

Earlier on, you talked about the swollen spines, is it about the size of a softball?

Beth:

Probably not quite that large. I'd say maybe the size of a ping pong ball or a little bit bigger.

Dr. Biology:

Okay. Size of a ping pong ball. Okay. And so the ants live inside there does a single colony live in one of those or are they just spread out amongst all these different spines?

Beth:

Yeah. So that's something that's interesting because it changes over the lifetime of the ant colony. So, when the ant colony is first formed, the newly mated queen will fly in and find her thorn and sort of colonize a single thorn. And that for a given tree that may actually happen in several different thorns around the same time. So you may have several sort of starting ant colonies getting going at once. But then as the queen starts to make more eggs and therefore have more workers as the colony gets bigger. One of those colonies, will usually start to overtake the tree. And ants can be quite aggressive when they run into ants that are of a different colony. And then the ants will fight the ants of the other colony and take over the thorns from that colony until the tree is one entire ant colony

Dr. Biology:

In your travels, in the savanna. I'm always curious, is there any time that you've been, and it may be there multiple times that you have been surprised ? You, you observed something and it just, you're just like, huh. And it's made you have a long standing question.

Beth:

Yeah. So, I think the thing that stands out the most when you first go to these savannas and we're talking about in central Kenya is where we work. Is that in some areas, you'll see what looks like a lot of different kinds of plants. So you'll see lots of different trees and grasses and understory plants. It'll look like a very diverse savanna. And then in other places, namely where these acacias live, you'll look out across the landscape and you'll only see this one kind of tree. [laughter] It's just one kind of tree across, you know, as far as the eye can see. And so the question is, you know, why, why are these occasions, the only tree that seems to exist in this particular part of the savanna?

Dr. Biology:

And so it gets us back to your original question in your research. Are they the only tree that managed to figure out how to do this relationship with the ants and the scale insects?

Beth:

Yeah, I think it must be. And it's what underlies those different tree communities are different kinds of soil. So we know that now that where the tree communities are more diverse, it's one kind of soil and where the acacia is the only tree it's another kind of soil, but what about that kind of soil is what makes this particular tree, you know, so successful. And it has to have something to do both, I think, with its mutualism, with the bacteria that make nitrogen for the tree, as well as the ants,

Dr. Biology:

As a biologist, one of your study sites is the savanna. Are there other places you also do research

that are as exotic as the savanna of Kenya?

Beth:

Yes. There are places that are as exotic and they include my backyard. [laugher] So, yeah, so I live in the great basin, which is a large desert region that spans all of the state of Nevada practically and Utah. Goes into California to the West and Oregon up North. And it's just as huge watershed. So, describing an area where a bunch of rivers all run together that spreads across a lot of the Western United States. And it's unexplored here too. You know, we have huge amounts of land where no one is living, it's a desert system, but lots of plants do pretty well here. So we're studying how plants do well in environments with very little water and how that affects their interactions with insects just here at home as well.

Dr. Biology:

Right. Right. I actually have another colleague who studies ants. And it was interesting because he discovered a new species literally in his backyard.

Beth:

Yeah. I would say the density of people working in the great basin is possibly lower than the density of people working in some tropical forest. We have very little knowledge about some of the ways that species get by in these desert ecosystems. There's some really interesting questions to be explored.

Dr. Biology:

So future scientists, your exotic world awaits.

Beth:

That's right. Absolutely your backyard or as far away as you like.

Dr. Biology:

Yeah. [laughter] Well, before my guests get to get away there are three questions, I ask all my scientists.

Beth:

Okay.

Dr. Biology:

The first one, when did you first know you wanted to be a scientist?

Beth:

So it would have had to be in college when I started working in a laboratory for the first time. I was lucky in that I got paired with a graduate student. So I was an undergraduate student at a college. And I was paired with a graduate student whose research project was on the interactions between caterpillars and a bacterial pathogen on plants. And he was a wonderful mentor because he would talk to me all about what was current in science relating to this interaction. And know I had no idea at the time about any of it. So I was learning as I was doing science with him. And then I had an idea for an experiment that we weren't doing together, and I decided to do it on my own.

And I think doing that experiment, you know, from formulating the idea to conducting the entire experiment on my own. You know, going in late at night to weed the plants, uh, after I was done with my homework for classes and sort of seeing that through to completion. Then coming out with a cool result, which in that case, was that the bacterial pathogen, when it infected the plant had an effect on subsequent success of the caterpillars, was it a, did it. It was something about sort of having the research idea, having a question and then getting all the way towards finding the answer to that question that I found deeply satisfying.

Dr. Biology:

Well, what might be surprising to listeners is that you come from a family of basically scientists and biologists, but you weren't planning on being one.

Beth:

That's right. Yeah. [laughter].

Dr. Biology:

What was it you wanted to be?

Beth:

I wanted to be a lawyer.

Dr. Biology:

You wanted to be a lawyer. And it was this one moment in time that actually just shifted you back into the world of science.

Beth:

That was what sealed the deal. I think there were other times when I had hints that maybe biology was for me. I had a conversation with an environmental lawyer, which is the kind of law that I wanted to do, where, uh, I asked her what she would do if she could do it all over again. And she said that she'd become a biologist because she needed more information on the biology and in order to make good law. That had made an impression. And, uh, I think in other contexts also, I would just, I, you know, I worked for the park service, for example, and watching the biologists in that case, they were studying the bears in the park and their behavior. That just seemed like a really interesting job. And so there were various experience that fed into it. And I think it sort of culminated in, Hey, I can have a question about something and then I can answer it for myself.

Dr. Biology:

Well, now I'm going to do my typical evil thing and I'm going to take it away from you. So I'm not going to let you be a biologist, a scientist. You don't get to teach because I know most of my biologists actually are pretty passionate about teaching. And now that you let me know that you are going to be a lawyer, I'm going to take that away. So you don't get to slide into that because what I want you to do is figure out what would you be, or what would you want to do if you could do anything?

Beth:

I guess. I was just trying to think I have one idea, but I'm not sure. I'm not sure it's what I want to say. [laughter].

Dr. Biology:

Well?

Beth:

Um, one thing that I always thought would be fun is to, to host a bed and breakfast somewhere. And I think that's just because I think I've always enjoyed traveling. And one of the things that also really attracted me to this career was the fact that I got to go to different places and look at the biology, but also interact with people and learn about different cultures. And I think that's probably what seems attractive about being a bed and breakfast host is that I could interact with all the people who came through and hear about their life experiences and learn about other parts of the world through my interactions with folks.

Dr. Biology:

Yeah. It's kind of the reverse of traveling the world. You have the world come and travel to you.

Beth:

That's right. I think that's, that's what it must be.

Dr. Biology:

Yeah. Oh, well, my last question is what advice would you have for a young scientist or perhaps someone who always wanted to go into science as a career?

Beth:

Yeah, I think the most important thing is, is to be curious, right? And to have, you know, foster curiosity by asking questions and you know, what gets really exciting is what is, when you discover how many questions still don't have answers. So we're really at the beginning, in a lot of ways, of understanding lots of different things about how the world works, how earth works. And I think that following that curiosity to the point where you discover what's unknown and how much is unknown is really exciting.

Dr. Biology:

Well, Beth, I want to thank you so much for joining me on Ask A Biologist.

Beth:

Thanks so much for having me, Dr. Biology.

Dr. Biology:

You have been listening to Ask A Biologist and my guest has been Beth Pringle, an assistant professor in the Department of Biology at the University of Nevada Reno. You can learn more about Beth by reading about her in our companion, Ask A Biologist story. It's called *Peeking Into Ant-Plant Pacts*. You can also ride along with Beth while she explores Kenya in our savanna biome. It's a virtual trip. It's easy to get to. You could do it from your phone. We'll make sure there's a link to both the story and the virtual trip in the description and the transcript of the show.

The Ask A Biologist podcast is usually produced on the campus of Arizona State University and is recorded in the Grassroots Studio, housed in the School of Life Sciences, which is an academic unit of the College of Liberal Arts and Sciences. And 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. And as always, I hope you're staying safe and healthy.